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PROMOTING SUSTAINABILITY OF RURAL WATER SUPPLY THROUGH HAND PUMP MAINTENANCE TRAININGS.

BY

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Key Words: ACCESS, MAINTENANCE, SUSTAINABILITY, PREVENTIVE MAINTENANCE, HAND PUMP

ABSTRACT

Many of the India Mark II hand pumps installed in Nigeria are not functioning for lack of maintenance. The two main causes are, of first importance a lack of maintenance personnel in the communities where the pumps are and a second lack of maintenance working tools and hand pumps spare parts.

Between March 2009 and March 2010, the National Water Resources Institute (NWRI),Kaduna conducted nine (9) hand pump maintenance trainings for Bicycle Repairers and Motor Cycle Mechanics in nine states in Nigeria.

The main objective of the trainings is to develop the capacities of Bicycle Repairers and Motor Cycle Mechanics in hand pump maintenance so that they can be readily available in their communities to maintain hand pumps.

The paper is a brief account of the trainings highlighting the training specifics in the nine states where the trainings took place. The first day of the course was used for a detailed presentation of the maintenance procedures of India Mark II hand pumps which are widely used in Nigeria for rural water supply. The remaining three days of the trainings were spent on the field in scattered villages repairing broken down hand pumps and also encouraging some of the WASHCOM members who came around during pump repairs to practice preventive maintenance on their water facilities.

There were a total of 180 participants in the nine trainings and a total of 32 non functioning hand pumps were restored to service thus improving access to water supply in the rural communities where the repairs were carried out. From the participants written evaluation, the trainings were seen as useful and a wonderful opportunity for them to acquire Hand pump maintenance skills that can help them add value to their communities as they render much needed Hand pump maintenance service.

INTRODUCTION

Water sustains life and human development. Sanitation ensures that water supplies remain safe from faecal waste. Hygiene provides the principles for stewarding water and sanitation facilities and preventing the spread of disease. Together, WASH (Water, Sanitation, Hygiene) improves all areas of life. This fact was reinforced by the former Secretary-General United Nations, Kofi Anan who remarked that, "We shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation and basic health care."[1].

Access to safe water is critical for human progress. The following statistics underscores this point.

(a) One in eight people worldwide lack safe water.[2]
(b) While access to safe water can decrease childhood water-related deaths by 15 to 20 percent, improved hygiene practices such as hand washing reduces deaths

caused from diarrhoea by 35 percent, and access to adequate sanitation reduces rates by 40 percent [3]

(c) As a result of WASH improvements and others that address basic needs, childhood deaths are declining steadily worldwide. In 2007, more than 12.6 million children under five died from largely preventable or treatable causes; the number is around 9 million today, despite population growth.[4]

(d) No other single intervention is more likely to have a significant impact on global poverty than the provision of safe water.[5]

The National Water Resources Institute (NWRI) located in Kaduna, Nigeria makes its contribution in developing the human capacity to ensure sustainability of access to safe water, sanitation and hygiene.

In the 2008 Capital projects, the NWRI Management approved the implementation of three hand pump maintenance trainings for Bicycle and Motor Cycle repairers at Ilesa (Osun state), Ikot-Ekpene (Akwa Ibom state) and Zaria (Kaduna State) as a pilot project. Because of a delay in the release of funds, the three pilot trainings were eventually conducted in March 2009.

The main objective of the trainings is to develop the capacities of Motor Cycle mechanics and Bicycle repairers in hand pump maintenance so that they can be readily available in their communities to maintain hand pumps. The trainings also incorporate environmental sanitation of the water points as well as encouraging WASHCOM members to make provisions for preventive maintenance of community water supply points. That way, the reliability and sustainability of hand pump water supply systems can be promoted. In 2008 project, there were 58 participants comprising 14 Water Supply, Sanitation and Hygiene (WASH) officers who participated as assistant Training Facilitators and 44 trainees who are a mixture of Motor Cycle Mechanics and Bicycle repairers having functioning shops in 15 Local Government Area (LGAs) where they are resident- 3 trainees from each LGA.

In 2009 Capital projects, the NWRI Management made provisions for similar Hand pump Maintenance courses to hold for Motor Cycle Mechanics and Bicycle Repairers in Six (6) states with the towns and cities hosting the training indicated in bracket i.e. Ebonyi (Abakaliki), Ekiti (Ado – Ekiti), Kebbi (Birnin Kebbi), Niger (Minna), Ondo (Akure) and Yobe (Portiskum).

Training in Hand pump Maintenance is used by many organizations around the world in other to ensure sustainability of access to safe water supply most especially in developing countries. For example, International Aid Services (IAS) is a Swedish organization currently involved in six major sectors which include Water and Sanitation. The organization's focus in Water and Sanitation cover: protection of springs, digging of shallow wells, drilling of deep boreholes and maintenance of hand pumps including community training. IAS has eight Programme countries where it is registered and has offices like Ethiopia, Kenya, Sudan and Uganda to mention a few. IAS also has Support countries like Nigeria, Paraguay, Sri Lanka and Tanzania where IAS supports projects through local implementing partners. [6]

Another organization that uses training in Hand pump maintenance to promote sustainability of rural water supply is Lifewater International. Lifewater International is a Christian not-for-profit development organization that believes all people should have safe water for life. With a focus on sustainability, Lifewater helps communities gain safe water, adequate sanitation, effective hygiene, and the skills they need to pass on these resources to future generations.

Lifewater's **Hand Pump Repair** course is a high-activity, learn-by-doing training mixing interactive classroom sessions with hands-on exercises. Participants usually encounter and repair real broken hand pumps collected from around the world including

the Bush, India Mark II & III, Afridev, and Tara pumps. This class requires no prior knowledge of hand pump repair, but good mechanical aptitude is necessary. Class size is generally limited to twelve students, a student: trainer ratio as low as 3:1. The Lifewater Training Centre is at San Luis Obispo, California.

Lifewater's volunteer field trainers are the bridge through which valuable knowledge, skills, and tools are shared with in-country partner organizations. With more than two hundred fifty certified field trainers, Lifewater has multiplied its effectiveness by training its in-country partners to engage communities as project decision-makers, implementers, and evaluators. Lifewater's in-country partners strive to include representatives of all members of society in their work: men and women, young and old, rich and poor. An example of this is the establishment of water committees, which are representative of community diversity and are responsible for maintaining safe water sources [7].

PROJECT IMPLEMENTATION METHODOLOGY

The author who was appointed the Project Desk officer presented a Project Implementation Plan (PIP) before the NWRI Parastatal Procurement Planning Committee with other Project Desk officers in attendance. Inputs were made to improve the PIP presented. The approved PIP essentially indicates the activities, the personnel involved, the spare parts to be procured and the cost estimates for project implementation. The sourcing of the trainees was through collaboration using mainly the WASH staff from the LGAs that were trained by NWRI in Hand pump maintenance in 2007 during the implementation of the Federal Rural Water Supply and Sanitation project. 430 WASH staff was trained then by NWRI [8].

Specifically participants for each course were selected in clusters of 5 LGAs in the selected states of the Federation where hand pumps are extensively used. Each of the 5LGAs participating in each course for a state was allowed to source for three trainees. Five (5) LGA WASH staff that functioned as assistant training facilitators during course implementation helped in sourcing for the trainees initially. Before each training was conducted, one NWRI staff who was the designated resource trainer for a course conducted a preparatory visit to the participating LGAs to conclude arrangements for the course. The venue for the course was fixed to be at the headquarters of one of the participating LGAs. Maintenance practicals on hand pumps were to hold in the local government hosting the training and two other adjoining local governments. It was also during the preparatory visit of the NWRI resource trainer that the proposed trainees were authenticated, training hall arranged for and the places for maintenance practicals were identified.

Provision was made for 15 trainees for each course with 5 WASH staff participating as assistant training facilitators. Two NWRI staff were involved in conducting each course. One is the trainer while the other managed the participants' welfare. The author was resource trainer in four states i.e. Osun (Ilesa), Ekiti (Ado – Ekiti), Niger (Minna) and Ondo (Akure) Altogether fourteen (14) NWRI staff participated in conducting the training courses.

HIGHLIGHTS OF THE COURSES

Essentially the trainings were similar in all the nine states where the trainings took place. There was a classroom session which presented the maintenance procedures for India Mark II hand pumps using the maintenance manual developed by NWRI with assistance from UNICEF [9]. Group exercises took place to reinforce learning. Some of the pictures during the classroom sessions are as follows.

Fig. 1 Cross section of hand pump maintenance Course Participants at Ado – Ekiti.

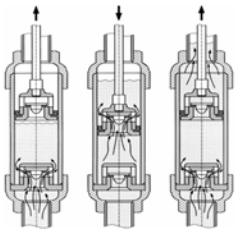
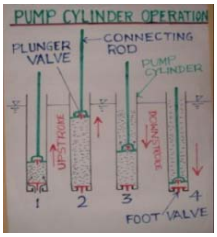


Fig. 2 Hand pump Cylinder Operation



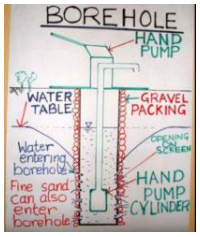


Fig. 3 Borehole Illustration.

Fig.4 A WASH Officer explaining Pump Operations.

Fig.5 Pump operations Illustration.

Fig. 6 A trainee explaining. Pump operations.

Fig. 7 Class session in Minna

Fig. 8 Group exercise session In Minna.

In addition to the classroom sessions, the trainees had varied exposure having hands on experience to repair broken down hand pumps. The field practical usually began by appraising the physical condition of the pump. This mainly includes the pump above the ground components shown in Fig.9. For an India Mark II the area of interest for physical examination include the following:

Fig. 9 India Mark II above ground components.

Fig.10 Damaged rubber cups on plunger.

a.) Pump lever (If shaky , it may mean that the axle bearings need to be checked to determine if a replacement is necessary) If worn out axle bearings are not changed some of the materials being lost in the bearing can find its way into the below ground assembly to cause damage on plunger valve rubber fittings shown in Fig. 10. Sometimes the brass cylinder lining may be damaged as shown in Fig. 11.

b.) The water tank. It is essential to check whether all the eight bolts and nuts holding the water tank to the pump head are in place and tight.

c.) The Inspection Cover is as shown open in Figure 12. This compartment is examined to ensure that the space is not stuffed with dirty things which can find its way to the below ground assembly and lead to further damage. An examination of the chain in this compartment can reveal whether it needs greasing. Also the check nut holding the first connecting rod with the chain is examined for tightness.

d.) The pump platform and the surrounding environmental cleanliness.

Fig. 11 Damaged Cylinder Brass lining.

Fig. 12 Pump Inspection Cover

After pump physical examination, the participants were observed as they dismantle hand pumps in order to examine the below ground components of the hand pump to determine the needed parts replacements e.g. pipes, connecting rods, pipe fitting, plunger valve rubber cups, foot valve replacement kit etc. The photographs showing an example of this process carried out in repairing an India Mark II pump at Maikunkele, Bosso LGA of Niger state are as presented in figures 13 to 18.

Fig, 13 Riser pipes removal

Fig.14 Pump cylinder removal

Fig. 15 Plunger assembly with new rubber cups. Examining plunger valve sitting.

Fig. 16 Examining the foot valve for parts replacement.

Fig. 17 Re assembling riser pipes.

Fig. 18 Pump being tested by a WASH Officer.

LESSONS LEARNT

A.) Preventive maintenance is generally lacking in the communities where our project team carried out hand pump repairs. This point is reinforced by the fact that all the eighteen

(18) Hand pumps that were restored to service during the six courses conducted in six states were not working before our project team repaired them.

B.) Each community WASHCOM need to be trained and strengthened to perform Preventive maintenance of hand pumps. Preventive maintenance at the community level is feasible and is limited to the above the ground components of the hand pump.

Preventive maintenance is carried out on a pump that is working with the aim of preventing it from becoming dysfunctional which will then require repairs to make the pump functional. For India Mark II hand pumps the preventive maintenance that WASHCOM can do include:

i.) Open the Inspection cover and clean the compartment housing the chain of refuse that children in the area might have introduced into the pump head.

ii.) Checking the axle nuts for tightening after checking that the pump handle is not moving sideways. If there is a sideways movement it suggests that the axle bearings are bad and should be replaced.

iii.) Checking for tightening the check nut below the chain head and the first connecting rod. If the check nut is not tight, the first connecting rod can disconnect in the process of pump operation, rendering the hand pump dysfunctional.

iv.) Checking for tightening the 8 bolts and nuts holding the pump head and Water tank together.

v.) Apply grease to the chain if necessary.

vi.) Ensuring that the environmental cleanliness of the pump surroundings is in order.

vii.) Perform pump leakage test. Borrow a bucket from a nearby user. Operate the pump handle to fill the bucket. If the handle needs a few idle strokes before the pump begins to deliver water, it means that the water level is dropping in the riser pipe. If the pump needs **more than five idle strokes** before yielding water, there is cause for concern and below-ground repairs should be scheduled. If the pump needs **ten or more idle strokes** before yielding water, below-ground repairs should be scheduled immediately.

The area mechanic handles the below-ground repairs of hand pumps.

If Preventive Maintenance is carried out by WASHCOM regularly, it can prolong the time of good performance of the hand pump. All the technical aspects of the Preventive Maintenance to be done by WASHCOM (except changing of bearings) can be accomplished using one each of 17 and 19 flat spanners as well as one each of 17 and 19 ring spanners . Also needed is a tin of lubricating grease. In the case of Afridev hand pump one composite tool is provided to do preventive maintenance.

The area mechanic is to replace the upper and the lower fulcrum pins on the Afridev pump lever assembly.

C.) Some of the repairs carried out on hand pumps are not expensive. In some cases ordinary washing of below ground components is enough. Majority of the repairs involved changing of replaceable rubber fittings on the plunger and foot valve which is about $6.8 US dollars altogether. It was apparent that the lack of structure for maintenance of water facilities in a community often leads to the community members suffering untold hardship for things that can be replaced with a little amount of money.

CONCLUSION AND RECOMMENDATIONS.

The National Water Resources Institute (NWRI) conducted nine (9) hand pump maintenance courses in nine (9) states i.e. Akwa – Ibom,Ebonyi, Ekiti, Kaduna, Kebbi, Niger, Ondo, Osun and Yobe states. A total of one hundred and sixty-five (165)

participants took part in the courses. This number comprised one hundred and twenty-four (124) trainees and forty- one (41) WASH officers who assisted fourteen (14) NWRI staff in facilitating the courses.

A total of thirty-two (32) broken down hand pumps were repaired and restored to service during the practical hand pump maintenance sessions that took the participants to various communities.

By and large, the participants were enthusiastic about the trainings and the goodwill expressed by the community members with whom our project team had interaction was heart warming. From the evaluations received from the participants, the training courses were generally perceived as practical and useful [10]. The recommendations are as follows:

i.) There is a general need to mobilize communities in ownership of the water facilities in their domain. WASHCOM need to be constituted and empowered to carry out preventive maintenance of water facilities.

ii.) At least one artisan/person in a community should be trained to repair/maintain the below ground components of a hand pump which function is outside the scope of WASHCOM.

ACKNOWLEDGEMENT

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Water Flow Monitoring in Accra, Ghana, Using a Sensor Network

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Key Words: Water Distribution Network (WDN), Sensor Network, Water Flow, Dry Taps, Intermittent Water Supply

Abstract
Ghana's development and progress has been noticed the world around, but its capital city of Accra continues to experience dry taps. This paper begins by discussing the causes of this water problem, the frequency with which it occurs, and any known methods used to detect the inadequate flow. The paper then proposes a sensor network as a technical solution to correcting this problem, whereby water flow levels are monitored throughout Accra's piped infrastructure. Upon detection of inadequate flow, the sensors would alert water works personnel; detection would facilitate action, and action would facilitate water availability. Of note, the sensors would be placed within the pipe, vertically suspended such that they are submerged, but not resting on the bottom of the pipe; the exact vertical position would depend on what the acceptable flow level is for a given pipe. These sensors would be solar powered and would transmit their readings to a central processing unit via pre-existing infrastructure (e.g. WiMax, cellular, etc.). To support the reality of using sensors within a WDN, case studies are provided that discuss what metrics such sensors can measure. Understanding the need for experiential results related to this network, suggestions for future work are also provided.

Introduction
From a development and economic growth perspective, Ghana is often viewed as the model post-colonial African nation. Residents of the capital city, Accra, can easily take advantage of Internet cafes, modern roadway systems, cellular networks, and water and sewage systems.

In certain parts of Accra, though, running water is not always a constant. On any given day, a resident may turn on her faucet to find that no water streams from it. This water problem, also known as "dry tap", is unfortunately, all too familiar to those living within the capital city.

Since piped infrastructure is in place, which implies easy access to potable water, why then do dry taps exist in Accra? And how are water works employees alerted when a section of the city experiences this? The author cites as the answers to the former (1) an insufficient water system capacity compared to the demand for the water and (2) an unreliable pumping system; these causes are discussed in more detail in the next section. The exact answer to the latter question though is unknown; however, the author proposes deployment of a sensor network throughout Accra's water distribution network (WDN) as the primary means to alert water works employees that a neighborhood is experiencing dry taps. When such information is made available to these employees, they can quickly take the appropriate measures to restore water to those lacking it. Discussion of this sensor network is the focus of this paper.

The remainder of the paper is outlined as follows. The Water Flow Problem section discusses dry taps within Accra in more detail, and Sensors in Accra's WDN discusses details of the proposed sensor network. Case Studies: Using Sensors Within WDNs provides

examples of sensor networks deployed within real WDNs. The sections on Future Work and Conclusion are self explanatory.

The Water Flow Problem

The water flow problem in Accra is not a new one, as it has been occurring for several years. It is a serious problem, evidenced by the existence of the Water Directorate within Ghana's Ministry of Water, Resources, Works, and Housing [4, 8].

The frequency with which residents experience dry taps is regular. For example in February 2010, a resident of the Sowutuom neighborhood said that water had not passed through her taps for two weeks [7]. Likely unbeknownst to this resident is that water works employees purposely ration the little water that is available so that it can be shared equally among Accra residents [5].

But why is there so little water? Why does this problem continue to exist? One reason the water supply is continually insufficient is due to Accra's consistent population growth [1]. In fact in 2003, the collective water demand of Accra East and Tema was roughly 60 million gallons per day (MGD), whereas the volume of water supplied was 39 MGD; only Accra West had a surplus of water after serving the demand. Unfortunately, it is projected that the population of Accra will continue to grow exponentially.

The second reason for the regularly insufficient water supply is an unreliable water pumping system. The basic mechanics of a WDN often requires a series of pumps to transport water from the source to the treatment plant and then to the end consumer. In February 2010 however, Accra West's pumping system literally halted. Four pumps are used to pump water from Densu River (one of Accra's water sources [1, 6]) to Weija Water Works (a treatment plant that provides water to at least ⅓ of Accra [1, 6]); in February, all four pumps failed due to a blown air valve. This pumping failure resulted in only 11 MGD being supplied to Accra West, in comparison to the normal 55 MGD [1].

With this problem apparently pervasive, how are water works employees alerted when a section of the city is without water? No known detection methods were found, but one can presume that the alerting mechanism is either via word-of-mouth, phone, or in-person, or no alerting mechanism exists, as the problem may be too common for such reporting to be meaningful. Regardless of whichever is true, this paper proposes a sensor network as the primary mechanism for detecting inadequate water flow, thereby alerting water works personnel of the water insufficiency. With this information readily communicated, water works personnel can quickly take action to restore water flow to the affected neighborhood.

Sensors in Accra's WDN

The technical details of this sensor network have a direct bearing on how quickly and reliable the communicated information is transmitted; therefore, a discussion of its topology and configuration details is warranted here.

The sensors within Accra's WDN shall be placed within the pipes, periodically sensing the pressure level, flow, and/or water volume; these metrics would allow a water works employee to determine if a certain neighborhood is experiencing dry taps. At least two sensors shall be placed in each main line (and arterial main and/or distribution main, depending on the layout of Accra's WDN), where two sensors are recommended for redundancy. Furthermore, they shall be placed as close to the line's egress point, so as to

capture readings as close to the consumer as possible. Regarding the sensor's capacity, it should be able to store both its unique identifier and readings from one capture.

Within the pipe, the sensor would not rest upon the bottom of the pipe, as water would likely always have some sort of pressure, flow, and/or volume there. Instead, the sensor shall be suspended within the pipe, with its vertical position determined by the water depth that corresponds to that pipe's acceptable flow level. For example, a pipe with a given acceptable flow level and a water depth of 20cm would have a sensor suspended approximately at the 3-5cm depth level; this depth level is chosen so that the sensor can be completely submerged. Similarly, a pipe with a different acceptable flow level, but also with a water depth of 20cm, would have a sensor suspended approximately at, perhaps, the 9-11cm depth level. Therefore, depending on what the pipe's acceptable flow level is, the sensor's vertical position could be at a variety of depths (Figure 1).

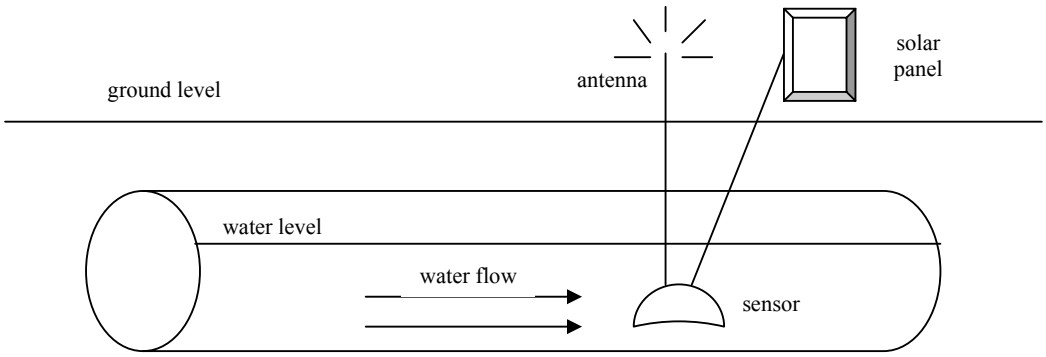

Figure 1. Sensor Placement Within a Pipe

The sensor itself would also have a wire affixed for its antenna and another wire for its power supply; these wires are the means by which the sensor would be suspended within the pipe. These wires would exit the pipe via a vacuum-sealed protrusion, and then both would continue to above-ground level where the sensor's antenna and power supply would be located.

Solar power is chosen for the power supply, so as to eliminate the need to frequently replace batteries. With this power source, the sensors can be provided enough power to transmit directly to one of the network's infrastructure towers (e.g. an existing WiMax or cellular tower). Depending on the technology used within the network (WiMax, cellular, etc.), the data would be routed among the towers until it reaches the central processing unit at a water works station; this unit is what water works employees would monitor for below-acceptable pressures, flows, and/or volumes. The data reported to the unit would include a unique identifier for the sensor itself, along with the sensor's readings. These readings would be transmitted on a pre-defined schedule, possibly every 4-8 hours.

Regarding deployment of this network, the pipe form for these sensors is so unique that it would not be reasonable to replace all the pipes at once for the sole purpose of deploying the sensors. Instead, the sensors could be rolled out progressively, possibly in accordance with regular line maintenance and pipe replacement.

Case Studies: Using Sensors Within WDNs

This section highlights how sensors have been used in real WDNs; these examples provide evidence that WDN sensor networks do exist.

An EPA report that surveyed various sensor technologies for a water contamination warning system (CWS) discusses various metrics that sensors can measure. Some of these metrics included contaminant levels, flow, and pressure, temperature, and turbidity [2]. A second EPA report provides examples of several municipal water systems and how they are using sensors [3]. Cincinnati, for example, used sensors for measuring chlorine, pH, turbidity, total organic carbon (TOC), oxidation reduction potential (ORP), and conductivity. Similarly, the city of Tucson used sensors for monitoring various contaminant levels, and the city of Ann Arbor monitored contaminant levels and pressure.

Future Work

The sensor network proposed here is a proof-of-concept, so it warrants experiential data to determine the reliability and transmission speed of the data transmitted. Therefore, the author recommends that a pilot study be conducted that measures such metrics. Also since pump failure was cited as one of the causes of the dry taps, expanding the sensor network to node placement at pumping stations could help immediately detect when a pump has failed. This would allow for easier identification of a pumping problem, as well as enable quicker part replacement.

The author also recognizes that transmitting flow-like metrics to water works personnel is only an information transfer, and it does not necessarily imply water flow restoration is guaranteed. Therefore, the author also recommends that a study be conducted on how the sensor network can play a role in actively restoring the water flow to an acceptable level.

Conclusion

Despite Ghana's development and upward movement, its capital city of Accra continues to

experience dry taps. This paper discussed a proposed sensor network as the primary mechanism to alert water works personnel when a given neighborhood experiences dry taps. To support the practicality of such a network, examples of WDN sensor networks were provided. Recognizing several opportunities to build upon this proof-of-concept, several suggestions for future work were also provided.

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Special thanks are extended to Dr. Alex Hills for inspiring me to go forward and do what I can to make a difference in the global community. Thanks are also extended to Dr. Ronald Johnson for providing useful resources in helping understand WDNs and sensor technology within those networks. Finally, thanks to Mr. S. Hunte for continuous motivation and encouragement in making this paper a reality.

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The Potential of Hydram Technology for Rural Communities.

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Key Words: water, hydram, Appropriate Technology, rural communities, environment, poverty.

Abstract

The high cost of using fuel driven pumps, has seriously affected the potentials for the rural communities to be able to pump water for domestic and irrigation use leading to increased poverty in Africa. The Hydraulic Ram Pump (Hydram) gives a very good alternative for pumping water for a large population who live in areas with fast flowing rivers. The Hydram is an environmentally friendly pump that is very easy and cheap to make using locally available materials. It is an automatic water lifting device that uses the energy in the flowing water such as spring, stream or river to pump part of the water high above that of the source.

This paper explores the potentials of the hydram by examining its use by over 40 individuals and communities in Central Kenya. It gives detailed drawings for the manufacture and installation of Hydrams to show that the equipment can be made simply and at very low costs. The paper also looks at the alternatives to the use of the hydram and why I think it's a viable addition or alternative to these solutions. It concludes that compared to other water lifting devices, the Hydram is easier to build and can be made in simple rural setting workshops using materials that are affordable and widely available.

Introduction

It is ironic that the problem of access to water has haunted many poor communities in areas with abundance of water sources. The problem is taking the water from the water sources and delivering it to the communities and households that need them. This is especially true in the uplands where most people in Kenya live and where water is very important because of the role it plays in the livelihood of farmers. To meet these communities water requirements, provision of modest amounts of water to smallholder farmers that meets their household, livestock and micro-irrigation is required and can enhance household economic production, save labour time especially for women and children, and improve family health [1].

Fossil fuel pumps have been the water pumping method of choice with electricity pumps playing an important role where electricity grid is available. However, in most developing countries, electricity supply is very poor and the high cost of fuel and spare parts for the maintenance of conventional water pumping systems is the main reason for their failure to provide an adequate water supply. A hydraulic ram pump (hydram) does not require fuel and has only two moving parts. They are very simple and cheap to operate and maintain. Hydrams have been in use since the 18th century when they were widely used. Usage of the hydram remained popular until the latter part of the 19th century, when the harnessing of electricity and use of the internal combustion engines became more popular as they have a capacity to draw higher amounts of water than Hydrams. Although there is a greater need for Hydrams in remote areas, the difficulty of carrying the traditional imported Hydrams which are expensive, bulky and heavy has discouraged more widespread use. Light-weight hydram

which can be fabricated of cheap locally available materials and assembled locally is required. Fortunately many studies have been carried out resulting in the production of very efficient and high quality affordable Hydrams that can be fabricated by local artisans and are very simple to operate and maintain. This has resulted in increased use of Hydrams which has also been helped by the rising cost of fossil fuels and the interest of find energy alternatives that are more environmentally friendly.

The Problem.

In 2004 only 12% of rural Kenyans had household water connections [2] and approximately two-thirds of poor rural households depend on unprotected sources of water (wells rivers, lakes, ponds and rainwater) in all seasons. The vast majority of people in the rural communities have to fetching water from water sources that are sometimes very far and drive their domestic animals to water directly from the sources. Other activities include washing of clothes and bathing. All these activities result in pollution of water sources that lead to disease, time wastage and destruction of water beds. Contact between animals while watering also increase transmission of diseases from one herd to the other. Little attention has been given to supply water to the rural communities in areas with good water sources by the government and Non Government Organisations, whose efforts are mainly targeted at the urban areas and the arid areas. Where the government has supplied water, the projects are mismanaged and very few people receive water from them. Government water policies have also further threatened the viability of community-based water supplies especially the Kenyan Water Act of 1999 and 2004 [3] implying less government support and more regulation of small community groups. Water pollution and the destruction of the "water towers" has reduced flow and has made use of streams and spring less favourable for human water use.

Overview of Available Solutions.

Water harnessing using Diesel and Petrol pumps has been wide spread in Kenya's rural communities, especially in institutions like schools and hospitals for a long time but the high cost of fossil fuels today, has made them uneconomical to run and many have become idle. The cost of installing electricity connections to the water sources and the cost of electricity has made it out of reach for the rural communities and only benefits the large scale farms most of which are owned by large multinational firms that have very little gain to the rural communities. Gravity water projects are a good alternative to other existing water supply methods and are widely used where applicable. However, they are only applicable in limited areas and require very large capital outlays to install, making them too expensive for most rural communities. Water turbine driven pumps are a good alternative for pumping water as good sites for their installation occur in the same terrain (mountainous) where there is greatest need for water-lifting needs. Although they are none polluting and can pump large quantities of water they are hard to fabricate and require well trained Engineers with expensive tools making them expensive and out of reach for many rural communities. Like the Hydram they have huge potentials as a sustainable technology for pumping water and are yet to be given the attention they deserve.

Hydrams as an affordable and sustainable water pumping solution.

One option for expanding the coverage of safe and productive water supplies is to empower individual households and community groups to undertake and operate appropriate water supply infrastructure. The Hydraulic Ram Pump also commonly referred to as a Hydram or Ram Pump is an automatic water lifting device that uses the energy in the flowing water to pump part of the water to a higher level above that of the source. With a continuous

flow of water a hydram operates continuously with no external energy source. A Hydram has only two main moving parts, an impulse valve, delivery valve and a smaller snifter valve. They are very simple to manufacture and very affordable and easy to operate and maintain. They are also very durable making them an affordable and sustainable solution for pumping water for domestic and irrigation use.

Hydraulic Ram-pumps (invented over 200 years ago) were once commonplace in Europe, the Americas, Africa and some parts of Asia. They have however been largely displaced by motorised pumping in richer countries, whilst in developing countries their use is concentrated in China, Nepal and Colombia . Generally, in rural areas of developing countries, this skill has been lost since about 1950, and the intermediaries that used to connect ram-pump manufacturers to pump users have disappeared [4]. Old systems lie broken for lack of fairly simple maintenance and new systems are few. A renaissance of interest for Hydrams spurred by the need for renewable energy and the escalation of fossil fuel cost has resulted to many studies and the development of high quality Hydrams that are affordable and can be fabricated easily by local communities.

Illustration of Hydram operation.

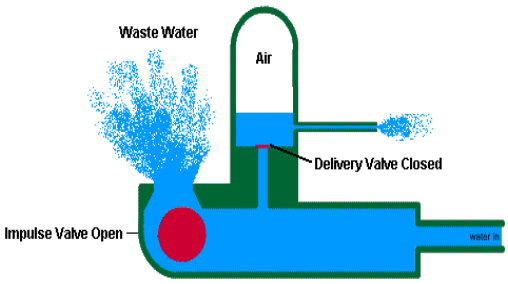

Fig. 1.

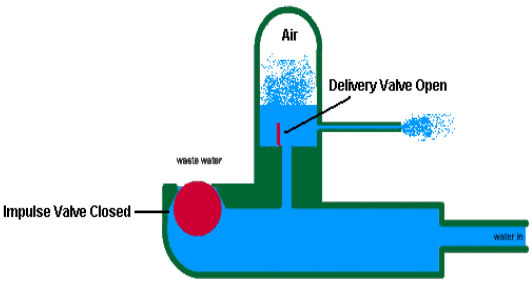

Fig. 2

Fig 1. illustrates the first stage of the hydram operation. Initially the impulse valve (or waste valve) will be open due to its weight. As water flows through the valve the flow accelerates, the hydraulic pressure under the impulse valve and the static pressure in the body of the hydram will increase until the resulting forces overcome the weight of the impulse valve.
Fig. 2 illustrates the impulse valve shutting, stopping the flow through the valve, which courses a surge (water hammer) in the Hydram body. The surge pushes the delivery valve (non return valve) open at very high pressure. The impulse is very short and as air can be compressed very fast the air chamber act as an energy buffer. The delivery valve closes as pressure reduces in the pump body and water is pumped through the delivery pipe. As the pressure reduces the impulse valves opens again and the cycle begins again.

Locally Fabricated Hydrams

Many studies and research has been conducted to produce affordable and simple Hydrams that can be fabricated with only the basic tools that can easily be found in most rural communities. Among many the Development Technology Unit of Warwick University the Department of Technology through their research in Hydrams and their work in Africa, since 1985 have developed high quality easy to fabricate Hydrams. They also provide free detailed drawings and manuals for fabricating and installing their Hydrams which are detailed and easy to follow.

Hydrams fabricated by Clean Air Energy Solutions Kenya (CAESK) are based on designs by DTU but have been modified over the years since 1999 to improve on their quality and reliability. CAESK has fabricated and installed 32 Hydram pumps out of which 28 are being used. One of the Hydrams was vandalised and two are not in use because of repeated theft of delivery pipes. There are more than 60 working Hydrams within less than 20 KM from Nairobi especially in Githunguri that mainly serve individual homesteads and institutions. One of CAESK trainee has installed most of the new pumps in the area and has also repaired many of the abandoned Hydrams in this area. Below is the basic design of pumps which are modelled on the DTU Steel Hydrams designs.

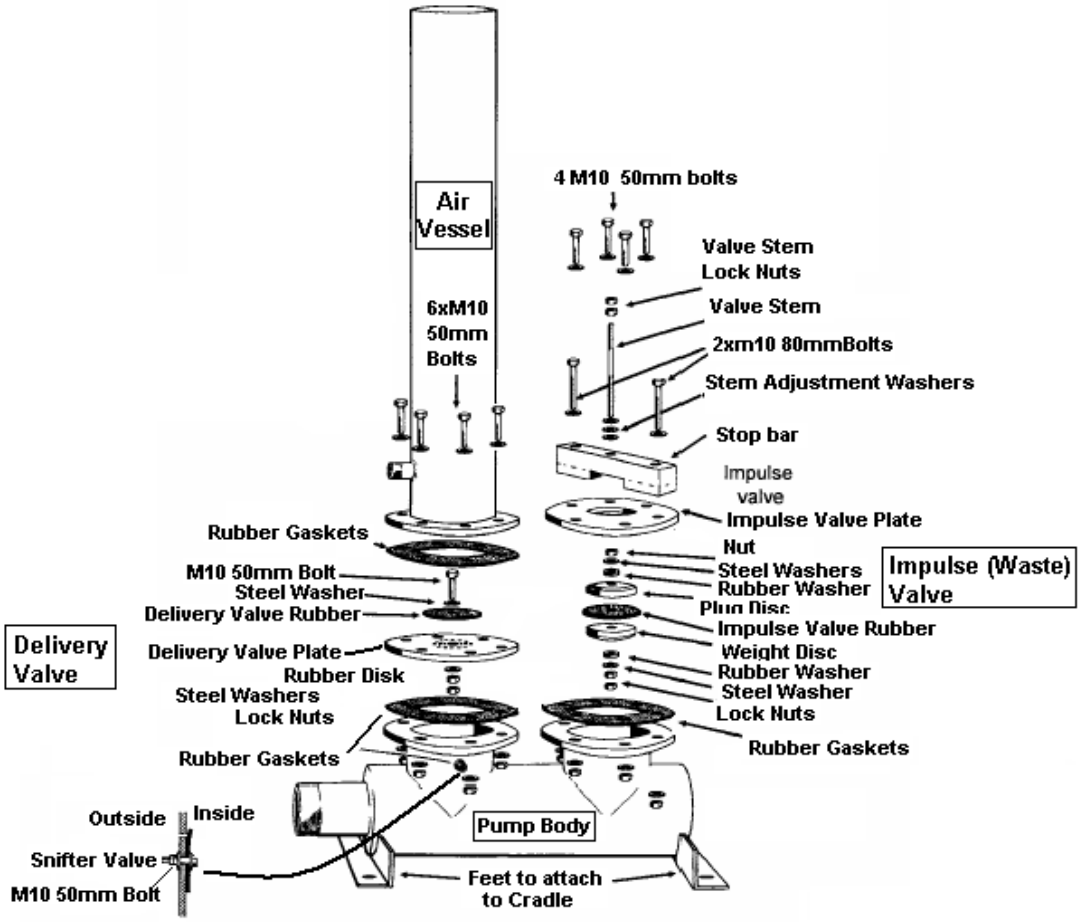

Fig 2. Exploded View of a DTU S2 Hydram

Fig. 2 shows the exploded view of a DTU 2 inch delivery pump with a 4" steel pipe body. This pump can be simply fabricated in metal shops with only the basic tools in the rural district towns. For well crafted parts simple lathes that can be found in larger towns, may be required to fabricate the 3 pipe Flanges, Weight and plug discs and the Impulse and Delivery valve Plates.

Fig. 3 below shows the details of the Impulse and the Delivery Valves which require greater care in fabrication. The Impulse valve requires most attention and although it is easy to make one that works making a high efficient Impulse valve requires a lot of experience as laboratories for testing the most appropriate design and weights to use for varying heads and

valve sizes are not found in the rural settings. Collaboration with local universities which are better equipped can result in improved Hydrams for local use.

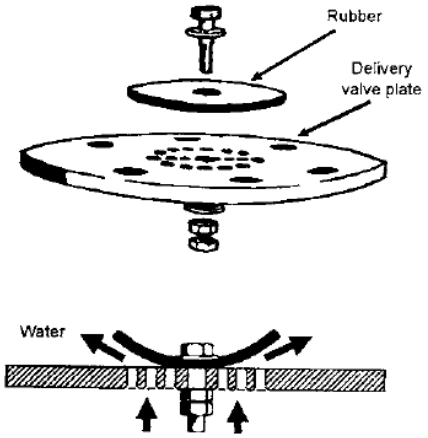

Fig 3. Cross-Section through a Delivery valve with the rubber open

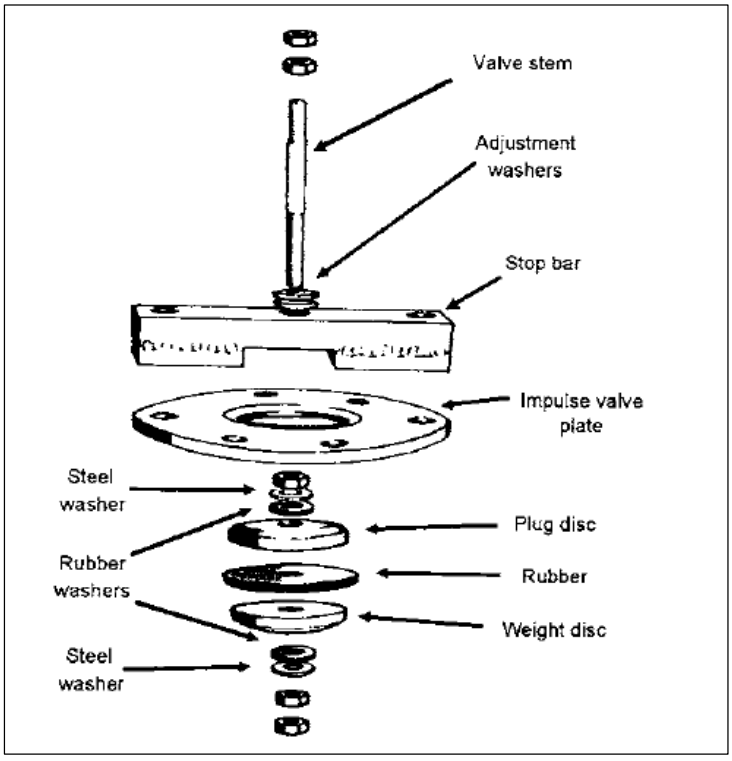

Fig 4. Exploded view of an Impulse valve

STEEL PIPE	4¹ (105MM INTERNAL DIAMETER)	1	1350MM	THE OUTSIDE DIAMETER OF 4 PIPE 115MM. THE WALL THICKNESS SHOULD BE 5MM	
STEEL PLATE	10 or 12mm	1	330X500 MM	Do not use plate less than 10mm thick.	
STEEL BAR	25 x 25mm	1	165MM	If this is hard to find, make some by welding together a stack of thinner 25mm wide bars.	
STEEL BAR	25 x15mm	1	165MM		
STAINLESS OR MILD STEEL ROD	10mm	1	280MM	If not available, mild steel reinforcing bar will do. This includes enough to make a spare impulse valve stem to supply with the pump.	
RUBBER	Size	No. OF	AREA	Notes	
GASKET RUBBER (inner tube)	Car or small truck	1	825X170 MM	Make sure that it has not perished. This includes enough to make a spare impulse valve stem to supply with the pump.	
IMPULSE VALVE RUBBER	6mm	1	152X76MM	Off-cuts of conveyor belt and shoe sole material have been used in the past. This includes enough to supply a spare of enough to supply a spare of each with the pump.	
DELIVERY VALVE RUBBER	3MM	1	160X80MM		
NUTS&BOLTS	SIZE	NO. OF	LENGTH	Notes	
BOLTS	M1O	1	30MM	These must be stainless steel or galvanized. The 4x40mm bolts, nuts and washers to hold the pump to the cradle are included. Extra nuts and washers are needed for the valve stem and are included in the totals. The totals. The totals also include a few spare that you should supply with the pump.	
BOLTS	M10M10	10	40MM		
BOLTS	M10	8	50MM		
BOLTS	M10	3	80MM		
NUTS	M10	28			
WASHERS	M10	40			
CONSUMABLES.				NOTES	
WELDING RODS				Select rods to give good penetration on the 5mm walls of steel pipe and on 10mm plate.	
GAS				For cutting torch.	
PRIMER (PAINT)				Either have the parts of the pump galvanised or paint it. In most cases it is easiest to paint it.	
ENAMEL PAINT					
THINNERS					

Table 1 on pg 22
Table 1. shows the materials required to construct a DTU 2" drive pipe Hydram with a 4" steel pipe body. The materials can be sourced locally either new or from used parts that are in good condition.

Hydram size (inches)		**4" X 2"**				**6" X 3"**			
Head ratio		5	10	15	20	5	10	15	20
Driven (litres/sec)	flow	8.96	9.7	10	9.02	20.2	17.2	17.1	19.3
Delivery (m^3/day)		94	51	35	23	216	101	69	50

Table 2: Estimated performance of Hydrams

Table 2 shows estimated performance of high efficient Hydrams that can be achieved with a 4" drive pipe and a 2" delivery pipe and a 6" drive pipe and a 3" delivery pipe at varying heads with head ratios delivery head of 5, 10, 15 and 20 to every 1 meter of drive head [5]. This shows that the Hydrams will pump more water where the drive heads are large with lower delivery heads. Very low heads require larger Hydrams which increases the cost of the pump. It most importantly shows the large volume of water Hydrams can pump making them very effective.

Cost of Hydrams.

The costs of commercial imported Hydrams are typically in the range from about US $1500 for small 2-inch drive pipe sizes up to as much as US $5000 for 4-inch or 6-inch sizes [6]. Locally manufactured Hydrams are typically in the range of as low as US $250 for 2-inch drive pipe sizes, US $800 for 4-inch drive pipes up to about US $2000 for large 6-inch drive pipe sizes. This makes locally manufactured pumps more suited for rural communities that cannot afford imported Hydrams. Although high quality imported pumps can last for over 50 years without any major repairs high quality locally made pumps can last for over 15 years before major overhauls. Even where pumps are replaced with new ones the costs remain lower than imported pumps.

Costs of large steel drive pipes are also quite high making Hydrams best suited to relatively low flow rates and high head applications. Availability of high strength and durable PVC pipes has reduced the cost of pipes significantly. Since there is no fuel cost and negligible maintenance costs associated with Hydrams their application is very favourable. Simple cheap intakes can be used if well constructed but require regular management to reduce residuals passing through the pump.

Conclusion.

Although most of the country is semi arid the largest concentration of the rural people who form the largest population live in areas with very good water sources on the slopes of the country's five "water towers" (the Aberdares Ranges, Mount Kenya, the Mau Forest Complex, Cherangani Hills and Mount Elgon), where there is great potential for communities to harness water from natural springs and rivers [7]. The hydraulic ram pump can be used with great effectiveness in these areas meeting domestic water needs and increasing land under irrigation. Hydrams are easy to fabricate and maintain in rural setting workshops than other water lifting devices and do not require electricity or fuel making them a very sustainable alternative. Although they are most economical where delivery flows and heads should not be too many times the drive head they are still practical even where the delivery

heads are very high as they are relatively cheap to build and few alternatives other than people collecting water from the rivers and springs exist. Hydrams do not pollute rivers as they do not require lubrication and are normally installed far from homes and the noise they make has very little negative impact to society [8]. They automatically run for 24 hours a day with human management resulting to high flow yields even where flows per minutes are low. This makes Hydrams a sustainable appropriate technology whose significance is higher than ever.

For the Hydram to fully realize its potentials efforts must continue both to simplify the design of reliable systems and to propagate fabrication and design skills. More help is required not only to train but to installers and manufacturers. Expansion in micro-irrigation and better water management to reduce water pollution and protection of "water towers" should improve its use. Conducive government policies that realize the potentials of Hydrams, its contribution to renewable energy and the fact that it only extracts a small percentage of the water that drives it, sustaining river flows are required to propagate its use.

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SUSTAINABILITY OF RURAL WATER SUPPLY AND SANITATION IN WEST AFRICA

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Key words - water utilization, rural water supply, water and sanitation, sustainable water supply system, water service management, technology management, Rain Water.

Abstract:

Bad water and bad sanitation kill 2.8 million people a year. Three in four victims are children. Reacting to this catastrophe, some philosophers argue that declaring clean water a human right would save lives. Alas, solving this problem is not as easy as that. The connection between intention and result is tenuous. People kill each other over diamonds. Countries go to war over oil. But the world's most expensive commodities are worth nothing in the absence of water. Fresh water is essential for life, with no substitute. Although mostly un-prized, it is the most valuable stuff in the world

Community management of the rural water supply and sanitation services is considered as one of the options for achieving sustainability of the water services. International communities and donors are steering this concept. National water policies in African countries put more emphasis on community participation and management of water and sanitation. This paper on the sustainability of the rural water supply and sanitation services focused on community management and participation as one strategy, which could contribute to the sustainability of water supply.

Nature has decreed that the supply of water is fixed. Meanwhile demand rises inexorably as the world's population increases and enriches itself. Homes, factories and offices are sucking up even more. But it is the Africa's growing need for food and water (involved in the producing of crops and meat) that matters most. Farming accounts for 70% of withdrawals.

About 1 billion people of the world are still without access to decent water supply while others suffer from flooding, pollution and poor sanitation. Yet if man wants to solve these problems, he can. He has applied far more money and know-how to issues far less important than the shortage of water. And if he does tackle them successfully, the big causes of human suffering – diseases and poverty- will be automatically alleviated. Investing more thought and cash in the better use of the world's most valuable commodity is surely worthwhile.

Introduction

People kill each other over diamonds; countries go to war over oil. But the world's most expensive commodities are worth nothing in the absence of water. Fresh water is essential to life with no substitute. Although mostly un-prized, it is the most valuable stuff in the world

The green revolution, in an inspired combination of new crop breed, fertilizers and water, made possible a huge rise in the population. The number of people on Earth rose to 6billion in 2000, nearly 7 billion today. The area under irrigation has doubled and the amount of water drawn for farming has tripled. The proportion of people living in countries chromatically short of water, which stood at 8% at the turn of the 21st century, is set to rise to 45% (4billion) by 2050. An already one (1) billion people go to bed hungry each night, partly for lack of water to grow food.
Africa has the lowest total water supply coverage of any region in the world. Currently about 300
Million people in Africa do not have access to safe water and about 313 million have no access
to sanitation. This situation exacts a heavy toll on the health and economic progress of African
countries.

In response to the Africa Water Vision and the UN Millennium Development Goals, in 2005 the African Development Bank Group conceived the Rural Water Supply and Sanitation Initiative (RWSSI) with the view to accelerating access to water supply and sanitation services in rural Africa to attain 80% access to water supply and sanitation by the year 2015. The objectives of the Initiative would contribute to poverty reduction and spur economic growth.

In order to meet the 2015 RWSSI (Rural Water Supply and Sanitation Initiative) target of 80% access to water supply and sanitation, a total of approximately 270 million rural people will need to be provided with access to improved water supply and about 300 million to sanitation. The major challenge would be mobilizing sufficient resources to provide access to RWSS services. Additional challenges include policy and institutional strengthening to plan, design, construct and operate rural water supply and sanitation systems.

Community management of the rural water supply and sanitation services is considered as one of the options for achieving sustainability of the water services in Africa. International communities and donors are steering this concept. National water policy in Ghana puts more emphasis on community participation and management of water and sanitation schemes. This paper on the sustainability of the rural water supply and sanitation services focused on community management and participation as one strategy, which could contribute to the sustainability of water provision

Background about Water Supplies and Sanitation in perspective

Water is the essential resource for life. It is also a scarce resource both in quantity and quality, and when available it is often of poor quality depending on location. Lack of potable water and basic sanitation services remains one of the world's most urgent health issues. It is estimated that 1.1 billion people in developing countries do not have access to safe drinking water and 2.6 billion people lack access to basic sanitation (UNDP, 2006 UNICEF and WHO, 2005). In Sub-Saharan Africa, about 250 million people in rural areas lack safe and accessible water. Unsafe water, inadequate sanitation and poor hygiene habits play a major role in child mortality in rural Africa. Lack of clean water and basic sanitation is responsible for about 1.6 million preventable child deaths each year and millions more children suffer from water borne diseases such as typhoid, worms and diarrhea (UN, 2005; UNICEF and WHO, 2005; UNICEF, 2005). It is also observed that inadequate water supply, insufficient sanitation and unsafe hygiene cause and reinforce poverty and deepen the disparity between rich and poor. It is the rural and urban poor

communities who are mostly impacted by inadequate water supply and sanitation services both socially and economically and thus lead them into a vicious cycle of poverty. To unlock this poverty cycle in order to achieve socio-economic development for the vulnerable group in the society, various factors have to be taken into consideration by all stakeholders involved in water supplies and sanitation provision in rural areas. Sustainable water supply and basic sanitation services under community management system might change the existing situation.

Water supply and basic sanitation services have important contribution to achieving Millennium Development Goals (MDGs) due to the fact that water is crucial for almost all Development Goals (DGs). There is no doubt that water supply and sanitation services have an impact to other DGs such as poverty, hunger, education and child mortality to mention few. For the case of poverty, it is obvious that household livelihood security rests on the health of its members. Illness caused by drinking unsafe water and inadequate sanitation causes a health cost that claim a large share of poor household income which could have been used for other productive purposes. In terms of child mortality, improved sanitation, safe drinking water sources and availability of enough quantities of domestic water for washing reduce infant and child morbidity and mortality (UN, 2005). By realizing the importance of water and basic sanitation services and the links to the MDGs, it is therefore necessary to have an understanding of the situation in rural areas in Africa where the majority of poor people make their living.

Background and Country Context

Water is used not only to grow food but to make every kind of product, from microchips to steel girders. The largest industrial purpose to which it is put is cooling thermal power generation, but it is also used in drilling for and extracting oil, the making of petroleum products and ethanol, and the production of hydro electricity.

All humans however need a basic minimum of two liters of water in food or drink each day, and for this there is no substitute. That is why many people believe water to be a human right, a necessity more basic than bread or a roof over the head.

About 1billion people are still without access to decent water while others suffers from flooding, pollution and poor sanitation.

Case in Kenya

In the Kolwezi Water Project in Kenya, a community Wells Committee initiated an evaluation of a water program which had been underway for about six years. Because the community had been closely involved with the project from the start they were able to devise their own ways of identifying problems and combating them. With the help of African Medical and Research Foundation, the wells Committee undertook a sanitary survey of wells and also tested the quality of water in people's homes. Committee members quickly learned how to use bacterial dip sides to test for water pollution. Photographs also played a big part in the project evaluation helping to identify pollution sources and prompting rapid corrective actions by community members. Successful community management approach should replicate itself.

Case in Ghana

In Ghana, it is estimated that about 44 percent of the population in rural areas and small towns do not have access to clean water and two-thirds do not have access to adequate sanitation. Although important gains have been made over the years, the overall access to water remains low at 56 percent (2009-2010) and progress towards achieving the MDG target of 76 percent for water by 2015 is slow. Water-related diseases such as guinea-worm infections resulting from inadequate water supply and sanitation continue to plague the population living in small towns and rural areas.

The Government of Ghana has identified water supply in rural areas as priority and this is reflected in the GDP. Ghana's rural population is about 15.46 million with about 6.22 million (41%) having access to water supply and 4.4 million (29%) having access to sanitation.

Studies in Ghana suggest that the long term impact of malnutrition associated with diarrhea infections cost the country 4.5% of Gross Domestic product (GDP). This can be added to a similar burden of "environmental risk" which includes malaria and poor access to water and sanitation, as well as indoor air pollution. The World health Organization thinks that half the consequences of malnutrition are caused by inadequate water, sanitation and hygiene. In Ghana, the total cost of these shortcomings may amount to 9% of GDP.

Rural Water Supply and Sanitation Initiative

The RWSSI was conceived by the African Development Bank primarily to address the problem of low access to WSS in rural Africa

The RWSSI is anchored and focuses on the most critical dimensions of the African Water Vision and the Millennium Development Goals: "accelerating access to drinking water supply and sanitation in rural areas" while ensuring that the facilities are sustainable". Essentially, the Initiative is intended to help mobilize as well as facilitate the flow of available and potential resources to accelerate investment in RWSS in Africa.

Most of West Africa's population, especially Ghana, lives in the rural areas (62%) and yet access to WSS services is low. In view of the low access to WSS services in rural areas, rural populations are burdened to a greater extent by preventable water and sanitation related diseases, suffer great deprivation of women and children from embarking on productive economic activities due to time and efforts used to fetch water. That is why many people in poor Africa-usually women or children-set off each morning to trudge to the nearest well and return five or six hours later burned with precious supplies. The deprivation also results in low

enrolment rate in education. These problems contribute to accentuate poverty in the rural areas

Water Supplies and Achieving Community Management

In the field of water and sanitation services, Community management means that the beneficiaries of water supply and sanitation services have the responsibilities, authority and control over their services:

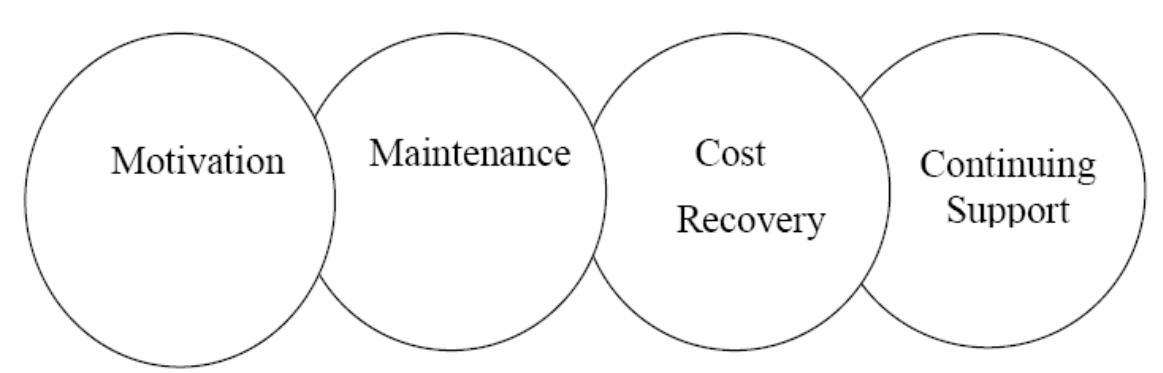
- Responsibility – The community takes ownership of the system with all its attendants' obligations.
- Authority – the community has the legitimate right to make decisions about the system
- Control – the community has the power to implement its decision regarding the system.

  In other words the community is able to control, or at least to strongly influence the development of its water and sanitation system. Because it also has the authority and responsibility for operation and maintenance, this will be more effective and efficient leading to improved sustainability.

To ensure effective community management of rural water projects for achieving sustainability, both internal and external factors must be taken into consideration because they have important contribution to the success and failures of the water projects. Internal factors like lack of community cohesion, lack of management skills, lack of technical skills, unrepresentative water communities, technical issues, strong traditions, misplaced priorities and financial problems must be given priority under community management model.

Community Management and Sustainability

Fig 1 Sustainability Chain



Source: Cater & Hoswan (1999)

The four aspects in the chain are considered very important for the sustainability of community managed schemes. Regarding motivation, it is said that motivation of communities to utilize new sources (water schemes or toilets) is crucial for sustainability. On the other hand where local communities have a role in maintenance activities of the water schemes, training (management and technical aspects) and backup from the government, NGOs and private sector is necessary for sustaining the schemes. Cost recovery is very important for sustainability of water schemes because spare-parts, tools, replacement units and training all need money. Finally, continuous support from the government, NGOs and private sectors is vital for sustainability of community managed water and sanitation schemes.

Implementation Framework

A sound legal framework for RWSS services delivery should articulate the following:

- **Communities** should be the owners of the WSS assets so that responsibility for operations and maintenance is unambiguous;
- **Local government** structure is responsible for supporting the communities to access funds for WSS sub-projects as well as assisting in planning, procurement of goods and services;
- **Central government** normally represented by a parastatal agency is responsible for facilitating access to water supply and sanitation services through the setting of clear national policies and strategies, capacity building and mobilizing funds for investment;
- **The private sector** would play an increased role for the provision of goods and services and technical assistance to communities in sub-project implementation and O&M;
- **NGOs** support and complement the efforts of governments by investing in RWSS projects with support from international NGOs and other sources of funds. NGO's also provide technical assistance to communities for sub-project preparation and implementation

Fig 2 Private Sector NGO Roles in Rural Water Supply and Sanitation Entity Roles

Entity	Roles	
Local NGOs/Partisans	Undertake community training, hygiene education, construction of wells.	
National NGOs/Consultants	Support local government in District WSS planning, engineering, design of pipe systems and district level training	
International/National Suppliers and contractors	Manufactures, import and distribute equipment, pumps and spare parts, undertake the construction of water supply and sanitation systems	

Technical Infrastructure and Sustainable Technologies.

Improved WSS solutions include a wide range of appropriate technologies. The choice of Technology option is location specific and depends on community demand, affordability and willingness to pay, community size and household density, resource availability and electricity
availability. Technological options for community water supply include but not limited to the following;

- Improved shallow wells (with or without hand pumps);
- Boreholes equipped with hand pumps;
- Spring development ;
- Motorized boreholes connected to standpipes or house connections;
- Surface water catchments (with treatment facility) connected to pipe system;
- Gravity flow pipe systems;
- Rain water harvesting.
- Tube wells;
- Improvement of storage and delivery by creating underground reservoirs.(subsurface dams)

The range of technology for sanitation includes the following:

- Ventilated improved pit latrines for households, institutions and communal use.
- Sand-plat latrine.
- Small bore sewers.
- Simplified sewerage.

Results and Outcomes

The opportunities for successful implementation outlined for the Community Management of water supply and sanitation in West Africa are the following:

1. Contribute to poverty reduction through access to water supply and sanitation
2. Access to improved and sustained rural water supply and sanitation services accelerated to achieve the MDGs targets.
3. Improve health and quality of life of the rural people.
4. Reduced time and effort spent in fetching water supply.
5. Availability of increased investment funds
6. National, District and community institutions strengthened to enable efficient programmed Management, implementation and sustained operations and maintenance.

7. Mobilize resources from official international funding sources, special funding schemes, NGOs, Governments.
8. Planning, programming, and monitoring country interventions.
9. Develop national implementation manuals/guidelines and Operations and Maintenance System Planning.
10. Build capacity at national, regional (provincial), and district and community level for different aspects of water service delivery.

Conclusion

Community management of water projects in rural Africa is a good idea if implemented in a good manner, where there is a demand driven community involvement right from the beginning of the project. It is apparent that community management of water schemes is a useful tool for community development because it stimulates a sense of ownership. It is appropriate for local communities under the guidance of the government, NGOs and private sectors to decide how rural water schemes should be managed. Communities' management of rural water schemes does not mean that communities should do everything. Management of the rural water schemes can be done at different levels. Communities as the owners of the schemes should make strategic decisions on how the schemes should be managed, while operation and maintenance can be outsourced to NGOs or private sectors. Nevertheless, with the right capacity building and continuous support, community management of the rural water schemes and sanitation can deliver reliable and effective sustainability.

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Appropriate Technology and Environmental Sustainability in Africa: A Definition and a Discussion

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Abstract
This paper evaluates the effectiveness of constructing environmentally sustainable models, which include gender specific variables as critical factors in the application of appropriate technology. The impact of traditional Western development strategies upon rural African women, in general, and Ghanaian women, in particular, is briefly reviewed. The intent of this paper is to reveal and document the favorable relationships and results of appropriate strategies for the inclusion of a gender partnership model within the field of appropriate technology. The paper addresses many aspects of the links between sustainability and environmental justice and, more generally, between environmental quality and appropriate technology. Critical issues related to the topic that require significant discussion include applied sustainability and the green movement; women and appropriate technology; ecological footprints; global environmental justice; and community participatory research.

INTRODUCTION

In February 1989, the First African Women's Assembly on "Women and Sustainable Development" was held in Harare, Zimbabwe. Participants highlighted women's predominant role in aspects of resource management and agricultural production. They concluded that African women spend a significant portion of the day engaged in agro-forestry, animal husbandry, water supply, and energy management. In certain parts of Africa, women provide between 60 to 90% of the agricultural subsistence labor and constitute a substantial amount of paid labor in male-run commercial agricultural schemes [15].

The Assembly further concluded that many socioeconomic factors contribute to the restriction of women's participation in natural resource management. For example, the high rate of urbanization has led to dramatic increases in female-headed households in many rural areas. These socioeconomic factors are largely a result of the colonial legacy of exploitation and marginalization of African natural and human resources. Compounding this reality are: limited access to land title; low literacy and training rates among women (due in large part to cultural biases favoring male education); inadequate support systems to ease traditional loads and the added workload created by some projects; as well as limited access to technology and tools necessary for successful agro-forestry endeavors [15].

Current estimates indicate that 80% of Africa's farmers are women and 60 to 80% of Africa's food is produced by women. However, African women continue to be marginalized from access to agricultural extension and rural credits [2]. The application of new knowledge and techniques through farmer's education is typically delivered by male professionals to male farmers. Until appropriated technology advocates honor the voices, knowledge, and experiences of African women, *just sustainability* will remain only a theoretical goal. Ghana—where women have traditionally assumed the bulk of planting, weeding, harvesting, preparation and preservation of food products. The Ghanaian "female farming system" presents a case study.

The cultural factors in some traditional Ghanaian societies are congruent with appropriate technology approaches related to women's roles in resource management and rural development. Frequently, new technological innovations introduced into developing societies are not desired nor are ultimately beneficial to the local populations. Critical input necessary for sustainable development to occur may mean readapting traditional, ecologically sound methods rather than the acquisition of shiny pieces of new machinery.

STATEMENT OF PROBLEM

Women in Africa are responsible for 60 to 80% of the work in the rural areas [11]. However, current literature points to gender-based inequalities, which suggests a failure to recognize the potential role African women could play in creating a model for a sustainable future. In many parts of Africa, the livelihoods of entire communities depend on biomass-based economies. Over thousands of years, women in these communities acquired and perfected a knowledge allowing them to enjoy a harmonious coexistence with their natural environments. These balances have been disturbed by population growth, urbanization, and capitalist cash economies. As stated in a recent report from the Food and Agriculture Organization of the United Nations, "Women make up over half the agriculture labor force yet they are frequently subject to discrimination, poverty and hunger. In Ghana it is estimated that if women and men had equal rights to land, and if women had equal access to fertilizer, profits per hectare would double" [10].

Just sustainability for Ghanaian women addresses past and present economic and social stressors that marginalize women from access. The deleterious effect of historical changes in the African socioeconomic reality, coupled with the vital role women play in meeting the food and energy needs of a large section of the local population, make it imperative to incorporate women into planning and implementation of just sustainable development and appropriate technology projects.

GHANAIAN WOMEN AND APPROPRIATE TECHNOLOGY

Central to the idea of the application of appropriate technology is the question, "Appropriate for whom?" [7]. the concept of appropriate technology has become so fashionable that this question is often overlooked. What needs to be identified here are those technologies that are appropriate for Ghanaian women of whatever ethnicity: Ga, Ewe, Ashanti, Fante, or Hausa.

The potential range of available technologies is limited by the inability to assess the specifics of women's circumstances, as in the example of the solar cooker. Proponents of this technology may argue its appropriateness for rural consumption, but the error is the lack of consideration given to the life situations of rural people and practical factors related to its use [5].

The late E. F. Schumacher recognized the necessity of exposing and creating a whole range of "intermediate technologies" that fill the technological gap between subsistence and high capital activities.

At the University of Kumasi, extension workers built solar dryers for a December 31st Women's Movement pepper farm project. The dryers were considered appropriate technology since they were able to dry larger quantities of pepper under more sanitary conditions. The traditional methods were simply to sun dry them on the ground. However, the technology was not readily accepted because the process bleached the peppers white. Project participants were not able to sell the discolored peppers nor did they desire to.

THE CHALLENGE TO MODERN ENVIRONMENTALISM

Environmental scientists, activists, and academics alike are realizing that creating a sustainable society for Africa must use an approach that seeks a *just sustainability*. This is especially critical with regard to the development of culturally appropriate and environmentally friendly green technologies. Environmental degradation is almost always linked to questions of human equality and quality of life. Throughout Africa, those segments of the population that have the least political and economic power and are the most marginalized too often suffer the heaviest health burdens from the current ecological crises.

Western scholars, especially those within the field of Environmental Studies, must begin to re-evaluate the values and perspectives underlying the tenets of their curricula. These values inherently support present ideas and attitudes about women, development, and appropriate technology. Many of these values are gender- and culture-based [24]. It is critical for those appreciative of traditional cultural approaches and "third world" issues, as an aspect of environmental theory, to research and develop curricular strategies that include non-Western scholars of both genders in more democratic partnership relationships. A concerted effort is necessary to achieve a truly multicultural, multidisciplinary field of study. All peoples of the world have created a variety of systems that approach resource management. In some societies these systems are often initiated by women [24].

APPROPRIATE TECHNOLOGY

The adherents of appropriate technology (AT) hold the philosophy that decentralized, small-scale development that uses low cost, intermediate, self-reliant, improved technologies will increase local development. This viewpoint can be described as an outgrowth of Schumacher's "small is beautiful" philosophy. Adherents of AT advocate "scientific rationality and technical efficiency as ways to increase productivity" [24], but they have left out one of Schumacher's most vital ingredients in the AT equation—democracy [20]. He concludes,

> One can call it self-help technology—or, a democratic peoples' technology—a technology to which everybody can gain admittance and which is not reserved to those already rich and powerful [20].

While the proponents of AT have criticized top-down decision-making within the development strategies, noting that they fail to consult end users, the AT strategists also fail in applying a horizontal approach to the introduction and dissemination of new technologies. For example, African women who experimented with solar cookers found serious drawbacks in this fuel-saving technology. Such cookers must be used during the heat of the day and moved continually to collect the sun's rays. Another objection to the cookers was that women were unable to fit large family group *pots* on the delicate stoves [7].

The introduction of technology into developing communities around the world is closely tied to the everyday jobs of international aid workers, engineers, health professionals, social workers, and members of religious organizations. In addition, engineers have not been trained to consider societal implications of introducing new technologies into developing communities [3].

The advocates of AT (and most scientists and engineers) may bring with them not only unconscious cultural and gender biases but also situational biases that influence the adaptability and acceptability of new technologies. The "appropriateness" of a technology is not measured only by the form, amount, and type of energy required, but also by *who* "controls its development, dissemination, and products" [13].

JUST APPROPRIATE TECHNOLOGY

An ideal place to begin a discussion on the topic of a just AT is to look at a working definition that will serve as the foundation for thoughts and deliberations in this paper. Appropriate technology concepts have been discussed by many respected statesmen, such as Ghandi and Julius Nyerere; however, it is generally accepted that E.F. Schumacher, a British economist, is the undisputed founder of the AT movement. Schumacher outlines his philosophy of AT in his book, *Small Is Beautiful*, where he described the central doctrine of AT as (a) simple, (b) small scale, (c) low cost, and (d) non-violent [20]. The U.S. Office of Technology Assessment has further refined these tenets by describing AT as (a) small scale, (b) energy efficient, (c) environmentally sound, (d) labor intensive, (e) controlled by the local community, and (f) sustained at the local level [17].

Many definitions have evolved from this legacy; however, when considering the scope and focus of AT, the following explanation of just sustainability must be incorporated into the definition used in this paper posits the following definition.

Just sustainability argues "the need to ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems". Technology and development strategies must result in the most egalitarian benefit for the most impacted communities insuring that within Africa in general and Ghana in particular, that social and environmental justice is an integral part of the policies and agreements that promote appropriate technologies for sustainable development.

DEMOCRATIC APPROPRIATE TECHNOLOGY

The role of technology in rural women's development presents a special focus within resource management and environmental theory building. Appropriate technology provides some practical options for resource management. Sim Van der Rym defines some key elements of appropriate technology as: "smaller scale, more skillful, more understandable, diverse and non-violent" [23]. More recent literature challenges the advocates of appropriate technology to extend the definition to include an approach that is sensitive to gender and culture specific issues as well (e.g., [8], [12]).

Schumacher expounds on Van der Rym's appropriate technology definition:

> The technology of production by the masses, making use of the best modern knowledge and expertise is conducive to decentralization, compatible with the laws of ecology, gentle in its use of scarce resources, and designed to serve the human person instead of making them the servant of machines. I have named it intermediate technology to signify that it is vastly superior to the primitive technology of bygone ages at the same time much simpler, cheaper, and freer than the super technology of the rich [20].

Schumacher's description extends Van der Rym's by including a class and cultural analysis that is especially suited to indigenous Indian cultural needs. It is an important that appropriate technologies be indigenous and economically stimulating to local rural developing economies. The ideal situation would have been to integrate the new technology into the social, cultural, and economic environment of the traditional leather shoe production. This would have required the inclusion of the primary producers and indigenous artisans, many of whom are women, in the planning and design of the new shoe factory from the onset. Such a planning policy would require a social context of sincere appreciation and understanding of the intricate value systems of the host culture.

Recognizing women's importance in resource management in traditional and contemporary societies can facilitate a balanced use of the productive social elements, thereby approaching a gender partnership mode1 for AT.

Ghanaian women continue to practice this self-reliance philosophy in colonial and post-colonial society. In the economic spheres, Ghanaian women predominate in the areas of agricultural and marine production and processing [1]. Fish and cassava are two of the main staple foods. These foods represent important areas of Ghanaian economic life, therefore women's roles in the production and preservation of these commodities is pivotal [9]. It is therefore logical and natural that they become the innovators for improved technologies in food industries in particular.

The author of this paper was in Ghana in 1990 and had the opportunity to interview the director of the Ghanaian Environmental Protection Council, Christine Debrah. Debrah explained the success of several projects due to these factors. Traditional sun-drying methods for preservation of locally caught fish and of cassava have been improved upon by local women. Many preserve fish by using a smoking technique; however this is a health hazard. Women and children who use smoking techniques suffer many respiratory illnesses due to inhaling large quantities of smoke [9].

The Ghana Rural Fishery Research and Development Project (RDP) have improved on these local innovations (for example, recent introduction of improved racks on a limited basis in the village of Elmina, in Ghana's coastal region). Government support for the dissemination of these racks into other villages and areas through local institutions and leadership will determine its ultimate success. Sun-drying racks are used for drying fish and *kokonte* (cassava) and have been well accepted by local women. The improved rack stands on poles and is much more sanitary and efficient than the traditional method since it takes only a few days for the fish to dry [9]. The fact that this specific example of appropriate technology was introduced first by the initiative of local women and then improved upon by a local government body, contributed to both its acceptance as well as access to the technology by women.

Because social and cultural constraints create the greatest challenges to the adaptability and acceptability of appropriate technologies, the gender and age-group roles that guide the division of labor must be fully evaluated and understood. Compatibility with cultural and religious values is a critical factor in acceptance. When development schemes are based upon an appreciation of these traditional methods and variables, the results are encouraging. A culturally compatible non-hierarchical, democratic locus of control by the female workforce can evolve.

The Green Belt Movement in Kenya offers a good illustration of how a socially and culturally palatable project can gain power and recognition. The project is concerned with re-foresting Kenya's indigenous forest which in the past century has been depleted by 90% [16]. The project founder and director is a well known Kenyan woman who is a scientist. The project is also run and financed by local Kenyan women and indigenous organizations. The key to its success has been its ability to demonstrate through examples that are not alien or uncomfortable for women's participation. Women who have adapted and benefited from the tree planting project voluntarily initiated a campaign to recruit more women. A good indication of the acceptability of a given project is how fast the word spreads through informal communication systems.

Appropriate technology for rural development, by design, seeks to be inclusive of people, especially women by providing opportunities for meaningful income generating enterprises. A significant benefit of AT is the creation of income and service options that would not exist without this form of development. In addition, the types of incomes associated with AT often

lead to self-employment or small-scale business operations where the opportunities for cooperative and productive work environments are more possible.

Modern high technology industries seek to provide maximum output of product while limiting human involvement. The efforts to achieve uniformity of product quality using high tech systems often leads to the creation of toxic, environmentally unsafe, non democratic and exploitative work. Just appropriate technology concepts seek just sustainability that maximizes human involvement with reasonable product output. The result of this approach would stimulate growth at a level that could be sustained locally and provide jobs which are considerably more interesting than what is typically found in many high tech manufacturing facilities.

Sustainability is a central concept of AT and is essential for the success of AT projects being developed. The only way that sustainability can be achieved is by the end-users of the technology taking responsibility for all facets of the project. Therefore, the development of localized self-reliance in creating and maintaining AT projects is fundamental to the overall success of the project. The availability of local materials and low-cost equipment used in the AT project should also be within budget of the end-users. The infrastructure required for this process should be limited to what exists at the local level.

After decades of toxic industrialization, enormous pollution has had a significant impact on the planet and localized grass root communities, some of which may not be repairable. In many geographical regions around the globe, large-scale destruction of the biosphere has resulted from over extraction of capitalist planning. A key concept of AT is the design and function of devices that cause minimal negative impact on the environment and local communities. Success of AT is directly measured with regard to its ability to operate and meet human needs without causing undo pressure or stress on the local environment. Just sustainable appropriate technology could provide a workable alternative with regard to environmental issues for the developing world.

Non-toxic and non-polluting technology provide the philosophical underpinnings for a just and sustainable AT and are fundamental for all future discussions of this subject. The following goals represent the intended focus of a just and sustainable appropriate technology:

- Assist people, especially women at the grassroots level
- Provide income generating enterprises for local community members
- Sustainable/durable over time
- Utilize locally available resources
- Promote self-reliance and Encourage self-supporting processes
- Low cost, No cultural damage and No environmental damage

GENDER FACTORS RELATED TO AT FOR RURAL DEVELOPMENT

A common assumption in technological and socioeconomic development planning is that development is gender neutral. This partly explains why many target groups for projects are given genderless names such as "small farmers" or "the rural poor" [18]. While the use of such terms leaves the impression that these groups are men, the reality is that many of them are groups of women. Contrary to conventional thinking, technological and socioeconomic development does not have the same impact on males and females. Women make up more than two-thirds of the 1.3 billion people living in poverty today in the developing countries. It is not uncommon for the impact of a development project to increase earnings or labor-saving techniques for the males while also increasing the unremunerated workload for the females.

To resolve this tool and skill disparity will require that more women become involved in the decision making, planning, and designing of technology-based development projects, and that the introduced technologies be appropriate to their capabilities. AT can improve

women's productivity and save them time for other activities only if they become part of the decision-making body and/or have a means of communicating their needs to decision makers. In reality, women are rarely involved or consulted when development projects and programs that directly affect their lives are planned or designed. Development of technologies for women's use without their input often results in unsuccessful development efforts.

Sometimes an AT may not apply universally. Some technologies may be appropriate only in one region but not in another. As Bourque and Warren pointed out, "What may appear appropriate to engineers and development workers may not be at all appropriate to the people expected to use the new techniques" [4]. The case of solar cookers in India and Kenya seemed like an excellent example of AT considering the decimation of forests because of fuel wood needs. Children often spend hours away from school in search of wood for family cooking. As logical as the solar cooker appeared, it was not embraced enthusiastically by the rural women. Since the solar cooker must always be facing directly into the sun, it must be constantly adjusted to track the sun's changing position. Furthermore, solar cookers designed to make use of a small pot are inadequate when the needs of large families are considered. Finally, in many developing countries, the main meal of the day is prepared in the evening when the women return from the fields [8]. Obviously the solar cooker will not work after sunset.

Solar technology is often considered the green and clean appropriate technology that will benefit the developed and developing countries of the world. However there are disturbing global trends emerging. Much of the production of PV cells in taking place in China where environmental regulations are low to non-existent. The highly refined silicon used in the production of PV cells in countries like China, manufacturing costs and environmental regulatory enforcement are low. The dumping of toxic silicon by-products contaminates soil and air causing numerous health impacts. The soil becomes too acidic for plants, and causes severe irritation to living tissues, and is highly toxic when ingested or inhaled [21].

SUMMARY AND CONCLUSIONS

Deepening our understanding of environmental sustainability in a context of economic growth, by putting equity and sustainable development firmly on the agenda of the discourse can lead appropriate technology advocates to an agenda that takes environmental issues into account in the process of development and poverty reduction [14]. Rural African women should benefit the most from just sustainability and appropriate technologies. Solar and other green technologies are widely viewed as a “win-win” solution that can move the global community from grey to green economies. The development of green industries can improve environmental quality and quality of life, if an equity lens is applied.

A just approach to protecting people and the environment whether it’s rural agricultural development or manufacturing facilities, it is critical that strong standards for occupational health and safety, respect for all labor standards, and the free right of all toward a just and sustainable green economy.

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Comparative study of Phenanthrene degradation by *Aspergillus terreus* and *Saccharomyces cerevisiae* using HPLC

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Key words: *Aspergillus terreus,* HPLC, phenanthrene, *Sachharomyces cerevisiae*

Abstract
A strain of Aspergillus terreus and yeast strain Sachharomyces cerevisiae were selected from 24 enriched isolates extracted from a polycyclic aromatic hydrocarbon (PAHs) polluted soil. The metabolism of phenanthrene by this fungus was investigated in liquid submerged culture with 10%, 30% and 50% phenanthrene amended media. A.terreus indicated 39.21%, 36.32% and 2.65% of phenanthrene degradation at 10%, 30% and 50% concentration of phenanthrene respectively and the degradation by S.cerevisiae was 8.8%, 1.32% and 0% at 10%, 30% and 50% concentrations of phenanthrene when compared to controls. Solvent extracts of the broth and mycelium were analyzed for presence of metabolites by High Performance Liquid Chromatographic (HPLC) technique. The biomass increase in A.terreus and S.cerevisiae was from 3.96 to 4.656 and 2.53 to 5.613(mg/50ml of medium) with increase in phenanthrene concentration from 10% to 50% respectively when compared to control. These results suggest that though both these microorganisms can be used as effective decontaminants, relatively A.terreus provides faster decontamination of PAH affected sites.

Introduction

Polycyclic aromatic hydrocarbons (PAH) are highly toxic soil contaminants with degradation insolence. PAHs are constituents of crude oil, creosote and coal tar which contaminate the environment by improper disposal of wastes from the combustion of fossil fuels, coal gasification and liquefaction, incineration of industrial wastes, wood treatment processes and/or accidental spillage of petroleum hydrocarbons [5]. A number of individual PAH arise from natural oil deposits and vegetation decomposition, in addition to considerable anthropogenic production from the use of fossil fuels in heating and power production, wood burning, vehicular transport, runoff from bitumen roads, waste incineration and industrial processes [1].

Fungi degrade, decompose or transform a range of recalcitrant plant biomolecules, polycyclic aromatic hydrocarbons, nitroaromatics, chlorinated aromatics, BTEX compounds, as well as miscellaneous dyes, pesticides, effluent components and even cyanide [9]. Filamentous fungi, yeasts and non photosynthetic bacteria are the workhorses of biological degradation [3]. Though not green in color (except for a few spore types) and most certainly under appreciated (even by most microbiologists), the fungi possess the most varied and most efficient battery of depolymerizing enzymes

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of all decomposers [4]. When joined with their bacterial brethren in cooperative catabolism, fungal-bacterial consortia foster the ecological recovery of contaminated habitats worldwide. Filamentous fungi will always be major players in the "greening" of toxic waste sites and

other polluted habitats [2]. Ascomycetes are mostly able to degrade cellulose and hemicellulose, while their ability to convert lignin is limited. However for understanding different environmental routes, their degradation ability and identification of metabolites of new strains is essential while studying complexity and ubiquity of PAH compounds in the environment [10]. *Aspergillus* and *Penicillium* are rich in hydrocarbon assimilating strains. However the property of hydrocarbon assimilation is a property of individual strains and not a characteristic of particular species or related taxa. Hydrocarbonoclastic strains of *Candida, Rodosporidium, Rodotorula, Saccharomyces, Sporobolomyces* and *Trichosporon* have been reported from soil [12]. Several yeasts from coastal sediments, including *Trichosporon penicillatum* and various other fungi also transform phenanthrene. *A. niger, S. racemosum* and *C. elegans* may produce not only *trans*-dihydrodiols from phenanthrene but also sulfate, glucuronide and glucoside conjugates. *A. niger* metabolizes phenanthrene to 1-methoxyphenanthrene; the minor metabolites are 1- and 2-phenanthrol [9].

Phenanthrene has been used as a model PAH in the investigation of degradation and identification of metabolites while monitoring PAH-contaminated wastes [5]. It has a water solubility of 1.3 mg/liter and ionization potential (IP) 8.19 ev. An epoxide which is suspected to be an ultimate carcinogen can be formed by bay- and K-regions of phenanthrene [15,17]. Benzo[a]pyrene, benzo[a]anthracene and chrysene are some of thebay- and K-region containing carcinogenic PAHs. In general, bacterial degradation of phenanthrene is initiated by 3,4-dioxygenation to yield cis-3,4-dihydroxy-3,4-dihydrophenanthrene, which undergoes enzymatic dehydrogenation to 3,4-dihydroxyphenanthrene. The diol is subsequently catabolized to naphthalene-1,2-diol through both ortho-cleavage to form 2-(2-carboxy-vinyl)-naphthalene-1-carboxylic acid and meta-cleavage to form 4-(1-hydroxy-naphthalen-2-yl)-2-oxo-but-3-enoic acid. [18,19,16,8]. Non-ligninolytic fungi though unable to use PAHs as sources of carbon or energy, they may co-metabolize and this process though does not enhance fungal growth, it may result in a reduction of the toxic, mutagenic or carcinogenic properties of PAHs Yeasts are able to bring about fission of aromatic rings. Ring fission clearly occurs during the metabolism of phenol by yeast *Rhodotorula glutinis* and of aromatic compounds by *Trichosporon cutaneum*. They are also capable of assimilating long chain alkanes in two subcellular organelles- the microcsomes, Cytochrome P450 and and the associated NADH reductase [9].

The objective of this study is therefore, to isolate and identity some of the indigenous fungal flora and yeasts for the remediation of oil contaminated soils and to evaluate the biodegradation efficiency and biomass of the potent isolates.

Materials and Methods

Sources of soil sample

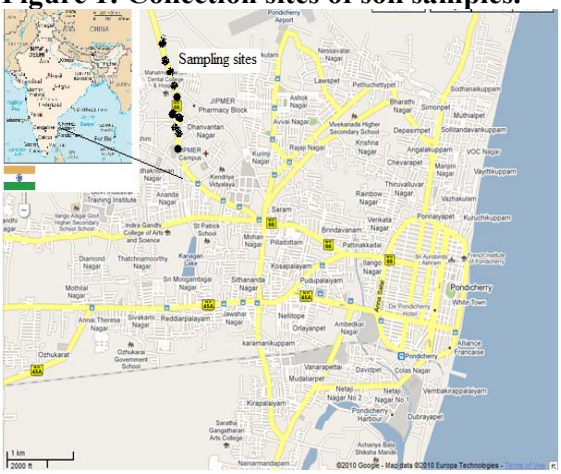
The oil contaminated soil samples used for the isolation is a composite of 8 workshops from Gorimedu area of Pondicherry, located geographically at 11° 55' 48" North and 79° 49' 48" East Figure 1. Samples from each site were collected randomly from different locations 1-2 cm below the soil surface and transported to the laboratory in white plastic bags and kept in a refrigerator (in order to keep the organisms viable and free from any contaminant) prior to analysis.

Media and Chemicals

Sabouraud Maltose Broth (SMA) containing 40g of maltose and 10g of peptone mixture per litre with final pH 5.6 ± 0.2 at 25°C was utilized for the isolation of fungi. Bacto Bushnell-Haas Broth (BBHC) containing $MgSO_4$ (0.2 g/l), $CaCl_2$ (0.02 g/l), KH_2PO_4

(1 g/l), K_2HPO_4 (1 g/l), $FeCl_2$ (0.05 g/l) and NH_4NO_3 (1 g/l) was used for the screening test. Tween 80 (0.1%), redox reagent (2% 2, 6-dichlorophenol indophenols) and crude oil (1%) were all incorporated into the broth.

Figure 1: Collection sites of soil samples.



Isolation of indigenous fungi

Each oil-contaminated soil sample was homogeneously mixed and carefully sorted to remove stones and other unwanted soil debris using 2.5 mm sieve. One gram of each sorted soil sample was homogenously mixed with 1 drop (0.1ml) of Tween 80 and a loopful (3 mm) of it was collected and inoculated by sprinkling method onto SMA agar plates, respectively. The plates were incubated at room temperature (28^oC – 30^oC) for 3 to 5 days for SMA. The grown cultures were carefully and aseptically sub-cultured onto fresh SMA. Potential isolates were identified by plate cultures.

Biodegradation assay of the selected cultures

Three agar plugs (1 cm^2) from 24 hr pure cultures, each of the two best potential strains (*Aspergillus terreus* and *Sachharomyces cerevisiae*) were inoculated into the SMA broth (100 ml Erlenmeyer flask) containing 50µl of phenanthrene (10%, 30% and 50%). Inoculation of each organism was carried out in triplicate. The incubation of cultures was performed by shaking the conical flasks at 120rpm and at 28ºC for 3 weeks in three replicates, at the end of which culture free extract is obtained by filtering through No 4 Whatman filter paper. Residual phenanthrene is extracted with a separating funnel twice and centrifuged for 10 minutes at 12000rpm and condensed in rotary evaporator and then filtered with 0.45µm GF/A filter papers and then analized by hplc.

Biomass determination

The filtered samples were dried in oven at 80°C for 48 hrs. Biomass was estimated after 3 weeks of incubation [20].

High-performance liquid chromatography

High-performance liquid chromatographic (HPLC) analysis of phenanthrene was performed using a HPLC system (Perkin Elmer) equipped with a silica column. . A sample volume of 20µl is injected into HPLC equipped with UV detector set at 254nm. Acetonitrile: Water (75:25) is the mobile phase and flow rate is 1ml/ min. Calibration curve at several dilutions of phenanthrene standard were used for determining retention time and studying linearity of the detector [2]. The retention times of PAH standards and the components of

phenanthrene were monitored at 254 nm. In a typical experiment, cultures were extracted as described above.

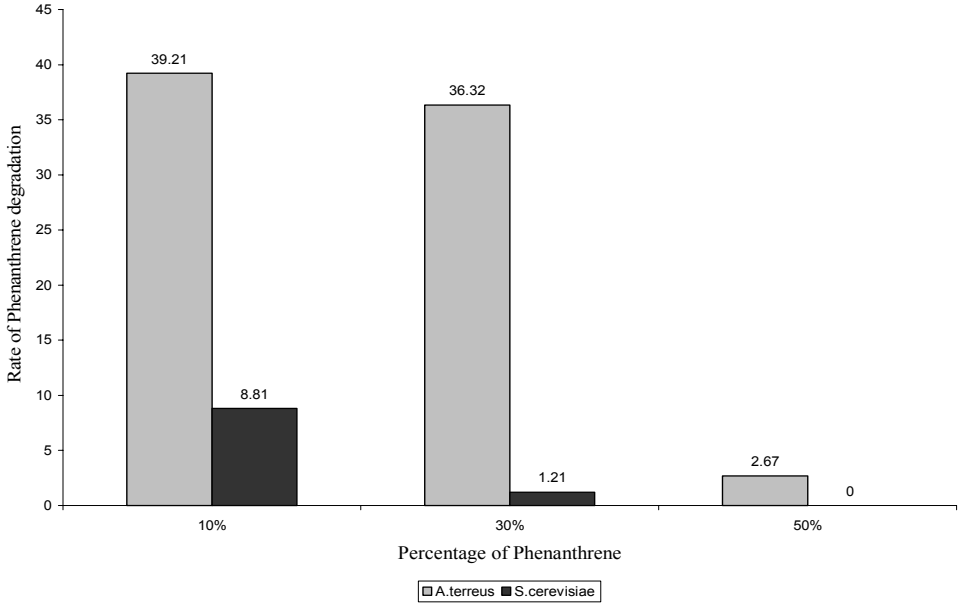
$$\text{Biodegradation efficiency (\%)} = \frac{\text{Co-Ce} \times 100}{\text{Co}}$$

Where Co = initial concentration of Phenanthrene (µg/g), Ce = equilibrium concentration of Phenanthrene (µg/g).

Results and Discussion

Fungal Species *Aspergillus terreus* indicated 39.21%, 36.32% and 2.65% of phenanthrene degradation (Figure 2) at 10%, 30% and 50% concentration of phenanthrene and the percent degradation by *S.cerevisiae* was 8.8%,1.32% and 0% (Figure 2) at 10%, 30% and 50% concentration of Phenanthrene when compared to controls.

Figure 2. Rate of phenanthrene degradation in *A.terreus* and *S.cerevisiae* cultures.



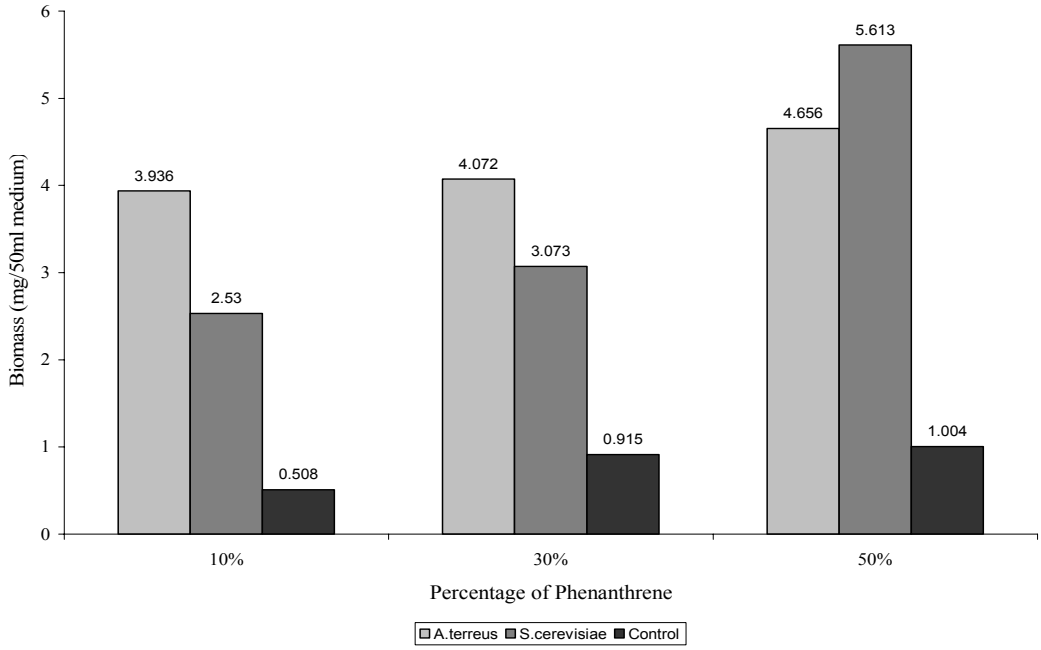
Similarly 58% phenanthrene removal was achieved by *Penicillium sp.* and 35% removal was reported in *A.terreus* in a medium added with 50mg per kg of phenanthrene in agar for 7 days [7]. Likewise highest of 76.7% percentage of phenanthrene removal was reported in the fungal cultures of *Trametes versicolor* at 10 mg/l of phenanthrene concentration and the transformation rate was maximal (0.82 mg/h) at 100 mg/L of phenanthrene concentration in the fungal culture [7].

Our results corroborate with the work on degradation of phenanthrene and pyrene by using five different wood-decaying fungi in straw cultures with *T. versicolor* (15.5%) and *K.mutabilis* (5.0%), *L.sulphureus* (10.7%) and *A.aegerita* (3.7%) capable of mineralizing phenanthrene in a period of 63 days. The results in this study are an extension of earlier studies on the fungal mineralization of phenanthrene and pyrene [15].

The biomass increase (Figure 3) in *A.terreus* and *S.cerevisiae* was from 3.936 to 4.656 and 2.53 to 5.613(mg/50ml of medium) with increase in phenanthrene concentration from 10% to 50% respectively when compared to control. In *A.flavus* and *P.farinosus* initial

biomass was 0.42 and 0.62 mg/ml, this parameter increased to 0.65 - 0.83 and 0.77 - 0.90 mg/ml with and without C16, therefore the increment was 97 - 54% and 45 - 24% [13].

Figure 3. A comparison on biomass of *A. terreus* and *S.cerevisiae* from phenanthrene degradation cultures.



Conclusions

These results suggest that though both *A.terreus* and *S.cerevisiae* are effective in the decontamination of phenanthrene in liquid cultures, the extent of biodegradability is dependent on chain length and complexity of chemical contaminants. The present study reveals that *A.terreus* provides relatively higher decontamination of PAHs. Further studies are directed towards degradation of a combination of PAHs by bacterial and fungal co-cultures with or without surfactants that relates to the situation similar to the degradation systems in nature.

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Enhancing Environmental Sustainability Through Tree Planting and Political Education

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Key Words: Sustainable Development, Pan-Africanism, Community Education, Community Assets, Community Organizing

Abstract
Ghana, a country on the West Coast of tropical Africa, has been experiencing the loss of its indigenous forests for many years. It ranks very high internationally in terms of the rate of deforestation. The impact of non-sustainable development in rural Ghana, while enriching individuals and enterprises outside Ghana, has left indigenous communities impoverished and with a deteriorating environment. The impacts of deforestation have been well documented. A project to reverse the trend of deforestation was undertaken in 2009. A tree planting exercise was undertaken which included as essential components: the education of the community around environmental sustainability issues, the political education and organization of the target community, and the building of organizing skills among student volunteers and others toward the objective of Pan-Africanism. The project resulted in the involvement of 35 student and youth organizers along with community members planting some 800 trees in the target community.

Introduction

The environmental and development challenges faced in Ghana are no different from those faced in other countries in Africa. Global systems and international policies result in many of Ghana's natural resources being exploited for production, use and consumption outside Africa. In this process, the environment is substantially and permanently altered causing yet further impoverishment and underdevelopment. With this background, it is the belief of the authors that appropriate technologies leading to alternative land uses and practices are essential to changing the course of existence for the majority of African citizens who struggle for basic survival. It is further posited that mass (public) education is a critical factor in helping to bring about necessary changes in the way in which technologies are used and in the way local and national decisions are made. The project described herein, attempts to address the environmental challenge of deforestation in a manner that introduces community education and organizing that can ultimately result in wider changes to land use practices and unjust social conditions.

The Need

Indira Ghandi, former Prime Minister of India is known for the famous quote, "When the last tree dies, the last man dies." [1] Today one of Ghana's principal environmental

problems is deforestation. The forest is being quickly and quietly depleted due to industrial development and exploitation of resources, public sector neglect, and general living practices of the population. Each year bush fires, illegal chain saw operations, mining and other activities take an unplanned and unanticipated amount of forest, while growing amounts are used for construction, cooking, logging, and trade. The rainforest in Ghana has been decreasing rapidly and significantly. Ghana's forest area has decreased from almost 7.5 million hectares in 1990, to 5.5 million in 2005. The deforestation rate from 1990 to 2000 was 18.2%. Ghana's tropical forest is now just 25% of its original size. [1]

Ghana is listed in the top ten nations with the highest deforestation rates. At one point about two-thirds of Ghana was covered with forest; now, less than 10% of that forest cover remains and none as frontier forest. At a rate of decline since 1990 of 28% (through 2009), the remaining forest doesn't stand a chance without better forestry practices. [2]

The negative consequences of these poor environmental and economic practices are many. Warnings by the Ghana Forest Service and others seem to go unheeded. Deforestation not only depletes the forest – it causes soil erosion, loss of wildlife and their habitat, flooding, landslides, the drying up of water sources such as streams and rivers, and desertification.

In Ghana, forests also provide many products on which the local population subsists. However, these resources are being depleted. [3]

According to a 2002 Conservation Report, an estimated 75% of the population in both the urban centres and the rural areas depend on traditional medicine for their everyday health-care needs. About 82% of the population in developing countries like Ghana live in rural areas. With a population of 18 million therefore, it means there are some 14.8 million rural dwellers in the country. [4] The reasons for the dependence on plant medicine among rural communities in developing countries are:

- Plant medicine is more easily available and they are comparatively cheaper in the rural areas. In some instances plant medicine is entirely free of charge.
- The practitioners live mainly in the rural areas.
- There are very few hospitals or health posts in the rural areas and these are often inaccessible.
- There are even fewer medical officers among rural communities. The figure is about one medical officer to 70,000 people in the rural areas, as compared to one medical officer to 4,000 people in the urban centres.
- The high cost of western or imported drugs can not be easily afforded by many rural dwellers.

Although man depends heavily on plants for his basic survival, and on plant products for food, medicine, clothing, shelter and numerous other needs, man's activities tend to destroy the forests and woodland – the natural habitats of these plants. [4]

Theoretical Framework

John McKnight and John Kretzmann (1993) detailed five comprehensive steps to use when attempting to mobilize a community's assets around a vision and a plan. [5]

Step One involves mapping the capacities and assets of the people, groups and institutions in the community.

Step Two involves building relationships among all the interested parties for mutually beneficial problem solving within the community.
Step Three involves mobilizing the community's assets fully for development and information sharing purposes.
Step Four involves convening as broadly representative a group as possible for the purposes of creating a community vision and plan.
Step Five involves leveraging all the funds, tools, supplies and resources needed from inside (first) and outside (last) the community to support locally defined development.

The All-African People's Revolutionary Party (A-APRP) is an international Pan-African political organization [6] that works locally in Ghana in conjunction with the Garvey-Nkrumah Institute (GNI). Since 2008, the organizations have focused on local development and political education work in Nkroful, Ghana. Nkroful, a small rural town in the Western Region of Ghana, was the birthplace of Ghana's First President and Africa's foremost Pan-Africanist leader, Dr. Kwame Nkrumah. The A-APRP was founded by Dr. Nkrumah and strives to achieve Pan-Africanism which he advocated as the total liberation and unification of Africa under one scientific socialist government. [7]

The A-APRP/GNI used the theoretical framework described above to approach the mission of 'trees for sustainable development'. The framework was not approached in a linear method or through sequential steps as the framework implies however.

First, Dr. Julius Garvey, noted medical physician, human rights activist, philanthropist, an honorary traditional leader in the town of Nkroful, and the son of the great Pan-Africanist the Honorable Marcus Mosiah Garvey, proposed the idea of planting trees to Pan-African organizers working in Ghana. The ideas were further discussed with members of the community of Nkroful.

All parties involved thought the idea of planting trees would be relevant to the objective of Pan-Africanism, the scientific development of Africa and its environmental sustainability. It was recognized that long term sustainability can only come about within an economic and political system that is people-centered rather than purely profit driven. Otherwise, there is little or no motivation for ecologically sound and environmentally sustainable practices. The necessity of this community education and awareness led to adopting the objective of building and developing community organizing skills within the target community and within the participating organizations.

Dr. Julius Garvey offered to help pay for the cost of the trees and engaged members of the A-APRP/GNI to help actualize the plan. Organizational members from various parts of Ghana (Accra, Cape Coast, Takoradi, Kumasi and Nkroful) were involved in the project. They immediately conducted a mapping of assets in the Nkroful community. They identified a local museum coordinator, a senior secondary school teacher, and other local resource people. These individuals had skills and experience in organizing, planning, community education and supervision. All shared an interest and commitment to develop Nkroful.

These individuals and others had engaged with Dr. Garvey and the A-APRP/GNI to educate youth in local colleges and universities, and senior secondary schools around Pan-Africanism for several years. Students came forward and committed to provide the valuable asset of labor. Commitments were also obtained from the vendor providing the seedlings to provide tools to assist in planting. Community residents loaned machetes and shovels.

Community organizations and institutions agreed to provide wheelbarrows and additional labor.

Meetings were then organized with the various community, governmental, and traditional leadership bodies and community groups. This preparation allowed all parties to develop a singular vision and commit to how they would make the shared vision a reality.

A budget and plan were developed that covered the cost of advance planning with key members from Accra who temporarily resided and worked in Nkroful, the cost of seedlings and additional tools that were necessary, the transport, accommodation and feeding of student volunteers, and other needs. Dr. Julius Garvey assumed 100% of the cost for 1,000 tree seedlings (US$3,000) and more than 70% of the additional costs for transportation, lodging and food for the student volunteers and equipment needs. Several community groups and organizations such as the Accra Foundation for Intercultural Communication and Awareness, and the Moyo Pan-Afrikan Solidarity Centre, donated food, t-shirts, and funds to help students and the advance team with various needs (e.g., photo documentation, planning support, educational materials and public education activities).

Community members provided discounted meals, water, and other items to assist with the project. Discounted lodging for the student volunteers was provided by a local school. Police officers provided security and labor. Staff of the local hospital joined in and contributed their time and labor to the effort. The Nkrumah Museum served as the project meeting and coordination point as well as the meal site.

While the A-APRP/GNI did not work in a linear fashion, they did indeed complete each of the five steps in the model of McKnight and Kretzmann. Following the planting, the traditional leaders and the Local Unit Committee in Nkroful promised to take on the ongoing efforts to water, protect and nurture the seedlings to ensure maturation.

Throughout the advance planning and the two-day tree planting exercises, continuous political education took place to teach the community and the volunteers about the important contribution to Pan-Africanism made by Marcus Garvey, Kwame Nkrumah and others. Theoretical and practical education was also provided on the necessities of building mass-based organizations, the necessity of Pan-Africanism, and the importance of implementing sustainable development practices to ensure that a politically and economically unified and independent Africa would be ecologically inhabitable.

Methodology and Approach

An advance team from the A-APRP/GNI traveled to Nkroful to do a survey and assessment of the community. Meetings were held with members of the local community. A meeting was held with the Abusuapanyin, the traditional leader in Nkroful, at his palace. He gave his blessing and support for the project. The Abusuapanyin arranged a meeting between the organizing team and members of the Unit Committee in Nkroful. The Unit Committee is the main local organizing structure comprised of community volunteers. The Committee assisted with the identification and mapping of areas were trees would be planted. They would also have oversight responsibility of the trees after planting.

During previous travels to Nkroful, the organizing team used the opportunity to visit A-APRP work-study circles in Cape Coast and Takoradi. There, members were informed

about the tree planting project and its link with Pan-African development. Volunteers were recruited to work on the project. Arrangements for transportation and lodging for the volunteers were made.

At the time of the planting, community volunteers were recruited and notified by the banging of the gong gong -- the traditional method of communication in rural communities.

One day was targeted to plant 1,000 trees. There would be four teams responsible for planting in each section of the town. Another team was to be stationed at the nursery.

Team leaders had also been identified to be responsible for the:

1) supervision of seedlings;
2) distribution and carriage of seedlings;
3) monitoring of tools/wheelbarrows, cutlasses, digging tools and watering cans;
4) distribution of drinking water to working sites; and;
5) the construction of protective fencing around the seedlings.

With the help of local volunteers including the Chairman of the Unit Committee, digging of the holes was started before the volunteers arrived the following day for the planting. Technical specifications for the planting were provided by the nursery which supplied the tree seedlings.

Initially, students from the local agricultural secondary school were to be involved in the tree planting effort. However, due to their academic schedule, they were not able to participate. The majority of the labor then came from residents and student volunteers from other locations in Ghana. Support was provided by the secondary school however as the visiting student volunteers were housed at the local secondary school.

Plan Implementation

On the evening prior to the planting, the student volunteers went into the communities to engage residents in their housing compounds on the importance of growing and maintaining trees in the environment. In addition to committing to assist with the labor, local residents also promised to supply cutlasses and other tools that would be needed.

After the engagements with the community, a mini-durbar (formal community meeting) was held at the Chief's Palace to launch the program and to provide education on the need for the trees. Education was given on the specific types of trees to be planted (Semia Cassia) and the various benefits they would bring to the community (medicinal, ecological, and practical).

The first seedling was planted by the District Chief Executive (DCE) in front of the Kwame Nkrumah Mausoleum. Dr. Julius Garvey then took his turn to plant after a brief speech about the symbolism of the day, April 27, 2009, which was 37 years to the day since the death of Dr. Kwame Nkrumah. Seedlings were also ceremonially planted on behalf of African women, and on behalf of African students and youth.

After the initial ceremonial plantings, volunteers were dispatched to the various sites to start work. Bamboo trees were used to provide fencing for the seedlings. The bamboo trees were cut into sticks and put around the seedlings to protect them from animals. Bamboo sticks for fencing were carted in wheelbarrows behind the distribution of the seedlings.

Simultaneous to the planting, additional holes were dug to accommodate additional seedlings. Planting took place around markets, squares, the local hospital, school fields, and various other locations within the community. The planting took place throughout the entire day. Refreshments and a lunch break were provided for all the volunteers. At the conclusion of the exercise, a total of 800 trees were planted. At the end of the day, a debriefing session was held at the Nkrumah Mausoleum during supper.

Conclusions and Lessons Learned

The successful conclusion of the tree planting exercise in Nkroful, Ghana saw a new group of student organizers ready to continue with the work of community education and organization. Approximately 35 student and youth organizers took part in the project. The skills and experiences gained have been useful in executing similar projects in other areas in Ghana. Specifically, the initial experience in Nkroful, Ghana has now been expanded with similar projects undertaken in communities in metropolitan Accra, and in the rural community of Wa, in Ghana's Upper West Region.

The trees planted in Nkroful now serve as an ongoing reminder and testament to the efforts put forth by the community and the volunteers to improve the environment.

Six months after the tree planting, it has been observed that approximately 10% of the trees have died. These trees, however, have subsequently been replaced by the local community. The community members also continue to monitor and nurture the trees on a regular basis. Subsequent to the initial planting, students from the local agricultural secondary school have also gotten involved with the project and have been working with and assisting the community workers and organizers.

Relationships with the local officials have been enhanced as a result of the project. Officials have acknowledged and shown an increased recognition of the ability of local community members to undertake and accomplish a significant project motivated primarily by knowledge and information rather than immediate material rewards.

Finally, it is not insignificant that community and political organizers have continued to apply their theoretical training in practical and important ways. Since the conclusion of the project in Nkroful, many of these organizers have used the experience to expand the practical application of their knowledge of Pan-Africanism and sustainable development, to the work of building community based participatory organizations. Several of the key conclusions and results from the exercise have been highlighted in the following table.

Table 1: Summary of Outcomes from Nkroful Tree Planting Exercise

Strengths – Positives	
1.	Number of student/volunteer participants was high (approximately 35)
2.	Project completed within budget
3.	Planted 800 Semia Cassia trees
4.	Had support and interaction with local officials including the District Chief Executive
5.	Turned absence of secondary school students into positive with use of campus housing
6.	Had positive interaction with community and conducted significant community education around Pan-Africanism, Marcus Garvey, Kwame Nkrumah, and Environmental Sustainability
7.	Gained valuable experience in community organizing

Challenges for Growth and Lessons for the future	
1.	Need to increase level of community participation
2.	Increase media awareness/publicity
3.	Involve community in early planning of programs and future activities
4.	Look to develop incentives to assure survival and maturation of trees
5.	Find a method for the community to absorb financial costs and to generate seedlings (develop local self-sustainability)
6.	Inform and involve DCE and District Assembly early in the planning process
7.	Ensure local organizing groups (Unit Committees) assume responsibility for nurturing trees
8.	Schedule exercise to coincide with the weekly communal work days

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Physico-Chemical And Biotic Factors Influencing Microalgal Seed Culture Propagation For Inoculation Of A Large Scale Raceway Pond

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Key Words: Seed culture; Raceway pond; Inoculum; Biomass; Lipid; Biodiesel

Abstract

The over reliance on fossil fuels will have a major impact on power supply in the near future if renewable sources of energy are not developed at a fast pace. We report here the monitoring of physico-chemical and biotic parameters affecting the propagation of Chlorella sp. seed culture for inoculation of a large scale raceway pond in South Africa (300 000L capacity). This is the first attempt of growing microalgae for biomass and lipid production for biodiesel production at large scale in the region. The Chlorella sp. used for this purpose was isolated from a wastewater maturation pond and characterized for its potential for biomass and lipid production. The isolate was grown aseptically in 4 x 25 L aspirator bottles in BG-11 medium under ambient laboratory conditions and the culture was supplied with filtered air and exposed to a light intensity of 200 µmol/m^2/sec using Gro-Lux agricultural fluorescent lights. The culture was transferred to a 500 L capacity portable pool under open conditions. This pond was used to further inoculate 3 more portable ponds. Physico-chemical and biotic growth parameters were monitored on a daily basis. Physiological studies were routinely carried out to determine the vigour of this strain with time using PAM fluorometric analysis.

INTRODUCTION

The depletion of fossil based fuels is becoming a reality as the global demand for energy fuels outpaces supply. Hence it is desirable to search for alternative, sustainable and non-renewable fuels such as biodiesel generated from microalgal lipids [1]. The success of this novel technology depends on selecting a suitable microalgal strain as well as the cultivation strategy adopted [2]. Successful large scale microalgal cultivation systems rely heavily on the quality, vigour and physiological properties of the seed culture. It is imperative to develop a seed culture propagation strategy that will result in the development of robust and high quality inoculum for seeding a large scale open raceway pond. Raceway ponds are preferred for microalgae cultivation due to a number of advantages as compared to photobioreactors [3-7].

Preliminary microalgal cultivation studies demonstrate that there are 4 fundamental steps for up scaling seed culture to be adequate to inoculate a large commercial raceway pond [7]. The four important steps to full realisation of a high quality seed culture are: (i) bioprospecting for hyper lipid producing microalgal strain; (ii) strain selection, isolation and purification using conventional and advanced methods; (iii) up scaling of the seed culture under laboratory conditions in aspirator bottles and (iv) seed culture propagation in a pond under open conditions [3, 7]. It is imperative to measure and understand the role of the physico-chemical and biotic factors affecting the growth of the target microalgal strain in order to take preventive measures to avoid system failure [7].

The commercial cultivation of microalgae and cyanobacteria on an industrial scale began with the culture of *Chlorella* in Japan in the 1960s followed by the cultivation of *Spirulina* in Mexico, the USA and China in the 1970s [8]. *Chlorella*, *Spirulina* and

Dunaliella are commonly cultivated since they can be easily grown in highly selective media and can be cultivated in open raceway ponds and remain relatively free from contamination [8]. The main driver for the open raceway pond technology is its possible low cost microalgae cultivation system with a wide array of process designs ranging from single, multichannel and cascading systems. Therefore the aim of this study was to investigate the effect of physico-chemical (pH, temperature, light intensity, salinity, dissolved oxygen, TDS, conductivity and ORP) and biotic factors (bacteria and microalgal contaminants) on seed culture propagation in three open ponds.

MATERIALS AND METHODS

Microalgal strain isolation and purification

An extensive bioprospecting exercise for hyper-lipid producing microalgae was carried out in aquatic habitats in KwaZulu Natal Province, South Africa. Subsequently, a robust high lipid producing *Chlorella* sp. (Accession no: HM063008) was isolated from a wastewater maturation pond at Kingsburgh wastewater treatment plant in Durban, South Africa. The microalgal strain was purified to homogeneity using standard conventional protocols and identified using molecular tools. The purified isolate was kept at 4 ^{o}C in suspension and routinely subcultured until needed for further research.

Growth conditions and media composition

The microalgal cultures were grown and maintained in BG-11 medium [9] for the entire seed culture preparation. The 4 x 25 L aspirator bottles were inoculated with pure seed culture (10 % v/v) and incubated under ambient laboratory conditions exposed to Sylvania Grow-lux 18 W lights. The seed culture growth was monitored daily and routinely checked microscopically for any contamination and population dynamics. Three open ponds each containing 500 L of BG-11 medium were seeded with 10% of the pure culture of *Chlorella* sp. and monitoring of physico-chemical and biotic parameters was done for 30 days during day time conditions.

Monitoring of growth parameters and biomass determination

Physico-chemical parameters (pH, temperature, salinity, evaporation rates, conductivity, dissolved O_2, total suspended solids and Oxidative Reduction Potential (ORP)) were measured using YSI probes. The variables were monitored daily at 1100h. A light intensity meter was used to measure light intensity. Samples (500 ml) were collected from the ponds for laboratory analysis. Biomass was determined gravimetrically.

RESULTS AND DISCUSSION

Biomass production and effect of pH on *Chlorella* growth

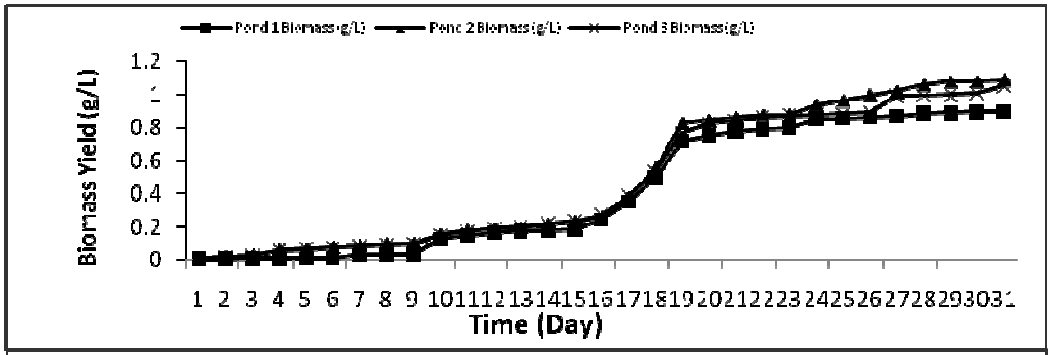
The biomass was monitored in the three ponds for 30 days and data generated show typical growth curves (Fig 1a). There was a prolonged lag phase in the three ponds and this is attributed to the open nature of the growth conditions and it took a long time for the pure monoculture to adjust to the open conditions as opposed to the controlled laboratory conditions. The exponential growth phase started on the 9th day of growth up to the 19th where the stationary growth phase set in. These findings clearly suggest that the inoculumn in the ponds can be harvested at this prime time before the cells lose their vigour. Similar work done by [7] also support the assumption that continued growth of *Chlorella* cells in batch culture will negatively impact on their viability and resuscitation and rejuvenation of these cell can lead to failure when transferred to large scale raceway pond. It was observed that settling of the cells was a major stumbling block and mechanical mixing of the

suspension was only achieved by physically mixing 3 times a day. The maximum dry weights achieved were 0.898 g/L, 1.09 g/L and 1.05 g/L for pond 1, 2 and 3 respectively. Free chlorine is a micronutrient for microalgal growth therefore initial free chlorine in all the 3 ponds was determined and was found to be 0.05 mg/L.

pH has a major effect on microalgal growth since it controls all metabolic and physiological functions of the cell. It is imperative to closely monitor pH in the ponds. The pH levels above 9 are desirable because some contaminants such as protozoans and rotifers are inhibited under these conditions and are therefore completely eliminated from the ponds [7]. The presence of these contaminating microorganisms can lead to disastrous consequences since they are known grazers and can therefore devour the target microalgal cells in a short space of time. The pH values in the 3 ponds for the entire growth period were in the desirable range (Fig 1b) therefore it was not necessary to supplement the ponds with additional CO_2. The pH ranged from 7.55 to 10.14, 8.78 to 10.08 and 8.72 to 9.95 in ponds 1, 2 and 3 respectively.

Carbon dioxide has a strong influence on pH fluctuations in the growth ponds and the data generated demonstrate that the utilisation of CO_2 for photosynthesis results in the formation of carbonates in the medium that increases the pH into the alkaline range. There was a gradual decrease in pH levels in pond 1 for the first 3 days of growth (Fig 1b) and this is attributed to rapid utilisation of CO_2 as the microalgal cells adjust to the new conditions in the open system. Findings show that pH is regulated by both the residual CO_2 concentration and photosynthetic rates in the pond. Using higher concentration of CO_2 may result in decreasing the pH since unutilized CO_2 will be converted to H_2CO_3 and on the other hand, if there is not enough CO_2 gas supply, microalgae will utilize carbonate to maintain its growth [10]. However, the data generated was only for day time conditions and future research will focus on monitoring the pH levels at night where photosynthesis does not take place.

(a)



(b)

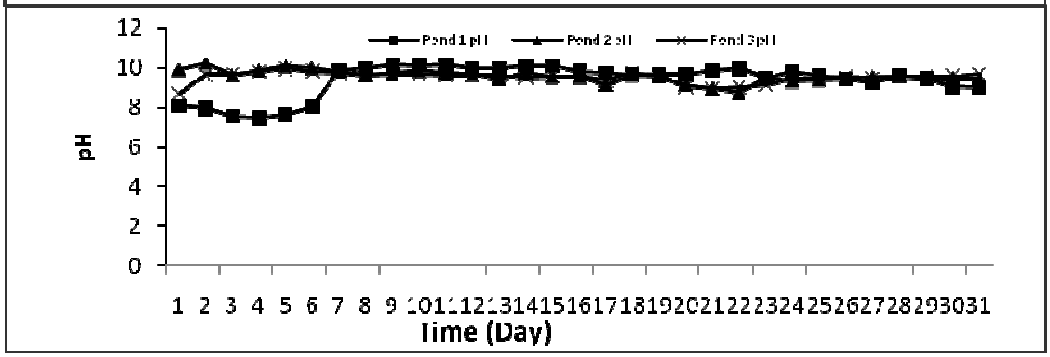


Fig 1 Graph showing biomass propagation (a) pH trends (b) in the three ponds.

Effect of temperature and light intensity on *Chlorella* growth

Temperature is one of the most crucial factors affecting biomass accumulation and lipid production by microalgal cells since it is pivotal in all enzymological reactions and

physiological functions of the cells [3]. It is well documented that freshwater microalgae require temperatures in the range of 25 to 30 ^{o}C for optimal growth [3, 11]. It was found that temperature ranged from 22.56 ^{o}C to 32.04 ^{o}C, 20.56 ^{o}C to 31.76 ^{o}C and 20.45 ^{o}C to 30.75 ^{o}C in pond 1, 2 and 3 respectively (Fig 2a). Regional seasonal temperature variations were within range and therefore the temperature variation at this site is suitable for microalgal cultivation throughout the year as reported by the South African Weather Services. Temperature fluctuations in the 3 ponds followed a similar pattern

Light intensity, quality and duration of exposure are the main driving forces for higher photosynthetic rates and subsequent high biomass and lipid productivities. The light intensities ranged from 18.92 to 306.7, 20.21 to 462.9 and 10.31 to 315.9 µmol/m^2/sec in pond 1, 2 and 3 respectively (Fig 2b) and this is mainly attributed to increased cell density in the ponds. It was reported that light intensity of around 300 µmol/m^2/sec is ideal for optimal microalgal growth although too much light intensities can cause photo-oxidation that is harmful to *Chlorella* though intermittent light fluctuations enhance microalgal productivity [12]. At the initial growth stages, the light intensity was fairly high in all the experimental ponds and there was a gradual decline with time.

The gradual decrease in light intensity is explained by the biomass accumulation in the suspension which caused retardation in light penetration into the media. Furthermore, the low light intensities on some days are due to overcast and rainy conditions which prompted the ponds to be covered by a plastic sheet hence lowering light intensity in the suspension. From our findings, it is generally accepted that light intensities at this site are ideal for *Chlorella* cultivation and it is feasible to grow this culture in a large scale raceway pond.

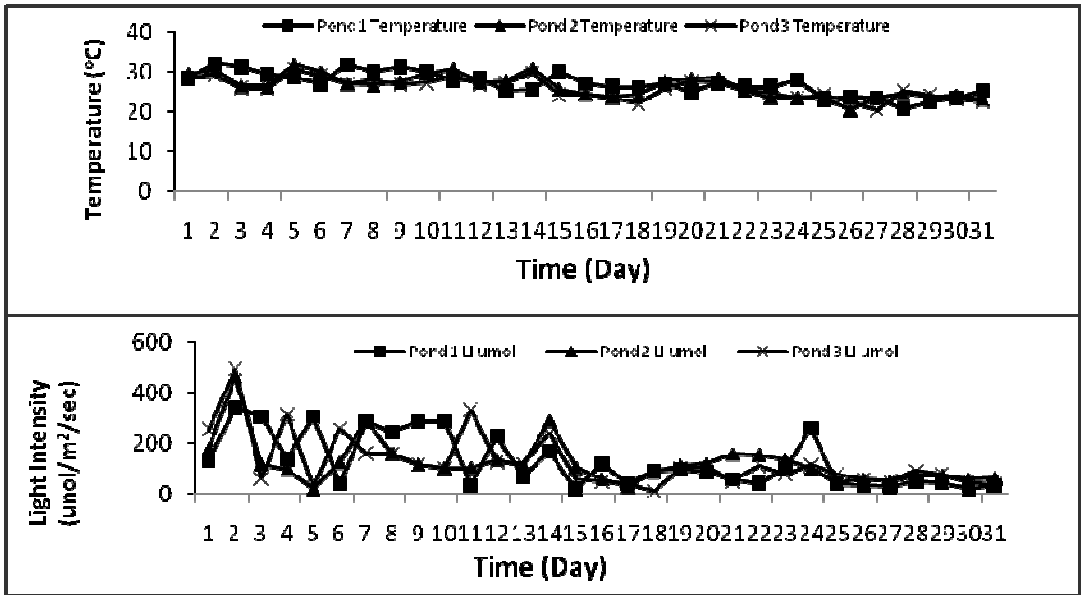


Fig 2 Graphs showing fluctuations in temperature (a) and light intensity in the 3 ponds (b).

Effect of salinity and dissolved oxygen on *Chlorella* growth

The additional expenditure of metabolic energy under stress conditions is required for maintaining ion homeostasis and electrochemical gradients, for the biosynthesis of organic compounds which play an important role in protection and osmoregulation, and for supporting the maintenance of cellular structure [13]. In addition, salinity controls the osmotic potential of the suspension therefore has a strong influence on the water relations of the microalgal cells. There was a slight increase in salinity in pond 1 from the initial 1.34 ppt

to 1.66 ppt on day 1 of incubation and this is possibly due salt residues on the seed culture (Fig 3a). For small scale laboratory shake flask experiments, it is recommended to wash the cells with ammonium formate and deionised water to remove the salt residues [2]. In both pond 2 and 3, there was a gradual increase in salinity up to 2.89 and 2.23 ppt respectively on day 22 and this is mainly attributed to slightly higher evaporation rates in the ponds (Fig 3a). On this day, additional water was added to the pond with a corresponding decline in salinity levels. On the final day of incubation i.e. day 30, the salinity levels were 0.68 ppt, 1.23 ppt and 1.24 ppt in pond 1, 2 and 3 respectively. The salinity levels recorded for the 3 points are ideal for *Chlorella* growth. High salinity is reported to increase lipid production by microalgae but however, too high salinity levels above the threshold are detrimental to *Chlorella* and can lead to microalgal inhibition [14].

Environmental conditions such as temperature, salinity and atmospheric pressure greatly affect oxygen solubility in water. The dissolved oxygen is an important parameter for microalgal respiration and therefore energy production. The subsequent biomass and lipid yield is affected by the dissolved oxygen in the medium. Data generated in our experiments show intermittent fluctuations in the concentration of dissolved oxygen with time in the three ponds. Initial DO_2 concentrations were 8.05 mg/L, 19.1 mg/L and 13.45 mg/L for pond 1, 2 and 3 respectively (Fig 3b). The final DO_2 concentrations on day 30 were 17.42 mg/L, 15.78 mg/L and 17.13 mg/L for pond 1, 2 and 3 respectively (Fig 3b). The dissolved O_2 saturation in freshwater under atmospheric pressure at 20°C is 9.1 mg/L. The increase in dissolved oxygen in the three ponds is attributed to high photosynthetic rates in the ponds where surplus oxygen was liberated. The fluctuation of dissolved oxygen is mainly a result of changes in temperature which affects O_2 solubility.

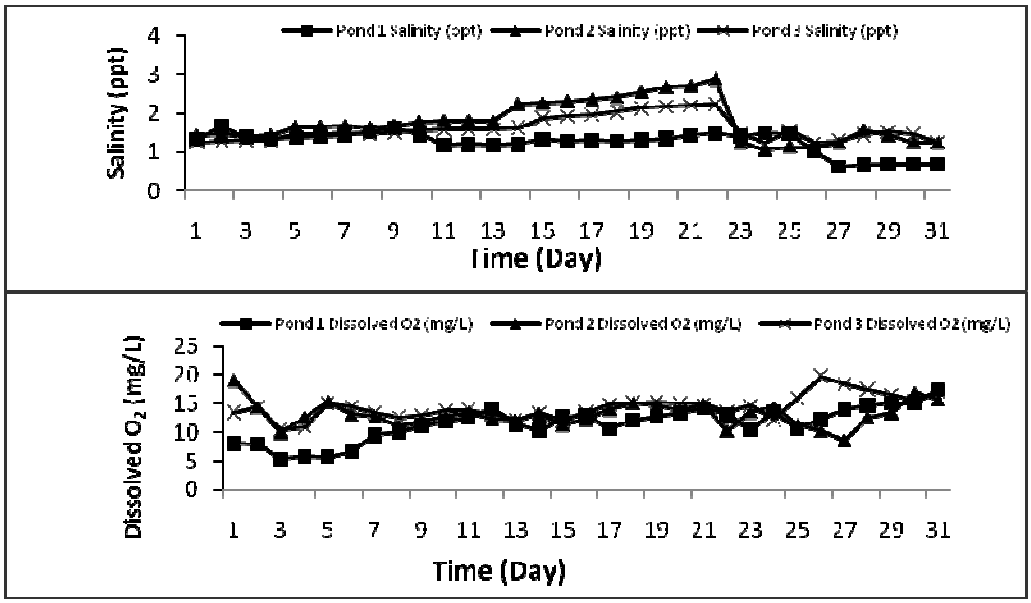


Fig 3 Graphs showing salinity (a) and dissolved oxygen (b) in the 3 ponds.

Effect of total dissolved solids and conductivity on *Chlorella* growth

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in the aqueous suspension in molecular, ionized or micro-granular suspended form. Salinity also comprises some of the ions that constitute TDS. The most common chemical constituents of TDS are calcium, phosphates, nitrates, sodium, potassium and chloride ions. These ions are readily found in BG-11 medium used in this

investigation. There was a steady increase in TDS with time in the 3 ponds and a dramatic decrease in TDS (0.815 g/L) was observed in pond 2 on day 17 (Fig 4a). The sharp decrease in TDS on day 17 in pond 2 is explained by the addition of water into the pond to supplement evaporated water. In pond one, TDS decreased from the initial 1.394 g/L to 0.889 after 30 days of incubation. In pond 3 there was a steady increase in TDS from 1.592 g/L to 3.116 g/L after 28 days of incubation and thereafter the TDS concentration dropped to 2.184 after 30 days of incubation (Fig 4a). These findings demonstrate that TDS is a function of both salinity and evaporation rates. It is reported that microalgae cultivated in raceway ponds remove TDS as they use the organic and inorganic ions for their primary production [15, 16].

Conductivity is a measure of a material's ability to conduct an electrical current and due to the presence of electrolytes in BG-11 medium, conductivity is an important parameter to measure so as to establish general utilisation of the inorganic materials in the medium by the microalgal cells. Conductivity is closely associated with the TDS. This is manifested by the findings obtained in this investigation whereby there was a dramatic decrease in conductivity (1.214 ms/cm) in pond 2 on day 17 in response to a decrease in TDS (Fig 4a and b). There was a steady decline in conductivity in pond 1 from the initial 2.774 ms/cm to 1.374 ms/cm after 30 days of incubation (Fig 4b). There was a slight increase in conductivity in pond 2 from the initial 3 ms/cm to 3.125 ms/cm after 30 days of incubation. There was a steady increase in conductivity in pond 3 from the initial 2.615 ms/cm to 3.415 ms/cm after 30 days of incubation. This observed phenomenon is explained by the bioavailability of chemical species in the BG-11 medium whose uptake by the microalgal cells lead to a decrease in conductivity in the aqueous suspension. The varying microalgal cell densities in the 3 ponds also contribute to differences in conductivity observed. The gradual increase in TDS in the 3 ponds is explained by the high evaporation rates due to high temperatures observed.

(a)

(b)

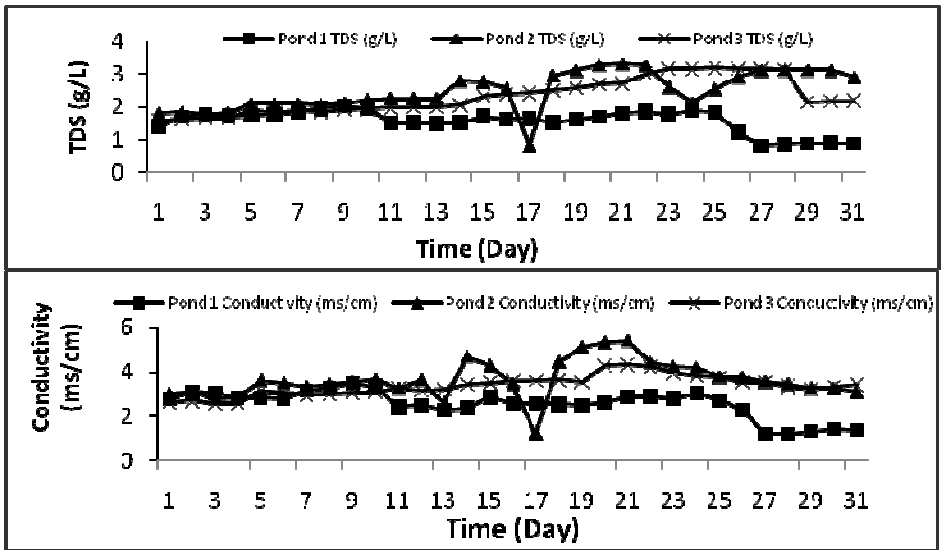
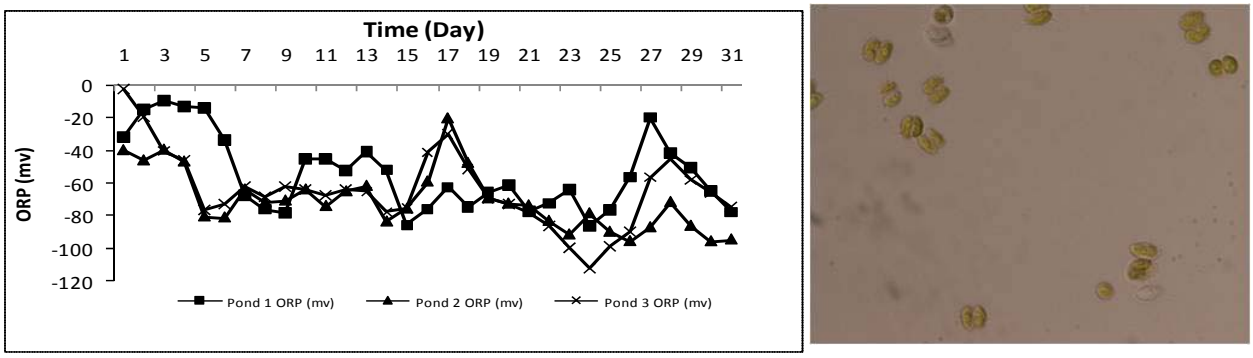


Fig 4 Graphs showing total dissolved solids (TDS) (a) and conductivity (b) in the 3 ponds

Effect of oxidation reduction potential (ORP) on *Chlorella* growth

ORP is a tendency of a chemical species to acquire electrons and thereby become reduced. The more positive the potential, the greater the species' affinity for electrons and tendency to be reduced. The results obtained in the three ponds indicate a fluctuation in the ORP with time (Fig 5a). In pond 1, the initial and final ORP was -32 mv and -77.6 respectively. The same trend was observed in pond 2 where the initial and final ORP was -39.7 and -94.5

respectively. The initial and final ORP in pond 3 was -2.6 and -74.6 respectively. The more negative values for the ORP are explained by the evolution of O_2 due to respiration of the *Chlorella* cells and this indicate the vigour and robustness of the *Chlorella* strain used with incubation time.



(a) **(b)**

Fig 5 Oxidation reduction potential in the 3 ponds (a) and a microscope slide of a wet mount of the culture from pond 1 showing the presence of *Senedesmus* sp (b).

Effect of biotic factors on *Chlorella* growth

It has been reported that biotic factors that may impact negatively on algal growth include pathogenic bacteria and predatory zooplankton and also that the other microorganisms may outcompete the target microalgal strain for essential nutrients [1]. Microscopic analysis of the cells was routinely done to check for contamination in the ponds. Microscopic analysis towards the end of the investigation revealed the presence of *Scenedesmus* sp. in all the 3 ponds under investigation indicating a population shift (Fig 5b). In any microalgal seed preparation, it is desirable to closely monitor population dynamics in the ponds to avert collapse of the system due to contamination by the undesirable microalgal strains. It is documented that under open cultivation system, *Chlorella* and *Scenedesmus* usually coexist and are the predominant strains of the phytoplanktonic communities [1]. PAM fluorometric analysis was routinely used to assess the physiological conditions of the microalgal cells in the 3 ponds (unpublished data).

Conclusion

From the above, it is clear that for successful seed culture preparation, there is need to closely monitor physico-chemical and biotic factors in the cultivation ponds. Under optimal conditions, these factors can lead to high growth rates of the target microalgal strains. However under the open system, it is very difficult to control the environmental factors and as a rule of thumb, population dynamics of the microalgae and any contaminants must be routinely monitored microscopically. A competitive advantage can be provided to the culture of choice in the seed inoculum by selectively controlling the physico-chemical parameters to support the growth of the target organism.

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Agri-Waste to Charcoal: Application of an Appropriate Technology for Ghana

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Keywords: Charcoal, Agricultural Wastes, Crop Residues, Appropriate Technology, Pyrolysis, Biomass, Ghana, Bioenergy, Agri-charcoal

Abstract
According to some estimates, over seventy percent of Ghana's energy demand is met by wood or wood-produced charcoal. Over the long term this supply is not sustainable as the country has already lost 85% of its forest acreage over the past century with annual deforestation rates currently at 2%, most of which is burned as fuel. The typical issues of large scale enterprise arise in the charcoal industry from wood harvest, production, transportation, distribution and utilization and this offers an opportunity for a synergistic- distributed- local- alternative. The D-Lab at MIT has developed just such an alternative in its small scale technology to turn agricultural waste to charcoal. Beginning with early plans in 2009 and culminating in a June 2010 project implementation, the authors, serving as a project team, undertook analyses of the potential for small scale local agri-waste to charcoal enterprises in Ghana and kicked off a demonstration project in Koforidua, in the Eastern Region of the country. This paper documents the results of the analysis including the potential for Ghana. Presented are the results to date of the prototype project in Koforidua including the tools involved in drying, carbonizing, binding, pressing and post-production handling of the product. A local investment analysis, including initial capital costs for equipment, labor and benefits in cost avoidance for product usage or in charcoal sales, is outlined for small scale deployment of the technology. Finally, suggested studies for optimizing the elements of this application are suggested.

Introduction

The word, 'Waste' in the title of this paper, though quite commonly thought of as the unusable part of agricultural production, is the very antithesis of this work as the by-products of crop production are indeed not waste at all but a resource arguably nearly as useful as the crop itself. This paper examines the value of crop by-products, which we nevertheless continue to refer to as 'agri-wastes' or 'agricultural wastes' in this paper per the common practice in the literature. The work described herein is founded in the technology developed in the D-Lab at MIT [13] in which a common 50 gallon drum is used to carbonize agri-waste, which is then crushed, mixed with an appropriate binding agent, pressed into briquettes and dried. The resulting product is relatively clean burning and otherwise similar in functionality to traditionally produced charcoal that is used in virtually all households especially in rural areas of Ghana.

Our work presents the context of traditional charcoal production and the transfer of agri-charcoal production to a small scale coop of farmers and vendors in a community in Koforidua in the Eastern Region of Ghana and documents what was learned from the experience. Finally, the potential for this technology to meet some of Ghana's charcoal demand is analyzed and recommendations for government and universities are offered.

Context

Energy

Woodburning has been common in human activity since the earliest days of human history and even today wood and wood-based charcoal dominate the energy inventory for billions of the world's inhabitants. Indeed wood and charcoal consumption uses 22 million m^3 of wood per year and accounts for 71% of Ghana's energy demand, with some 90% of the country's households using wood or charcoal for cooking according to the NCRC[9, 10, 11].

Traditional Production Method

The production of charcoal in Ghana traditionally takes two forms. The earth mound and the dug pit, also known as the earth pit [12] form of production; both are similar save for a few minor variations. Air dried wood is arranged to allow enough oxygen for the burning process, 20 cm layers of grass and then soil cover the wood. The grass prevents the soil earth from getting to the wood and the grass and the soil help insulate the pit from heat loss and control of air infiltration during pyrolysis. The pit is ignited, left to burn (for days to months depending on its size) and cool. The efficiency of the traditional method is about 10-20% by weight or 20-40% by energy.

Economics

Pricing of charcoal in Ghana varies by region, season (dry versus rainy), price of oil and, of course, by the transaction placement in the production to consumer chain. Some of this variation is found in the studies of NCRC [11]; our study included local interviews in markets in Madina near Accra. We found that charcoal producers in Ghana generally sell their carbonized product to roadside sellers for three to five GHC per bag. These roadside sellers then sell bags in large volume for six to eight GHC apiece to individuals or organizations that ship the bags to Ghana's markets by truck. These transporters in turn sell to middle traders and occasionally directly to vendors for eight to ten GHC. Middle traders in the markets generally sell bags to vendors for around ten GHC each. Consumers usually purchase from the vendors at a price of around fourteen GHC per bag, or a proportional price for a smaller amount of charcoal. On the whole, the charcoal market in Ghana typically generates on the order of 100 million GHC annually. Vendors are seeing the largest profits and the producers likely realize the least return in the charcoal economy. Yet, externalities exist and the charcoal market incurs the benefits that come from harvesting wood and the associated resource use but does not incur all of the associated penalties associated with the negative impacts of pollution and deforestation.

Environment

It is estimated that some 3 billion people on the planet use fuelwood as their primary source of energy creating pressure on forests throughout the world [14]. Ghana has lost 85% of its forests in the last 100 years and has a deforestation rate of 2% per annum, one of the highest in the world, and 60% of this is used to meet fuelwood demands [9]. Deforestation causes soil erosion, hydrologic changes and may lead to desertification that is costly to the environment and difficult to reverse. The charcoal production process results in emissions such as polycyclic aromatic hydrocarbons (PAHs) as well as greenhouse gases. Fuelwood and charcoal utilization will release 7 billion tons of carbon in the form of greenhouse gases to the environment by 2050, about six percent of the total expected greenhouse gases from the continent [15]. Inasmuch as charcoal is demand is spatially separated from supply, environmental impacts from transportation must also be considered including the effects of carbon monoxide as well as greenhouse gas emissions.

Health

In 2000, nearly 470 million tons of wood were consumed in homes in sub-Saharan Africa in the form of firewood and charcoal, more wood per capita than any other region in the world. More than 1.6 million people, primarily women and children, die prematurely each year worldwide (400,000 in sub-Saharan Africa) from respiratory diseases caused by the pollutants from wood and charcoal fires. Fumes from wood-charcoal cooking will cause an estimated 10 million premature deaths among women and children by 2030 in Africa. Indeed, indoor air pollution is the 8th most

important risk factor and is responsible for 2.7% of the global burden of disease [15]. Cooking using charcoal releases smoke that can contain hundreds of chemical components which include particulates, PAHs, carbon monoxide, nitrogen oxide and sulphur oxides. Indoor inhalation of PAH from cooking appears to pose a substantial health hazard. Some types of PAH's include naphthalene, fluorene, phenanthrene and acenaphthene. BaP (benzo(a)pyrene) exposure among urban poor exposed to cooking wood smoke has been estimated to compare with an exposure of more than two packs of cigarettes per day [14]. Inhalation of the fumes from charcoal causes carbon monoxide poisoning, chronic obstructive pulmonary disease, cancers, cataracts, asthma, otitis media and tuberculosis. 51% of all incidences of tuberculosis are attributed to the inhalation of fumes from fuelwood. Acute respiratory infections (ARI) are the leading factor disease burden worldwide and account for the deaths of 4-5 million children under five years of age in developing countries each year.

Agri-charcoal Technology

While the aforementioned MIT/D-Lab agri-charcoal technology also involves emissions, many of these take place at the source of production and less is expected in the kitchen. The basic tools and technique are rather simple and easy to transfer to farmers and workers.

Basic Tools

Figure 1. Crusher for the Koforidua Coop

While the specific tools depend somewhat on the scale of the operation, as spelled out in the MIT D-Lab's approach, these generally consist of a barrel, with 4-5 perimeter holes for air intake, kindling and ignition cut in the bottom and a large square or circular hole cut from the top cover to allow for escaping gases and a top plate for cutting off the air supply when the contents reach a sufficiently high temperature. A simple make-shift (e.g. bag in bag) crusher can be used for small operations though a hand-operated rotary bin crusher is best especially for crushing larger amounts of carbonized material and avoiding the dust that comes from this mechanical process [1]. The crusher given to the Koforidua Coop was made from a recycled wooden box and cylindrical concrete casting (fabricated form used tomato cans) by our team is shown in the photo in Figure 1. A hammer and simple 3-part press is used for preparing briquettes, which are then allowed to air dry.

Technique

The technique, evident from the description of tools, begins with the carbonization of wastes in the barrel. Dry wastes are arranged around a removable log of roughly 10-15 cm diameter with kindling leaves stuffed in the holes at the bottom of the barrel, which is elevated on 3 stones to allow for air intake to the barrel. The kindling is ignited and allowed to freely burn; one will notice water condensate in the exhaust, which becomes quite dense as the process continues; eventually brownish smoke will be seen in this effluent and finally as this dense smoke clears, the barrel and content will be quite hot, ~400-500^{o}C, the top plate is placed over the top hole and the barrel is lowered from the stones with dirt packed around the edges top and bottom to cut off air supply and the barrel is left to smolder and eventually cool after which the contents from the process can be removed for crushing. The stages of the process are depicted in Figure 2.

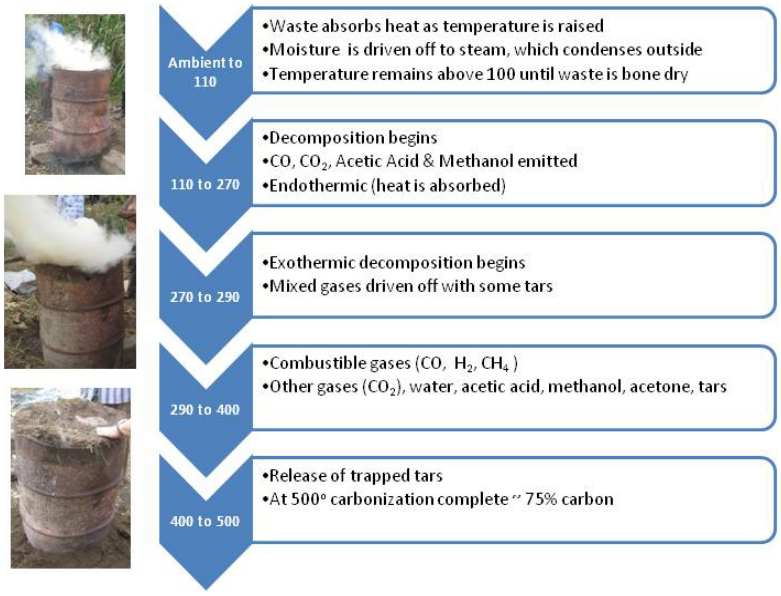

Figure 2. Stages of burning and pyrolysis process.

Binding Agent

In order to fabricate briquettes the crushed material must be mixed with a binding agent and pressed. The binding agent used in the Koforidua project was made by peeling and grating approximately 4 tubers of cassava (about 20 cm x 6 cm each) into a mash, adding ~1.5 liters of water (depending on the starch content of the variety used) and sieving into a pot to obtain a solution of water and starch. The solution is heated while stirring to obtain a gelatinized solution between thick and slightly soupy. This is then mixed thoroughly with ~15 parts of crushed material 2 parts of binding agent and then spooned into a press and compressed by hammering wiith a few swift raps. The briquette is removed from the press and allowed to dry for ~12 days. In the Koforidua project, simply framed sheet plastic was used to accelerate the drying process; while not necessary to the production process, these simple panels can also be used to pre-dry waste and to dry maize or other crops.

Scaling Issues

At the smallest scale, agri-waste charcoal can be produced by a single family on a small farm. At a large scale, it can be produced in a large production enterprise where there would be considerable raw material- and final product- transportation. It is tempting for entrepreneurs to think on this large scale but the aforementioned transportation issues suggest that the technology is best for many small cats versus one big lion. At a small scale (see Firgre 3), consider the economics of the small family farm and the small multi-farm coop , where a set of tools is loaned to participating members. The small family farm might have the capacity to produce 3 to 4 bags of agri-charcoal per year worth some 50 GHC with a barrel, hammer and press and a makeshift crusher with a total investment of about 24 GHC for a 1st year net of 26 GHC. In general, one can model the small scale operation with a generalized coop consisting of N farms of average size, S, requiring X barrels, Y presses and hammers and Z crushers, where the X, Y and Z are made consistent with N, S and a working coop operating schedule. An 18-farm coop, operating under a schedule shown in Figure 3d using 6 barrels, 4 presses, 2 hammers and 1 rotary crusher, would generate 56-72 bags of agri-charcoal per year with proceeds of some 896 GHC for a 1st year return to investment ratio of 6.4 compared to the single farm ratio of 2, a clear advantage for the coop. The operation works best if farmers

set up a burn, which takes ~30 minutes and go about their chores while the barrel is cooling and repeating this 5 or 6 times during the day. At the end of the period, a few hands can take care of the binding and pressing operation for the accumulated carbonized waste. Moving to a larger scale, one must consider where the moving of equipment to the waste crosses to favor moving wastes to larger scale equipment.

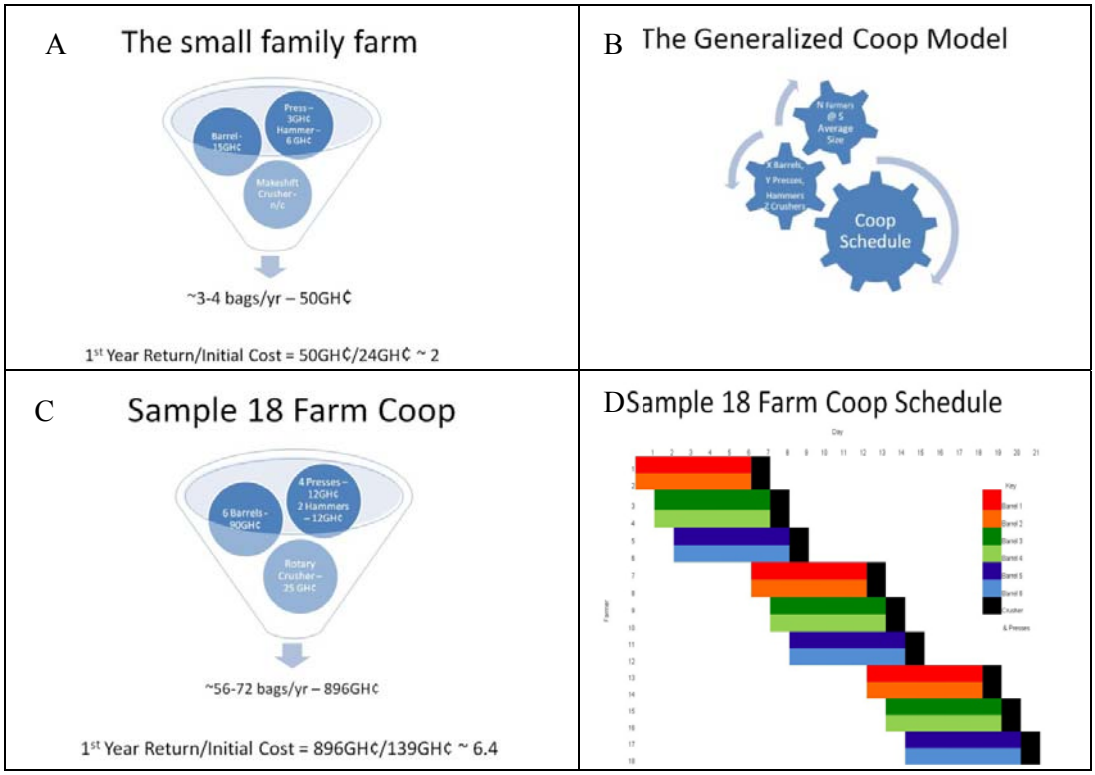

Figure 3. Scaling factors. A. Small family farm, B. Generalized Coop Model, C. Sample 18 Farm Coop, D. Sample Schedule for the 18-Farm Coop.

Potential

The energy potential in kJ of agricultural waste from a crop, C, can be approximated by

$$ER_C = M_C \times fR_C \times (1 - fW_C) fE_C \quad (1)$$

where

M_C = Mass of crop C that is harvested in kg
fR_C = fraction of agri-waste in crop C
fW_C = fraction of water in crop C
fE_C = average energy per unit mass of the crop waste in kJ/kg

fR_C can be approximated from HI, the harvest index for a crop, defined as the ratio of grain mass to grain plus waste (residue) mass. Unfortunately, harvest indices are dependent on a number of factors including soil health, planning densities, irrigation and rainfall among other things. Nevertheless, in order to make a first cut estimate of energy potential, published ranges of harvest indices were used along with average values for the other factors [5, 6, 7] and 2007 data obtained from Ministry of Food & Agriculture reports for 11 of Ghana's major food crops. Factors can vary widely from crop to crop. For example, moisture content (wet basis) of agricultural waste can be as high as 65% and 43% for yam peels and corn cob

respectively and as low as 7.5% and 8.8% for palm oil mill effluent and groundnut shell respectively [5]. Applying these data to equation 1 for each crop and summing the results gives an estimate of the total energy available from the wastes of these crops of 8.84 x 10^{13} kJ. If 10% of this energy was converted to agri-charcoal at an efficiency ~ 30%, some 2.7 x 10^{12} kJ or 7.5 x 10^{8} KWH could be realized. The potential is staggering and it offers the opportunity to alleviate the stress on Ghana's forests as well as many of the negative effects associated with traditionally produced charcoal yet leaving ample agri-wastes to maintain soil health. The 11 crops are harvested at various times and regions of Ghana as shown in Figures 4 and 5.

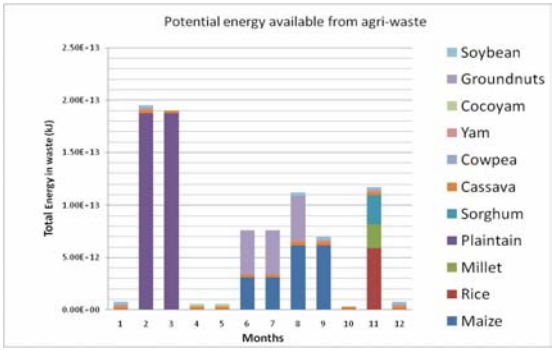

Figure 4. Potential agri-energy available from 11 leading crops in Ghana by time of year.

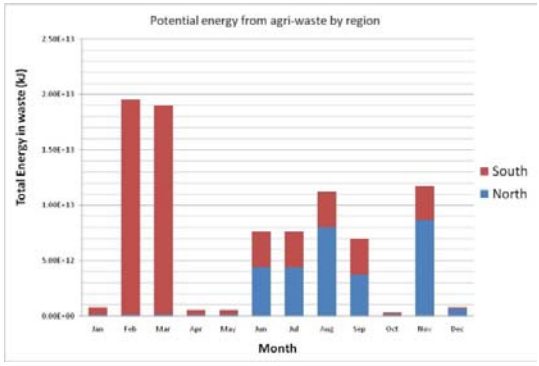

Figure 5. Potential agri-energy for 11 leading crops by region (North-South) in Ghana.

Concluding remarks

This study has demonstrated the potential for charcoal production from agri-wastes in Ghana, where forests are being lost as a result of significant harvesting to meet the demand for fuelwood, which dominates the country's energy mix. In addition, this work has pointed up the value and suitability for realizing the potential for agri-charcoal by the creation of a small coop in Koforidua, where in June 2010 at Matthew 25 House, three farmers and as many charcoal street vendors learned the process and functioned together to produce their first batch of briquettes from corn cobs and standing stalks from the harvest just finished. In addition, several representatives from regional ministries and organizations and even authorities from the prison system attended the demonstrations our team conducted in the field. The latter individuals expressed interest in the potential for training inmates on the technique to give them the possibility of a useful skill when they finish their term and return to society.

To move forward with an agri-charcoal program, there are roles for the Ministries and for the Universities. In particular, government should: support demonstration co-operatives, promote small scale projects, incorporate agri-charcoal production in its agricultural educational outreach using the classical "extension" model, facilitate the creation of the standard small-scale tools, perhaps encouraging vendors to create agri-charcoal kits, track production of agri-charcoal, and support related research. As an example of outreach activities, our team designed a sample poster to be strategically placed in farming communities to attract local interest. A project officer in the Ministry of Food and Agriculture assigned to develop, nurture and build capacity for agri-charcoal coops would be a small but well-placed investment.

Universities can also play a role. There are a number of projects that can have a profound outcome on the efficacy of agri-charcoal production; these include: modeling of the pyrolysis process with a view to controlling losses, improving yield, and designing

alternative kilns; studies to optimize the systemic utilization of biomass crop residues, and research to find: the optimum size for a briquette and for the particle size of the crushed material of which it is made, an optimum material to binding agent ratio, alternative agri-binding agents, the structural- thermodynamic- and effluent- properties of agri-charcoal. Finally, as with all technologies that offer an option to a traditional method, there are challenges going beyond the shear inertia associated with change. Harvests are not continuous; the rainy season follows the harvest of many crops presenting a challenge for air drying. Precise algorithms and recipes for mixtures and binding agents are impossible to write. Lastly, as this paper has emphasized, there is a tendency to "think big". With this technology as with many appropriate technologies, the title and thrust of the British economist E.F. Schumaker's seminal work, "Small is Beautiful", obtains.

Acknowledgments

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Woodfuel Usage: The Challenges For A Sustainable Approach In Ghana

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Key Words: Charcoal, Energy, Firewood, Furnace, Stove, Woodfuel

Abstract

In Developing Countries such as Ghana, the main household energy is woodfuel (firewood and charcoal). There are, however, other extensive uses for woodfuel i.e. Agro-Processing, Food and Beverages, and Some Small Scale Enterprises in the communities). The Paper looks at the sustainability of woodfuel through the use of suitable materials and the technology of building appropriate stoves and furnaces which reduces the consumption of woodfuel but at the same time efficiently utilizing the heat generated in the fire chambers. Efficient heat management implies less trees being felled and growth rate of trees, long enough to replace trees consumed by charcoal and firewood production.

Introduction

Ghana, like most African countries, continues to use woodfuel (Firewood and Charcoal) for their energy requirement in the households and some rural enterprises. The practice has been ongoing although the consequential effects on the ecology of our lands are clear to all. Governments, Development Partners, Non-Governmental Organizations and other Development Agents have tried various strategies to provide solutions to this problem. Alternative energy sources such as Solar, Wind, Nuclear, Bio fuel, Electricity etc have been propagated at certain stages of the country's development with varying degrees of success.

Available information indicate that, in the year 2000, Ghana Energy Consumption, showed that Biomass was the highest; close to 3,000,000 TOE consumed in the households, followed by industry, as shown in figure 1.0

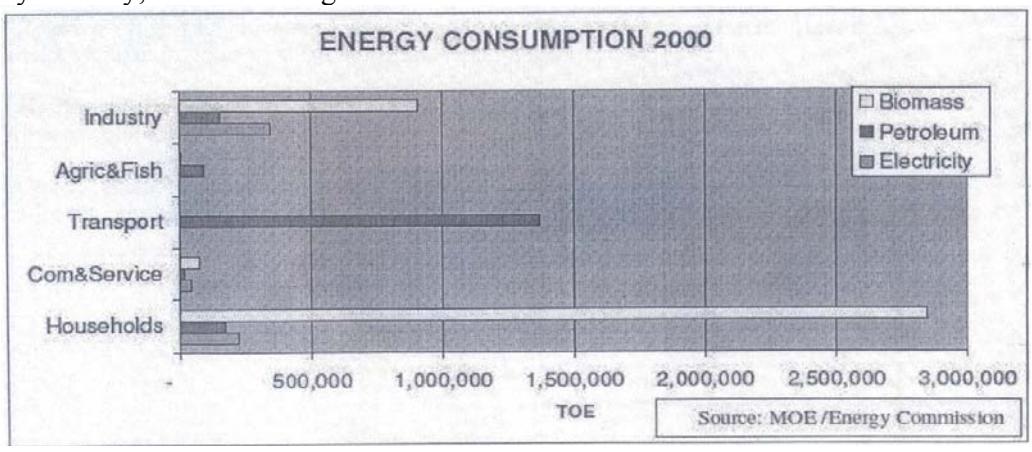


Figure 1.0

In the year 2000, Shares of Fuel in Total Energy Consumption in Ghana show that Woodfuel alone took 63%, Petroleum 30% and Electricity 7%, Figure 1.1. Further explanation revealed that 93% of the woodfuel was used for household energy (cooking and

heating). Firewood took 62.4%, and Charcoal, 30.6%, figure 1.2 (Energy crises in Ghana, 2007).

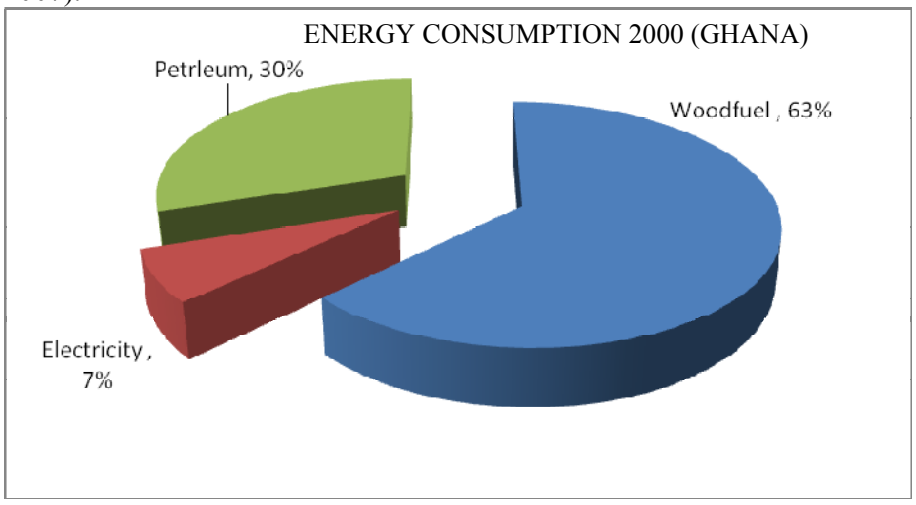


Figure 1.1

Source: Energy Commission – Ghana

These figures therefore paint a picture of how extensive and important woodfuel is in Ghana and other developing countries.

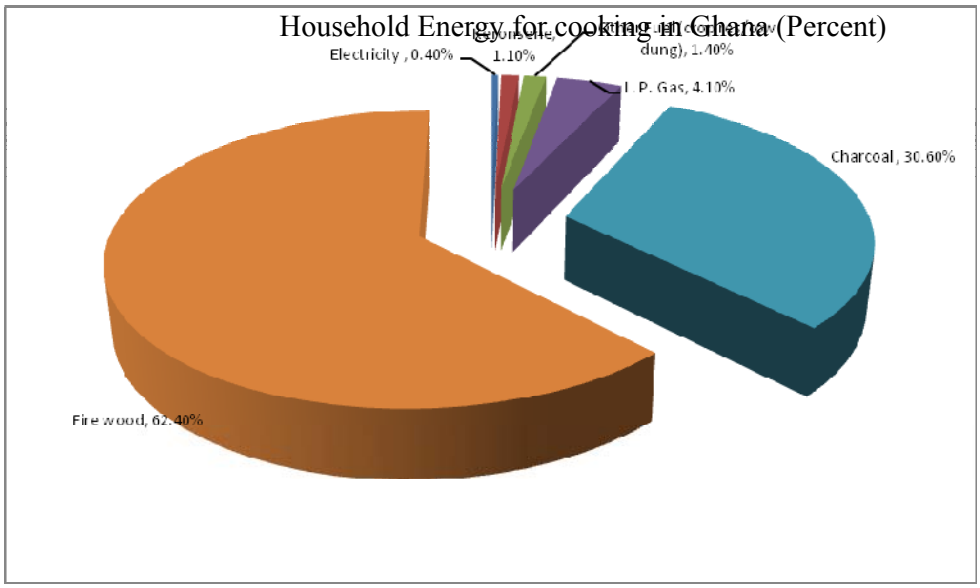


Figure 1.2 Source: Energy commission – Ghana (2000)

World wide, around 2.5 billion people, primarily in the rural regions of Africa, Asia and Latin America still depend on biomass (Firewood, agric-residues and dung) for cooking and heating.

The Strategic National Energy Plan (2005-2020) of the Energy Commission Ghana had taken cognizance of the significance of woodfuel as an energy source and stated that it will be in use for the next 20-30years. The Commission adds that apart from woodfuel there are not many alternatives available. Although it is known that Crude Oil and Natural Gas have been found in large quantities, off the coasts of Ghana, the acceptability of these new energy forms by the rural poor will depend on several factors (financial input, ease of accessibility, culture of cooking etc). It is also a known fact that remote communities in Ghana may be connected or linked to other energy sources such as LPG (Liquefied Petroleum Gas) not earlier than the next 10-20 years. Woodfuel meanwhile will continue to be used.

The Ghanaian situation of re-forestation is on going and spear-headed by the Forestry Research Institute of Ghana. Wood lots have been planted as well as nurseries and seedlings made available to individual farmers, communities, NGO's etc. However the wastage in timber logging, firewood production and inefficient charcoal production techniques are the challenges facing the wood industry. Therefore, the need to economize on its usage.

As mentioned earlier on there are not many energy alternatives especially for rural communities, apart from WOODFUEL. Policies on re-forestation would be rendered ineffective if the end users of Woodfuel continue to employ the same old wasteful energy practices for heating and cooking.

This paper therefore takes a holistic look at Woodfuel as a dependable energy source which has not been appropriately harnessed, thus its full potential as a sustainable energy has also not been realized. Secondly the paper will also like to disabuse the perception that woodfuel is archaic and therefore has no place in 21st Century, by re-packaging it with the required appropriate technology to suit the respective uses, applications and adaptations That

is, efficiently utilizing Woodfuel through the Design, construction and utilization of Stoves and Furnaces.

Some Reasons for using Wood Energy

- Woodfuel is an energy source which is cheap and readily available in most communities. Collection and usage are basic techniques which are known by all users.
- Alternative energies which were introduced were not cheap therefore out of the reach of the end users, in terms of cost and easy availability.
- Socially the cooking and heating patterns were not accepted within the social settings in which they were introduced.
- Wooodfuel industry is big business in the savannah regions and a major source of income for such communities.
- The major consuming markets are in the urban communities. The linkages involve, rural producers, middlemen/entrepreneurs, transporters, sales agents, local consumers and exporters. This is a long chain of activities linking the producers and the final consumers.

Challenges of Woodfuel Usage

- Forest exploitation and depletion of trees: Apart from felling of Trees for firewood and charcoal, other degradation factors and activities include Timber logging, surface mining and Agriculture cultivation.

- Inefficient charcoal production methods and wasteful charcoal and firewood heating systems.

Effect on the health of the users:

- Upper respiration infections due to inhaling of smoke. Irritation of the eyes due to contact with smoke. Unfriendly working environment caused by heat radiation.

A New Approach

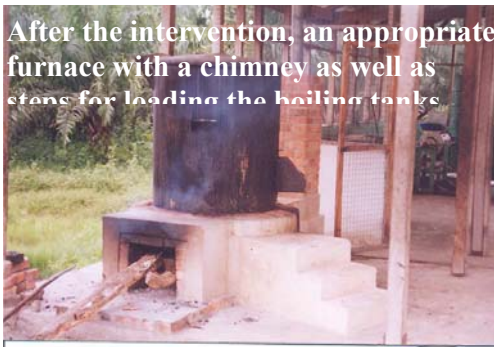
The need, therefore, is to design construct new stoves and furnaces which will address these challenges. This includes, enclosing the heating chamber with appropriate materials, (insulation) provision of chimneys to act as drafts for air and smoke, an ergonomically suitable sitting position for users and the positioning of the boiling utensils correctly to suit the cooking and boiling of specific meals and other products.

Some Interventions

Firewood and Charcoal are used in the household (cooking and heating) and the community for several purposes. The paper looks at these under 3 broad areas.

- **<u>Agro-Processing Industries</u>**: Palm Fruits Boiling. Palm Oil Clarifying, Coconut Oil, Kernel Oil, Gari Roasting, Grain Drying, Boiling of Traditional Medicines, etc.

Before the intervention Palm Oil Fruits were boiled in Barrels in this



After the intervention, an appropriate furnace with a chimney as well as steps for loading the boiling tanks

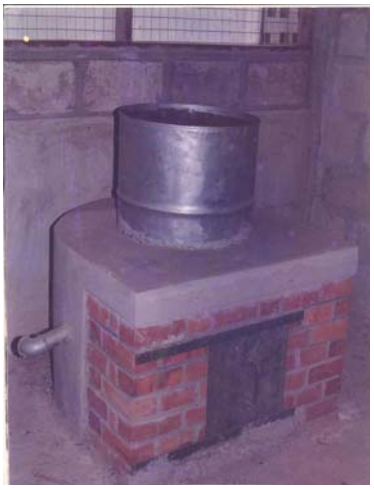
- **Food and Beverage**: Water heating and household cooking, Alcohol Distillation, Pito Brewing (corn and millet beer), Roasting and Frying of Plantain (Brokeman), Yam, Cocoyam, Kelewele etc. Grilling of Fish and Meat (Khebab/Barbecue) Fish Smoking (Chokor Smokers). Bread Baking, Chop Bar Operators (local Restaurants) etc.

Gari (a cassava product) is roasted on open-fires exposing the user to heat and

After the intervention, women and children can comfortably work in a clean environment.

- **Rural Industries**: Bricks and Tiles, Potteries, Batik/tie and dye, Bead Making, Blacksmithing, Foundries etc.

Before the intervention, fabric dying was done in barrels on an open fire.



An appropriate furnace built with Bricks and fitted with out-let drain to die and de-

Conclusion

It is believed that (policy makers, technologist, NGO's, Development Partners etc) have been challenged by the application and use of appropriate technologies in providing efficient wood energy. Vulnerable groups especially women and children should not be left out in addressing not only health concerns but also the use of Woodfuel stoves and furnaces efficiently to save the natural resource (wood). The enclosed chambers saved between 18 and 20 % on woodfuel used.

This paper however, is not to encourage, environmental degradation or the aggravation of climate change but will like to draw the attention of development partners to the fact that the proportion of communities, in the world who continue to use Woodfuel is very high,

hence the need to pay much more attention to suitable and appropriate ways of using this energy in the most sustainable ways.

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Current Trend In Engineering Education Using The Mobile Studio: A Tutorial (Workshop)

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Key words---- tutorial, circuits, digital, electronics, examples, mobile studio, tablet PC, I/O boards

Abstract
The Department of Electrical and Computer Engineering in several universities traditionally offer courses in several areas by separating courses and labs. This approach always presents difficulties to the average student bridging the gap between the course and the related lab even though the course objectives are met. The lab equipment is bulky and expensive. Recently, we have introduced the mobile studio approach that requires hands on and lectures simultaneously. The mobile studio is a lab on "wheels". Each student has his/her own work station that consists of: (a) a Tablet-PC (lap top) with special software that provides instrumentation and other features (such as analog and or digital circuits). (b) input/output I/O board that consists of dc power supplies, function generator and it can be used for analog or digital experiments. (c) A bread board that contains the hardware set up for the hands on approach. It is connected to the I/O board that is connected to the Tablet PC via a USB cable. The mobile studio is a lab together with instrumentation that can be carried anywhere. It occupies a rather small, space much less than 0.25 cubic foot. In this tutorial/workshop, participants will be introduced to the mobile studio. We will show how it works and the participants will be instructed on how to use it. Examples starting with simple circuits will be provided. It will also help participants to consider adopting the mobile studio concept in their respective programs. The mobile studio cost as little as $,1000 per station and prices keep going down. Use of the mobile studio has increased students participation including question and answer time combined with hands on verification of what has been learnt at the same time. The portable nature of this setup means that there is far greater student interaction with the equipment. Combining lectures and labs has greatly improved the attention of our students through hands on approach. Learning by doing makes it possible for the students' experiential learning process that reflects the students' capabilities in retention of knowledge.

INTRODUCTION

Generally, medium of instruction of courses with accompanied labs are offered separately. This approach creates problems for the students as well as the instructors. Lectures and labs are taught at different times, on different days and even sometimes both are taken in different semesters, and also sometimes by different instructors. Thus, students find it difficult to understand theory as well as the lab hands on. In order for students to fully understand the lectures and labs as proof of theories there is a great need to offer 'hybrid 'courses that consist of lectures and labs at the same time.

Additionally, traditional labs are equipped with bulky work benches and large expensive instruments and other equipment (such as large function generators, oscilloscopes and power supplies) sources that consume more electric energy than the mobile studio to operate. Due to limitation of space and bulky equipment students work areas are constrained and thus they

forced to work in overcrowded groups. It contributes to a few numbers of students in a group that can actually participate in performing hands on the tasks required for the lab under investigation.

Due to recent advances in technology (such material science nanotech) and miniaturization, large size instrumentations have been reduced to palm size computer notebooks. The miniature instrument (Tablet PC) is interfaced with input out I/O board that serves as source of power supply and function generators for analog and digital labs. The circuit under test is on a bread board is connected to I/O board. This unit (tablet PC, I/O board, bread board system) is known as the mobile studio. It occupies rather a small portable space (much less than a cubic foot). The cost is rather low, less than $1000 per station. There is available mobile studio for each student in a course as well as one for the instructors. The mobile studio provides the functionality of a regular lab in a portable package. The instructor, as well as students, work together to provide lecture and hands on at the same time. Data collection at the PC is a easy. The PC acts as instrumentation (ammeter, voltmeter, oscilloscope with two-channels) as well as the control panel.

The mobile studio-based classes have been used in courses in the department for over four years now. Initially, the department started with a few stations on experimental basis with networks (circuits) courses. It is used at several levels in the department as well as in our 'Smart Lighting' Institute high school students participating in the departments' summer outreach engineering programs. It is anticipated that through this workshop, the low cost mobile studio technology will be adopted by other nations in their educational programs since the mobile studio is inexpensive and uses small space. The mobile studio has been used extensively in electrical, computer and mechanical engineering as well as in physics courses.

THE MOBILE STUDIO CONCEPT

The mobile studio teaching concept that is a normal practice of other departments (such as architecture, arts) has been adopted by engineering departments due to its compact size and cost. It consists of Tablet-PC that acts as instrumentation and input/output I/O board that serves as computer interface via USB cable. Thus, the usual old fashioned laboratory setup that (see fig. 1a and b, old versus new studio)

Fig. 1 a.. Compact Mobile studio lab b. Old Fashion Traditional Lab Concept-Bulky Equipment

includes separate oscilloscope, multi-meter, power supply, function generator and others (digital equipment) has been replaced with the 'portable' mobile studio setup that consists of a breadboard, Tablet PC (personal computer) and a Rensselaer I/O Board that is a small hardware platform. The entire setup occupies much less space than a notebook. The package (shown in fig 1a, 2) allows individual participation since it occupies a small space and it is

less expensive compared with bulky lab expensive lab equipment. It also consumes much less electric energy compared with the traditional lab equipment.

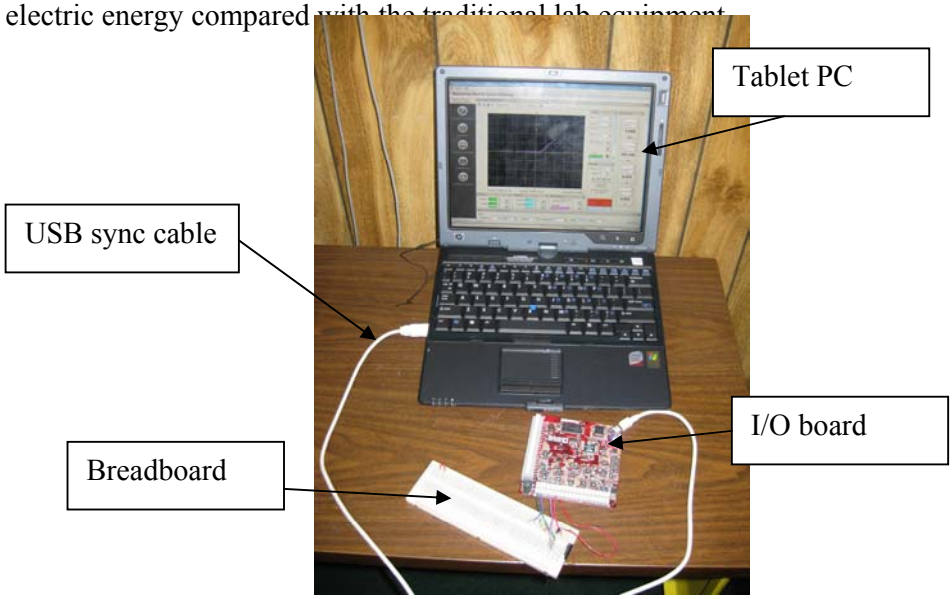


Fig 2: MOBILE STUDIO STATION

Fig. 3 below shows the I/O board instrumentation panel displayed on the tablet PC screen. The I/O board emulates a function generator, oscilloscope, voltmeter, Spectrum analyzer, ±4.5V DC power supply and is capable of digital operations.

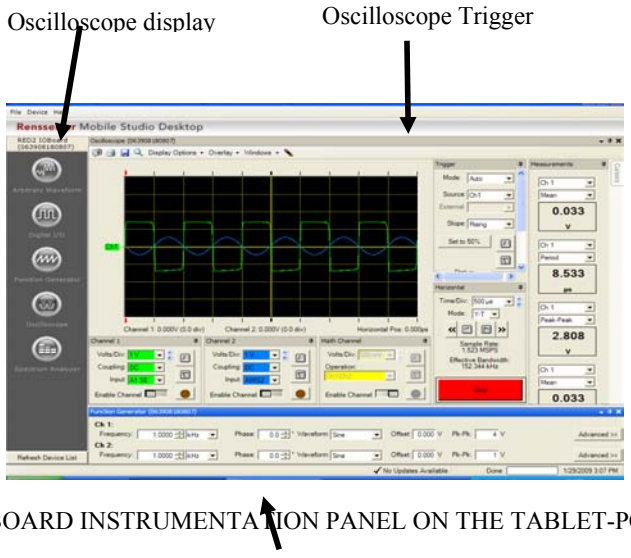


Fig 3: THE I/O BOARD INSTRUMENTATION PANEL ON THE TABLET-PC

The portable nature of the mobile studio setup means that there is far greater student interaction with the equipment since there is a workstation for each student. The instructor, and the teaching graduate assistants also have a similar set up. The students encouraged to individually explore the characteristics of the demonstrated circuit under several conditions.

MOBILE STUDIO-BASED COURSES

The mobile studio concept [1, 2] has been in use for several years by universities such as Howard University, in Washington, DC and Rensselaer Polytechnic Institute (RPI) in Troy, New York. The concept offers the flexibility of combining lecture, labs and demos by the professor at

the same time. This approach helps the student improved learning by lecture and doing at the same time. It is being used in several courses including circuits, electronics and digital systems. It is easy to use at all levels in engineering education including high school students. Students can save data gathering time using the mobile studio. They can obtain plots instantly (instead of traditional write down data, and plot graphs on paper by hand or other means later. The studio occupies a rather small space less than a notebook unlike bulky traditional bulky lab equipment that includes instruments, oscilloscope, power supplies and function generators.

In this tutorial/workshop, participants will be introduced to the studio and perform simple hands on techniques for possible adoption in their individual institutions.

EXPERIENCE WITH THE MOBILE STUDIO

Unlike separate classes and labs, combining both lectures with labs has greatly improved the attention of our students through hands on approach. The students are able to discuss results with other students instantaneously. They correct each other. The student works on an assignment with the mobile studio, and shows serious concentration and overall great enthusiasm.

The students obtain experience in experimentation; measurements also obtain direct plots instead of using paper and pencil for plot later when the experiment is completed. Instant plots allow for instant correction just in case of a wrong data set. The mobile studio enhances the individual's understanding of the subject both theory and practice (through experimentation). Pictures (Fig. 4a, b) below tell success stories of the mobile studio.

Fig. 4a. High School Summer Smart Lighting Outreach Program b. Undergraduate seniors presentations

WORKSHOP (TUTORIALS): SAMPLE OF MOBILE STUDIO APPLICATIONS

The workshop will cover introduction, hands on approach from simple circuits (such as resistive dc/ac circuits, simple passive filters (frequency response), nonlinear circuits (diodes) amplifiers, and digital circuits [3-7]. They will learn terminals of the I/O board; tablet-pc introduces instrumentation and control (voltmeter, ammeter, and oscilloscope) measurements and plotting (transfer characteristics).

Workshop Outline

a. Introduction to the mobile studio concept
b. USB cable connections
c. Functions of the tablet-pc, control icons, instruments, measurements, plotting

d. I/O board functions for analog or digital circuits, power supplies, function generators, terminals
e. Breadboard connections
f. Demonstrations
g. Drill exercises
h. Simple resistive circuits, voltage/current measurements
i. Digital gates logics circuits
j. Simple analog filters (low pass, high pass) frequency response, transfer characteristics, semi-log plotting
k. Nonlinear circuits (diodes) i-v characteristics
l. Amplifiers (BJTs, MOSFETs)
m. Chips (op-amps, timers, counters)
n. Other-questions/answers

Sample Mobile Studio hands on Exercises

1. Resistive circuit

This hands on introduce use of the voltmeter and ammeter, dc power supply, terminals of I/O board

Connect 2 resistors R1, R2 on a bread board. Supply 3 volts to the circuit. Measure current taken and the voltage across each resistor. Record data and proof voltage divider rule

2. Low Pass/High Pass (R-C) Filter

This exercise introduces use of the I/O board function generator, tablet pc oscilloscope and plotter

Connect on a bread board R and C as a low pass (or high) pass

Obtain the frequency response, and plot gain versus frequency, find the 3-3b frequency and compare with theoretical value (fo = 1/(2JIRC)

3. Diode Characteristics

The simple diode shown (Fig. 4) (a) Use dc supply to obtain the I-V characteristics of the diode are shown in the figure below. (b) Demonstrate its rectification characteristics. Plot V supply, Vout at 100 Hz, 1 Khz. Use 1-KΩ resistor.

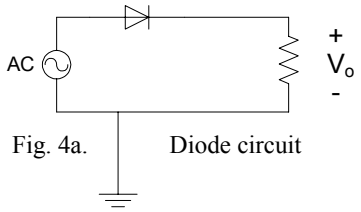
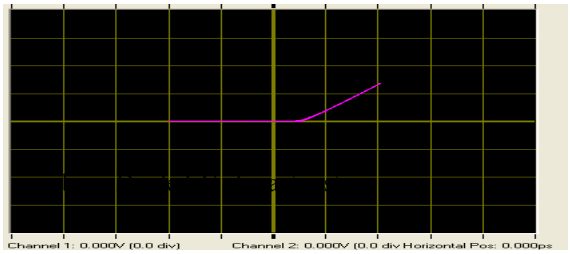


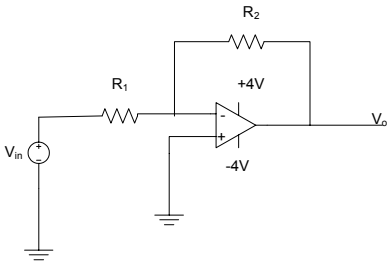
Fig. 4a. Diode circuit



4. The operational amplifier (inverting mode)

The exercises introduce chip connections, gain.

Connect circuit in inverting mode shown (Fig. 5) with two resistors Ri, Rf (feedback resistor). Gain A = -Rf/Ri. Use voltage supplies of (+4 volts, and -4 volts). Change the gain (adjust Rf) for no distortion, and distortion. Plot waveforms of input and output for both cases. Use sine wave at 1Khz, input 2 volts p-p. Observe the waveforms as shown below.



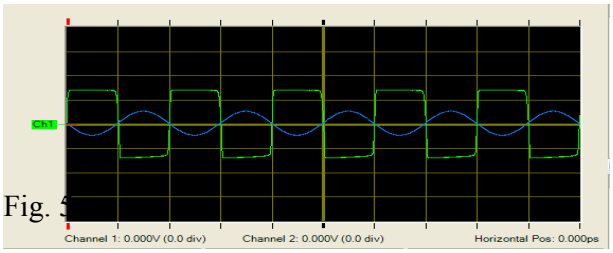
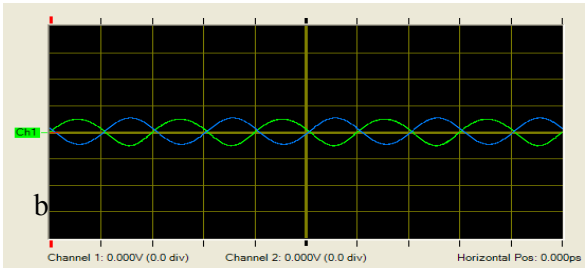


Fig. 5



b

5. Common source (C-S) NMOS amplifier

Connect the NMOS C_S amplifier shown. Obtain the midband gain, lower and upper 3-db frequencies. See fig. 6 below.

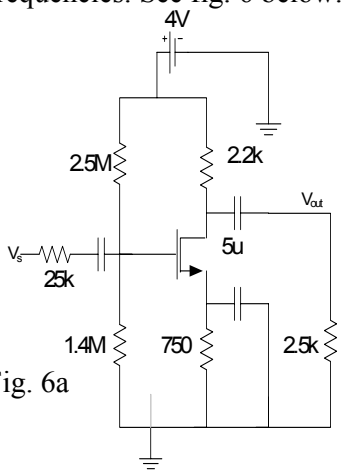
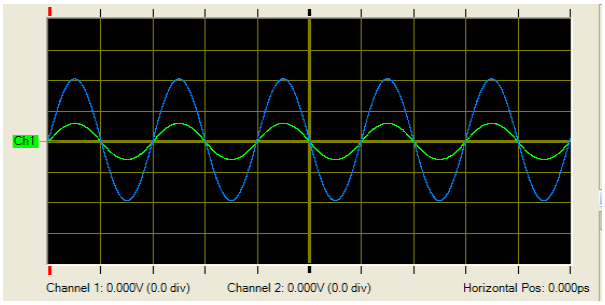


Fig. 6a



b.

Project

Time permitting, construct your own circuit and test it using the mobile studio.

CONCLUSION

The department has successfully implemented the mobile studio approach (while satisfying ABET requirements) in teaching several courses together (such as electronics, networks circuits) by combining lectures laboratory hands on by combining lecture, labs, recitation and homework projects. The new approach has improved students' understanding of the material and perform assigned tasks well. After completing this workshop/tutorial., we hope the participants will introduce the concept in their course instructions on their campuses. Further assistance can be obtained from the presenters. See our e-mails at the top of the paper. It is time to phase out bulky lab equipment and instrumentation and use the mobile studio.

ACKNOWLEDGEMENT

Thanks to the high school students participants, and to the students and faculty who have contributed to the continuous improvement of the studio based courses.

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Mobile Telephone accessible patient health records in Africa

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Key Words: Mobile Telephone, Electronic Health Records, Personal Health Records, Microsoft HealthVault, chronic disease

Abstract

Mobile telephone proliferation in developing countries has created an opportunity to leverage mobile telephone services with emerging Electronic Health Record (EHR) and Personal Health Record (PHR) capabilities exemplified by Microsoft HealthVault, Google Health, Dossia and others. We explore options for implementing a means where developing country patients utilize PHR capabilities in conjunction with existing mobile telephone services to increase health information flow. This increased information flow is an important component to improving health outcomes - especially in connection with persons who are living with chronic diseases. There is a misconception chronic disease burden in under developed countries is minimal in comparison to infectious disease burden. However, chronic disease mortality in undeveloped countries is within 10% of the infectious disease mortality.

We present two scenarios for populating a commercial off the shelf Personal Health Record: 1) Internet data entry, retrieval and maintenance 2) Mobile telephone data entry, retrieval and maintenance. A hybrid combination of these scenarios' is discussed in the context of the local point of care communication resources available to patients and health care providers.

Our focus is requirements for an SMS auto-responder integrated with PHR servers. This is an appropriate technology th is the central software element. Work flow processing optimizing this implementation is described.

Introduction

Patient medical records have been at the core of science based health care since literacy beginnings. It is universally subscribed that detailed and accurate patient health records provide the greatest opportunity for favorable health outcomes. In the developed world any contact with a licensed health care provider is documented according to applicable laws, standards and best practices. Health care paper documentation has become so voluminous frequently patient care is negatively impacted by paper overload, latency and inaccuracy that is a natural consequence of human activity throughout the process. Importance and challenge of maintaining accurate patient health records made this medical application among the primary database implementations during the previous forty years.

Information technology is acknowledged as a crucial element enabling optimal health outcomes in the modern health care delivery system. Electronic Medical Record (EMR) in developed countries is central to reducing health care cost, eliminating errors, and providing better service. Electronic Medical Records are the standard official repository of patient histories that maintained by medical professionals. PHRs are unofficial, but with services

provided by HealthVault interact with EMRs aggregating additional data maintained by patients that facilitate individual decisions leading to healthier lifestyles.

There is a dearth of comprehensive information about the chronic disease burden in Africa. (de-Graft Aikins A) Infectious diseases still account for at least 69% of deaths on the continent, age specific mortality rates from chronic diseases as a whole are actually higher in sub Saharan Africa than in virtually all other regions of the world

Looking more broadly at low-income countries the World Health Organization reports in a recent publication *Preventing Chronic Disease – a vital investment* that while the public perception is chronic diseases are primarily a high-income country issue, over 80% of the deaths world-wide due to chronic conditions are from low and middle-income countries

(World Health Organization Chronic Diseases and Health Promotion)

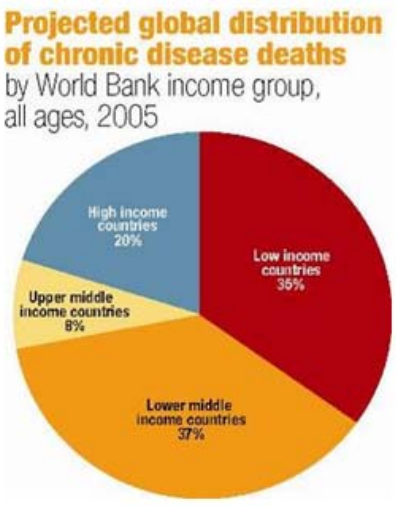
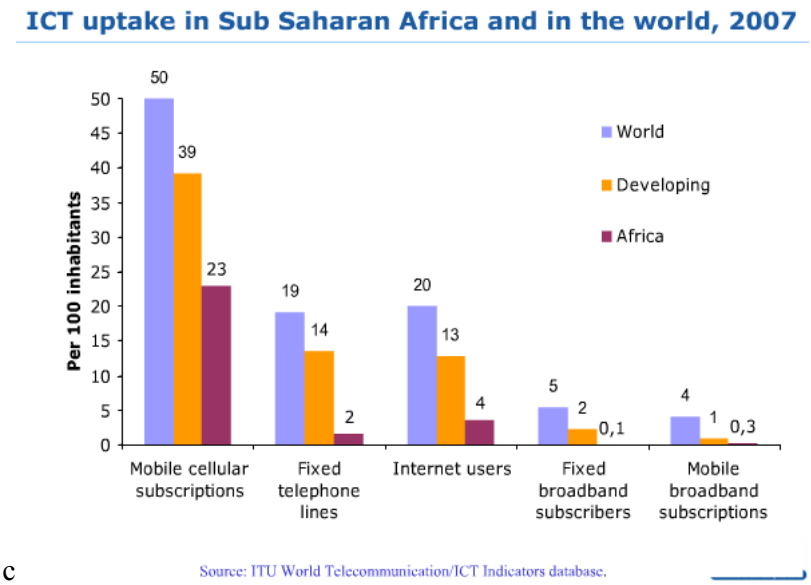


Figure 6 Projected Global Distribution of Chronic Disease Deaths (Sadki)

An approach to address this pressing need is to enable broader access to appropriate health records among patients and to providers at the point of care.

Mobile Phone penetration in developing countries



c

Figure 7 Information and Communications Technology (ICT) comparisons with Sub Saharan Africa (Sanaou)

Figure 2 illustrates potential for using mobile telephone technologies to capture and present health data. The mobile telephone penetration gap is less between Africa and other continents than it is in any other ICT context. This suggests mobile telephone technology is an excellent place to start to leverage its advantages in improving health.

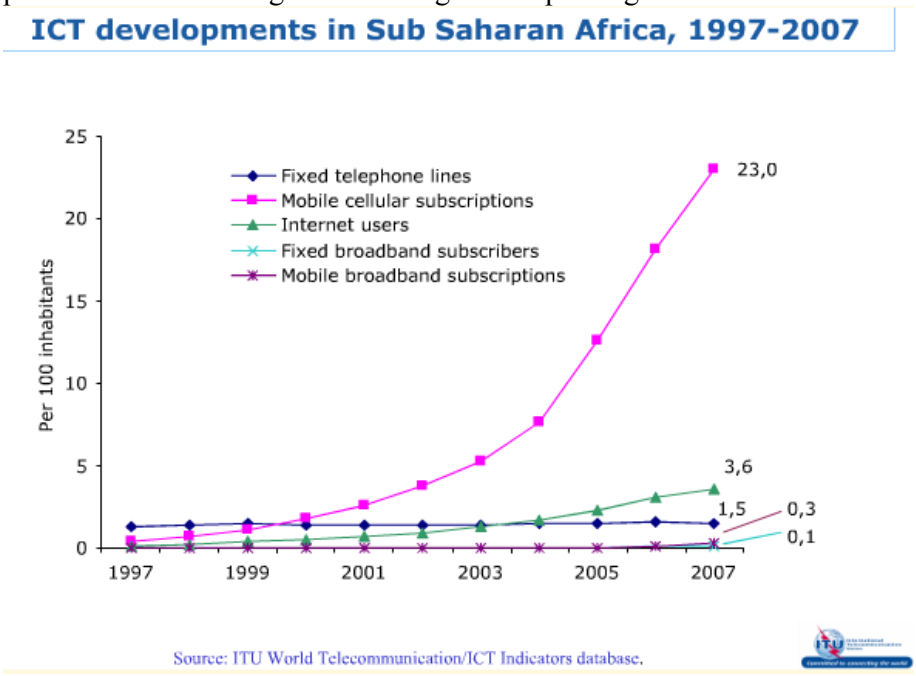


Figure 8 - Various ICT adoption rates in Sub Saharan Africa (Sanaou)

Adoption of various ICT technologies is another indicator that mobile telephones are the electronic communicator of choice. As shown in figure 3, the rate of adoption of mobile telecommunication services is greatly outpacing the communications growth using other mediums.

While the variance between mobile subscriptions and internet users shown in figure 3 is nearly an order of magnitude in sub-Saharan Africa, in high-income countries, this variance is much lower. As a consequence there are minimal incentives to implement SMS-responder type services to enable better health information exchange the developed world. However, in the geographies that are the subject of this paper, the incentives are great and potential is increasing.

An example of the growing interest in this area is indicated by the announcement of the "Africa Health Infoway." This project which seeks to invest up to USD$500m over several years to "to build capacity of African countries to collect sub national health data for analysis, dissemination and decision making in public health." This effort is a collaboration between the World Health Organization (WHO) and the International Telecommunication Union (ITU). Health care providers with internet access would be able to access (with patient authorization) patient-maintained health records (medication allergies, current immunizations, active conditions, etc.) at any time.

Microsoft HealthVault PHR platform was made available to USA residents in October 2007. HealthVault was established to enable consumers to store and manage their own health information obtained from health care providers, insurers, pharmacies and others. The service also enables consumers to generate their own health information. What was notable about this service is that enabling consumers to store and manage their health information enables consumers to efficiently maintain a lifelong health record. HealthVault adopters are using this valuable information to supplement their EMRs to assist health care providers better treat their acute and chronic diseases.

Figure 9 Microsoft HealthVault

Google has introduced a similar service, Google Health and a US corporate consortium has established a PHR services named Dossia. It's now possible for health conscious US residents to accurately maintain and securely exchange their daily health biomarkers.

It is notable that instances of the HealthVault service are planned for Canada, United Kingdom, Germany and Belgium. As such, the services gain worldwide acceptance, African

countries would benefit from exploring options to leverage these services to provide similar benefits to their citizens.

Potential mobile telephone accessible PHR
While developing countries do not have the end-to-end infrastructure in place that developed countries do, there is sufficient infrastructure to enable a creative use of existing technologies (such as web- based PHR platforms and mobile telephone services) to implement appropriate solutions for health data liquidity needs

While the presence of a stand-alone PHR can be a valuable resource to the patient and provider at the point of care, the optimal value derives from the ability for substantive data exchange between the PHR and physician-owned EHR.

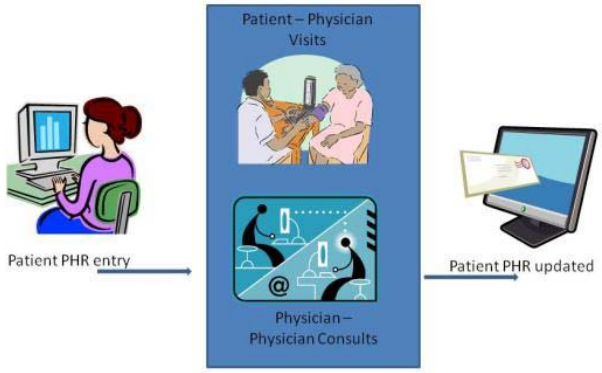


Figure 10 EHR to PHR Connectivity (Integrating the Healthcare Enterprise)

Missing elements to deploy proposed system in Ghana (or other countries)

- In order to enable optimal entry of organization via SMS, an auto-responder service based on SMS would need to be made available to patients. For example, values for lab results could be entered based on using specific text strings and values.
- A set of pre-established prompts to users could be generated that would require the user to only enter the value of the relevant biomarker requested by the prompt

Technical next steps
Implementing a SMS Responder service would be the next step to begin addressing the need to improve data exchange between patients and providers. Such an SMS Responder service would make use of existing infrastructure and technology that is widely available to many in our target geographies and too many of the citizens of low-income countries. Such a service would provide specific keyword prompts in text messages to a mobile telephone user, to which user would respond with specific readings as provided by their caregiver. In turn, this responder service might also integrate with PHRs and EHRs to enable optimal health data liquidity where such technologies exist.

Conclusions

Providing simple connectivity (even via SMS) between health records and mobile phones provides near-real-time access to important health information that may be use by health care providers at the point of care.

The development of a SMS PHR web server auto responder application is unnecessary in the developed world with almost pervasive internet access. SMS auto responder development is a bottom up approach to immediately improve health care and serve as an incremental step forward until broader internet access and EMR are available in Africa.

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DESIGNING TRANSITION STAGES TOWARDS A SMART GRID FOR EAST AFRICA

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Key words: electric smart grid, energy**,** transition stages, systems architecture

Abstract
The purpose of this paper is to present a blueprint of how best to design transition stages for an electric smart grid for the East African Community (EAC) by providing a map to the guidelines, tools, techniques and methodologies. This will consequently shorten the learning curve, promote awareness of the benefits, and reduce potential risks and design errors, as well as effort needed when designing such systems.

Based on a systems approach and, an analysis of policy, implementation, and regulatory needs of a smart grid, the authors share their proposal for the blueprint.

It is shown that a systems approach leads to properly defined design needs and requirements, ensures expertise, data access, and collaboration in smart grid standardization. The paper offers needed techniques, tools, and methods to arrive to a reference design for the EAC smart grid. Therefore, the paper presents how the EAC can adopt the blueprint to designing an electric smart grid for the East African Power Pool.

1. BACKGROUND

The East African community comprises five countries namely Rwanda, Burundi, Kenya, Tanzania, Uganda, and Rwanda. To coordinate and distribute energy to the various members of the community, the East Africa Community member states established the East African Energy Master Plan. Additionally, with five more non-member countries, the East African Power Pool was commissioned to design electric power transmission among member states.

This paper covers the East African Power Pool and limits the scope to the electric power smart grid.

One of the challenges of energy systems is how future technological, economic, and social changes can impact greenhouse gas (GHG) emission reductions to stabilize climate change to levels where ecological and human systems can remain sustainable [6].

The future energy system consists of various technologies, different stakeholders, integration systems, devices and strongly impacts other related systems. The achievement of integration of this complex energy system is presented as a smart grid or intelligent grid.

This paper suggests transition stages of the regional block towards a smart grid that will exploit use of current ICT infrastructure and the East African Power Pool (EAPP) plan that augments the East African Energy Master Plan. The East African Power Pool consists of additional countries (Egypt, Sudan, Ethiopia, Djibouti and DRC).

[1] Author for correspondence

1.1 INCENTIVES FOR A SMART GRID

The architecture of the EAPP grid focuses on a highly competitive and responsive market scenario with higher values for EAPP market penetration among end-users, demand response, impact on generating reserve margins, and electricity market competitiveness. The current situation of the East African energy sector as the region's oil and gas production prospects increase (under exploration in Rwanda, Burundi and Tanzania, and exploitation in Uganda) justify the urgency for member governments to harmonize policy, with implementation of the East African Master Plan (EAMP).

The incentives to undertake a profound transformation of the energy sector encompass economic, energy security, and climate change considerations. Therefore, the EAC should embrace an energy transition to a low-carbon economy not only as a path toward sustainable development but for coping with future pressures from spill-over effects in trading and technology transfers from Annex 1 countries and future advanced systems.

The transition to a lower-carbon energy sector requires innovative public policies and the political will to create new institutional frameworks. A smart grid transition plan offers the potential to deal with barriers to this transition.

1.2 AUDIT OF THE EXISTING ENERGY SYSTEM

An audit of energy supply and demand projections, regulatory and policy regime, infrastructure status, and economic growth projections for each member state is necessary to inform planning of the transition stages. Such an audit may focus on assessing energy in terms of systems and consider the time-scale of investments (vintage effects) in the analysis. Ensuring future supplies of energy resources will greatly inform design of the conceptual plan to move to an intelligent grid.

2. METHODOLOGY: SYSTEMS APPROACH TO INTEROPERABILITY OF SMART GRIDS

A systems approach to the development of the smart grid is proposed because of the nature of the electric grid [1]. This is particularly true considering current socio-technical challenges limiting the role-out of transmission grids to citizens in East Africa. Such a system comprises four major aspects:

a) Interconnection and interfaces
b) Technical standards
c) Advanced technologies
d) Systems integration

Distributed energy technologies and interconnection technologies are the core to the systems approach to designing adequate transition stages to future energy systems.

3. INTERCONNECTIONS AND INTERFACES

The Smart grid framework describes the design goal and layered architecture overview [3] as well as the smart grid community infrastructure and smart grid-node structure. [3] suggest that the design goal of the smart grid is to be a generic and modular framework in order to support intelligent and interoperable grid resource management using swarm intelligence algorithms and multi-type grid scheduling strategies.

Therefore, the proposed solution is layer-structured and aims at filling the gap between grid applications (which act as the resource consumers) and the grid resource low-level management systems (which behave as resource providers). To this purpose, the smart grid

design proposes an autonomic and evolutional grid community composed of smart grid nodes (SG-Node).

The smart grid framework is structured into two layers and one internal interface. According to [3] the Smart Resource Management Layer (SRML) is responsible for grid level dynamic scheduling and interoperation to serve grid applications with best use of the available computing resources. The Smart Signalling Layer (SSL) is in charge of monitoring and constituting knowledge on network and resources. Finally, the Data Warehouse Interface (DWI) is used to mediate the scheduling and signalling layers. The overall architecture of the system is shown below in Figure 1.

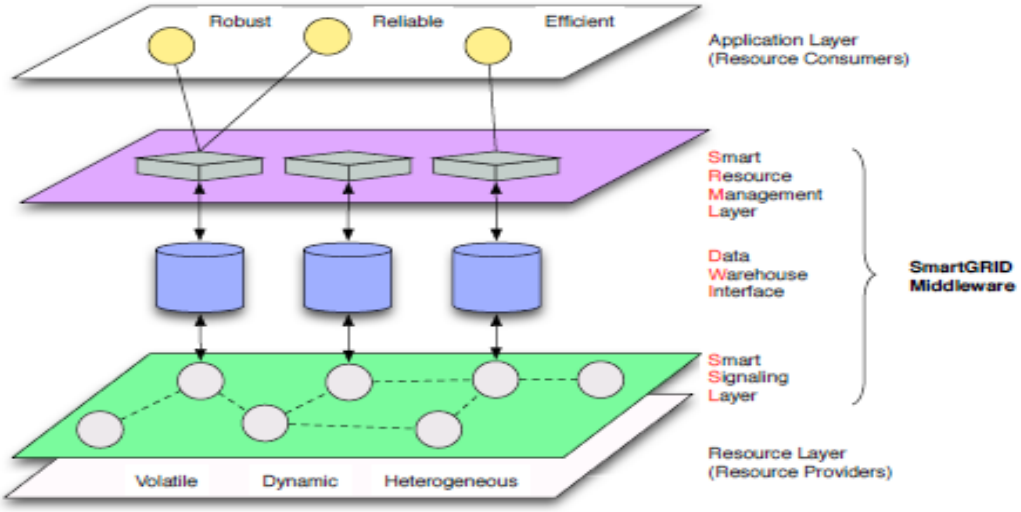

Figure 1: Smart grid architecture overview

The East African Power Master Plan is in the process of establishing a grid network. The current grid architecture is country-specific transmission lines between generation points and substation dispatch centers. The renewable energy sources in the community are mainly hydro-electric with mostly micro-and –often-island systems of solar PV and thermal sources [4]. Future possibilities exist in integration of the regional infrastructures like ICT, transportation, and petroleum resources.

[3] details and explores how the components in Figure 1 are further designed as part of the overall architecture. The proposed framework focuses on establishing an interoperable, autonomic, evolutional grid community to span the differences amongst heterogeneous grid environments, based on reactive and reliable grid infrastructure information provided by swarm intelligence technology.

4. STANDARDS AND ADVANCED TECHNOLOGIES

The Eastern Africa Power Pool Grid forms part of an overall interconnected transmission system. This requires common standards for satisfactory operational reliability and quality of supply and to ensure non-discriminatory access to the interconnected transmission system for all users. It also needs to encourage integrated planning of generation capacity and transmission expansion. Consequently, it is important to set out the obligations of all parties in developing a well-functioning and effectively integrated regional electricity market.

The following are some of the organisations involved in development of standards for the smart grid:

International Electrotechnical Commission (IEC), IEC TC57 is focused on International Standards for power systems control equipment and systems e.g., *EC61850* (architecture for substation automation) and *IEC 61970/61968 (* Common Information Model (CIM))

MultiSpeak (NRECA's MultiSpeak® Specification) which is focused on industry-wide software standard that facilitates interoperability of diverse business and automation applications used in electric utilities

Institute of Electrical and Electronics Engineers (IEEE), that contributes on standards for the advancement of technology related to electricity e.g., *C37.118* standard to support synchrophasors, *IEEE 1547* and *IEEE P2030* "Draft Guide for Smart Grid Interoperability of Energy technology and Information Technology Operation with the electric Power System (EPS), and End-Use Applications and Loads"

UCA International User Group that is focused on assisting users and vendors in the deployment of standards for real-time applications and,

LonMark International (LMI), that promotes and efficient and effective integration of open, multi-vendor control systems utilizing ISO/IEC 14908-1 and related standards.

According to [2] the smart grid of the future is generally characterized by more sensors, more communication, more computation, more control, and a certain generic configuration of more sensors, eventually utilizing the total information picture.

From this it can be projected that the present applications will be enhanced and new applications developed which will make the operation of the grid more secure and reliable. Finally, this requires a systematic plan that links system integration to constraints established by national policies and regulation.

5. SYSTEM INTEGRATION

Policy analysis and regulation rests on a well-developed microeconomic framework for making quantitative estimates of demand response and other benefits from wide spread implementation of the smart grid. To explore the sensitivity of benefits to the input data and assumptions, different models develop a series of scenarios representing different, but plausible, development paths for energy supply sufficiency in the context of climate change and compare the benefits calculated for different scenarios.

Smart grid technology has the potential to be the single-most productive innovation within the utility industry. The convergence of multiple technologies, standards and legislation will enable the smart grid to significantly impact the utility industry.

The information infrastructure and applications provide fundamental changes to the way energy stakeholders can interact and provide new services to end-users. This will require sector-wide skills development from industry level to enterprise and end-user level.

However, the deployment of the smart grid in the EAC has the risk to adversely affect the relationship within the energy sector, causing friction with regulatory bodies and policy

makers in member countries. It may also negatively impact the market systems if it is not effectively implemented. A structured systems approach is required to analyze and define the changes to each process and each role within the EAC to enable the achievement of the strategic goals and vision that the EAPP has set if the smart grid is to be deployed successfully.

Such transition into a fully deployed smart grid follows several stages according to [5]:

a. **Preparation –** Initial transformation stage that the organizational and process transformation is required for establishing a solid foundation. This may be done through extensive workshops and meetings with internal and external stakeholders needed for the smart grid

b. **Pilot –** The validation of the defined assumptions, processes, systems, and technologies, for the smart grid in a controlled setting

c. **Deployment –** an important stage before getting to the steady stage, the one-off deployment processes are used to deploy the technology

d. **Steady Stage –** The on-going smart grid processes and organizational changes, both internal and customer-facing, are completely deployed

6. CONCLUSION AND FUTURE WORK

A smart grid offers the EAC, through the EAPP plan and the EAPMP (developed in 2005), a roadmap and accruing advantages to deploy a system that will support future energy systems and their related industries while at the same time contributing to GHG emissions in the expected time-frame.

For this to be achieved, it will require policy intervention, design of energy markets, and establishment of standards that will not only guide interoperability standards but will also offer certainty to the energy industry.

The scope and extent of change within a country or even a region due to a complex system such as the smart grid is significant and thus a source of uncertainty. A plan of the scale of the EAC and EAPP needs strong, experienced, and committed leadership to direct the policy changes and to establish relevant regulatory regimes in member states. The smart grid architecture for electric, water, and gas energy resources ties together an otherwise, fragmented efforts to deliver basic energy needs to the community without adversely affecting the environment.

Recommended transition stages offer a platform of application and discussion on these important aspects of provision of future energy systems that interface with various sources including water that forms the major sources of base load electric supply in the East African Community member states.

The energy sector's processes will need to remain focused on long term strategy as unexpected challenges surface in order to achieve the full vision of the smart grid. As the GHG emissions reductions in Annex 1 countries guide technological innovation [6], the EAC smart grid road map would enable the member states to benefit from employment, technology transfer, and the carbon market.

Designing a reference model for the smart grid to be used by the EAC member nations would be a great step for the initial transition stage. Such a grid will need to overcome technical, procedural, and significantly depend on the efficiency of the Government planning assumptions [.

According to [3] during the evolution of the smart grid, the system engineering approach should be applied to ensure that each interface respects the principles of *symmetry, composition* and *transparency*. As observed by [5], the future power systems are complex and consequently modeling, analysis and design meet new challenges. Therefore, the models to be used must be able to account for uncertainty as away to simulate emerging behavior.

It is suggested [5] that numerical tools to perform the analysis must be capable of solving very large scale problems. The future power system is tightly coupled and non-linear and does not benefit of sparsity that typically characterized this problem in the problem. However, distribution, intelligence, communication, and autonomy make the intelligent agents as a suitable framework for realizing the evolution to the smart grid [5].

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Processing of Soyabean As a Cottage Industry Among Rural Women Farmers in Ogbomoso Zone of ADP in Oyo State.

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Keywords: Soybean, Cottage Industry, Recipe, Empowerment.

Abstract

The study investigated the soybean processing as a cottage industry among rural women farmers. The Soybean products produced and economic benefits derived from the cottage industry were examined. A total number of a hundred and twenty (120) women farmers were selected and interviewed using multistage sampling technique. Information was collected through the use of interview schedule. Data analysis was carried out using frequency count, percentages and regression. The results show that only three (3) recipes were produced on a commercial scale, the community had a favourable attitude towards the products, hence high rate of consumption pattern was recorded by consumers. The high rate of consumption encouraged increased income for the processors and thereby encouraged them to continue production because of the economic benefits resulting.

Analysis of the results shows that there is a positive and significant relationship between income (B=6.82E-002), family size (B=0.26)] and consumption pattern of soybean. However, there is a negative but significant relationship between years of schooling (B= -0.208) and consumption pattern.The significant effect on income suggests that soybean processing as a venture is capable of empowering women economically and therefore can be a viable business that could be fully developed into a commercial scale production. It is therefore, recommended that women should be financially assisted to make the cottage industry grow into a viable industry which would serve as a permanent source of livelihood for the women in the study area.

INTRODUCTON

[1] the director general of the International Institute of Tropical Agriculture, IITA, described Soybeans as a near-perfect crop for a country like Nigeria expressing that "Nutritionally, they carry twice the protein of meat or poultry and contain all eight essential amino acids needed for childhood development. Soybeans are also good for the environment, Brader says. Because they evolved in Asia hence, they are far less vulnerable to local insects than African bean crops and require fewer insecticide sprays. They also fix atmospheric nitrogen, which reduces the need for farmers to purchase fertilizer. Soybean is among the major industrial and food crops grown in every continent. The crop can be successfully grown in many states in Nigeria using low agricultural input.

Soybean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage. It is also a prime source of vegetable oil in the international market. Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in Nigeria. Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free. In Nigerian markets, they are affordable and cost about one-fifth as much as other forms of protein, including dairy, fish, and are easier to store and transport.

The direct human consumption of soybeans is significant in Nigeria, especially among rural low-income groups that cannot afford other alternative protein sources such as meat,

fish and eggs. Beginning in the early 1990s, the International Institute of Tropical Agriculture [IITA] promoted the use of protein-rich soybeans in everyday foods to curb malnutrition. Among the recommended uses of soybean, the common soybean-based foods vary from region to region based on the prevailing staple foods available for example in the Northern part of the country the common Soybean food includes *dadawa* [*nune*], *moinmoin* [*akpupa* or local bread], and *akara* [*akwese*]. Soybean *moinmoin,* Soybean *dadawa* or *nune*, the fermented bean flavoring, is a substitute for locust beans in daily cooking. [*akpupa*],wheras in the Southern part the common ones are soy milk, Soy-cheese[tofu], Soy- Ogi, Soy- iru, virtually Soybean can be added to all the staple foods available for consumption. [1] further remarked that Nigeria has been quick to profit from new technology that has helped farmers overcome a series of complex production problems and that soy bean recipe has become an hunger fighter and cash earner for women farmers and entrepreneurs in Nigeria.
Therefore the study provided answers to the following research questions:

i. What are the socio economic characteristics of the respondents?
ii. What is the Soybean products/recipe engaged in?
iii. What is the consumption patterns of the recipe produced?
iv. What are the community perceptions towards the different recipes produced?
v. What are the benefits derived from embarking on the cottage industry?

Objective of the Study

The main objective of the study is to investigate the processing of soybean as a cottage industry among rural women farmers in Ogbomoso metropolis of Oyo State.

The specific Objectives are to:

i. identify the socio-economic characteristics of respondents,
ii. examine the soybean products produced,
iii. investigate the consumption pattern of the recipe,
iv. determine perception of the community towards different recipes of production,
v. examine the benefits derived from the cottage industry.

Materials and method

This study was carried out in Ogbomoso area of Oyo State. Purposive sampling method was used to identify the women involved in the production of soybean recipe on a commercial scale. One hundred and twenty women were randomly selected and interviewed using structured interview schedules. However, only 117 respondents were good for analysis and so used. Information was collected on all the objectives of the study. A focus group discussion was conducted to establish community perception towards the consumption of soybean recipe.

Analysis of data was carried out using frequency counts, percentages and regression. The dependent variable is the consumption of soybean recipes and it was measured on three point Likert scale of Highly consumed [3 points], Consumed [2 points], Fairly consumed [1 point] and Not consumed [0 point]. The maximum score for consumption was 15 points while the minimum score is 0 point.

Result and Discussion

The result in Table I show the distribution of respondents by socio-economic characteristics. About 42.7 percent of the respondent are between the age of 41-50 years, 32 .5 percent are between 31-40 years, 20.5 percent are 30 years and below while 4.3 percent are 51 years and above. About 65 percent of the respondents are married, 14.5 percent are

widowed, and 8.5 percent are separated while 6 percent each are divorced and single respectively. About 32.5 percent of the respondent had years of schooling between 10-12 years, 29.9 percent had between 1-6 years, 27.4 percent had no formal education at all, 6 percent had between 7 and 9 years while 4.3 percent had 13 years and above as years of schooling with mean of 6 years. About 61.5 percent of the respondents have years of experience on soybean recipe commercial production between 1-4 years, 27.3 percent had experience between 5-8 years, 6.9 percent are between 9-12 years while 3.4 percent are 13 years and above. About 41.1 percent of respondents belong to the income range of ₦21, 000 - ₦ 50,000 per annum, 29.9 percent are in the range ₦ 60,000 and above while 29.0 percent are between ₦ 1000 and ₦ 20,000.

The mean income is ₦ 37871.8. The result implied that most of the respondents are in their active years of life, full of energy to move about but are of low economic status striving to make ends meet by different coping strategies for economic empowerment. The mean years of schooling of the respondents is low

Table I: Distribution of Respondent by Socio economic characteristics

Socio economic characteristic	Frequency	Percentages
Age		
≤ 30 years	24	20.5
31-40	38	32.5
41-50	50	42.7
≥ 51years and above	5	4.3
Marital status		
Married	76	65.0
Separated	10	8.5
Widowed	17	14.5
Divorced	7	6.0
Single	7	6.0
Years of Schooling		
Illiterate	32	27.4
1-6	35	29.9
7-9	7	6.0
10-12	38	32.5
≥ 13 years	5	4.3
Family size		
1-2	16	13.7
3-4	25	21.3
5-6	34	29.0
≥ 7	42	35.9
Years of Experience		
1-4	72	61.5
5-8	32	27.3
9-12	8	6.9
≥ 13 years	5	3.4
Income		
1-10,000	7	8.5
11-20,000	24	20.5
21-30,000	23	19.7
31-40,000	14	12.0
41-50,000	11	9.4
51-60,000	17	14.5
≥61,000	18	15.4

Source: Field Survey, 2010

Soyabean recipe production

The data in Table II shows the distribution of respondents by commercial soybean recipe production. The result shows that majority [89.7%] each of the respondents produced soymilk and soy cheese. About 88% percent are involved in the production of soy meat [fried cheese tofu] while 11.1 percent are into soy iru. The results confirms [1] that soybean can be used to produce a variety of processed food such as soymilk and formulated foods to help malnourished infants and children.

Table II: Distribution of Respondents by soybeans recipe produced on commercial bases

Soybean Recipe	Frequency	Percentage
Soy milk	105	89.7
Soy-cheese [Toful]	105	89.7
Soy meat	103	88
Soy iru	13	11.1

Source: Field Survey, 2010.
*Multiple Response.

Consumption Pattern of Soybean recipe

The data in Table III shows the rank order of consumption pattern of soybean recipe produced. The result shows that soymilk ranked highest with wms of 2.7. This is followed by soy meat with wms of 2.4. Next is soy cheese [Tofu] with mean score of 2.3 while soy iru ranked least with mean score of 0.3. This confirms the saying in [2] that soybean has become a hunger fighter and cash earner for women farmers and entrepreneurs.

Table III: Rank order of soybean recipe by Consumption Pattern

Consumption Pattern of Soybean recipe	wms
soy milk	2.7
soy-cheese [Tofu]	2.3
soy meat	2.4
soy iru	0.3

Source: Field Survey, 2010

Focus Group Discussion on Community Perception towards the Consumption of Soy bean Recipe.

Table IV shows that the community attitude toward consumption of soybean products was favourable especially towards soy milk and soy meat because it was a cheap source of protein to them and that the effect of soymilk is gradually a substitute to the evening palm wine taking after farms work because according to the farmers, soy milk allows them to enjoy their sleep better than when palm wine is taken at night.

The consumption of soy cheese is facing competition with the cheese made from cow milk. People tend to consume cow cheese more because it has no beany odour as in the case of soy cheese. However, Soy tofu is highly and widely consumed as snacks or be made into stew as one would cook meat. The attitude towards the consumption of soy iru is very low; the community still prefers the traditional locust bean to soy iru in terms of preference for taste.

Table IV: Distribution of respondents by community perception towards the consumption of soybeans recipe

Soybean recipe	FGD1	FGDII	FGDIII	FGDIV
soy milk	++	++	++	++
soy-cheese	+	+	+	+
soy meat [Tofu]	++	++	++	++
soy iru	--	--	--	--

Source: Field Survey, 2010
++ : Opinion strongly expressed
+ : Opinion mildly expressed
--: Opinion not expressed

Benefit derived from Commercial Production of soy bean recipe

The data in Table V shows the distribution of respondents by benefits derived from commercial production of soybean recipes. The result shows that majority [92.3%] of the respondents claimed that they are economically empowered. About 88.0 percent enjoyed improved standard of living, 84.6 percent experienced increased income, 74.4 percent claimed improved nutrition, 68.4 percent were able to render financial assistance to their spouses, 64.1 percent enjoyed better health, and 52.1 percent had good home welfare while 25.6 percent experienced less friction at home. The result implies that through processing of soybean women had a lot to benefit and this would lead to the economic dependence and empowerment.

Table V: Distribution of respondents by benefited derived on Production on commercial scale

Benefits	Frequency	Percentage
increased income	99	84.6
Improved nutrition	87	74.4
Economic Empowerment	108	92.3
Less friction at home	31	25.6
Enjoy better health	75	64.4
Rendering financial assistance to the spouses	80	68.4
Good home welfare	103	88
	61	52.1

Source: Field Survey, 2010

Test of Hypothesis

The data in table 6 show the relationship between socio-economic characteristics and consumption pattern of soybean recipes. The result shows that there is a positive and significant relationship between income (B=6.82E-002), family size (B=0.26)] and consumption pattern of soybean. However, there is a negative but significant relationship between years of schooling (B= - 0.208) and consumption pattern. Also there is positive but insignificant relationship between marital status (B=0.144), years of experience (B= 0.105) and consumption pattern. A negative but insignificant relationship also exists between age (B= 0.030) and consumption pattern. The result implied that the significant relationship of income with soybean processing can make it a viable enterprise that could empower the women economically. Also, the relationship of family size could be a strong determinant of soybean consumption i.e. the larger the family size the higher the chance of depending on

cheap source of protein for the family. However, it is expected that the higher one climbs the educational ladder, the better informed one should be. Therefore the negative implication of years of schooling with mean of 6 years would mean the respondents are of low educational status which is bound to affect their understanding and disposition towards issues especially in making good decision as regards their welfare.

Table VI: Relationship between socio economic characteristic and consumption pattern of Soybean Recipe

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	B	Std. Error
[Constant]	9.399	1.289		7.295	.000
Age	-.030	.020	-.147	-1.482	.141
marital	.144	.199	.069	.727	.469
Occ	.122	.230	.051	.530	.597
Yrs of schl	-.208	.101	-.224	-2.052	.043
Family size	.261	.107	.236	2.445	.016
Years of exp	.105	.073	.157	1.435	.154
Income	6.82E-002	.000	.175	1.843	.068

Source: Field Survey, 2010

Conclusion and Recommendation

Majority of the respondents are in their middle age with mean age of 37years, married with average family size of 5 members. The mean years of schooling is 6years with a reasonable percent of no education at all. The respondents engaged in the commercial production of only 4 recipes, however the consumption pattern of the recipes produced is very high except soy iru which had a perfect substitute of traditional locust bean which is widely preferred by the community. The community displayed a favourable attitude towards consumption of soybean recipe. The result of the analysis shows a positive and significant relationship between family size and income which is an indication that the respondents enjoyed some benefit from the production that is capable of enhancing the economic empowerment of the women. It is therefore recommended that women should be encouraged to expand their scale of operation and also form themselves into cooperative groups where they can source for financial assistance. Effort should also be given to the respondents to improve their educational status through adult literacy training especially for those who have no education at all.

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Wet and Dry Spell Probability Analysis for Selection of Appropriate Soil and Water Technologies for Reducing Crop Failure in the Central Highlands of Ethiopia, the case of Bishoftu district, Oromia region

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Key words: dry, wet, spell, Markovchain, Kiremt, Belg

Abstract

An appropriate technology selection work in the areas of agriculture always requires detailed analysis of climatic phenomenon. The dry and wet spell analysis in a growing season helps in design of soil and water conservation practices and run off collection structures. The dry and wet spell events in a growing season in any region are believed to determine crop yields in substantial amounts, especially in rainfed agriculture. Hence there is a need to reduce the risks associated with those climatic events in order to sustain optimum level of crop production. Accordingly, the concept of estimating probabilities with respect to a given amount of rainfall is becoming extremely helpful for agricultural planning. Recently many more researchers are becoming interested in the analysis of the dry-wet spell lengths using the Markov Chains model based on past weather record. This paper critically examined the probability of dry and wet spell in decades of the two growing season, ***belg*** *and* ***kiremt*** *using the Markov chain model. The analysis resulted that the probability of a decade being wet in the* ***Kiremt*** *is found to be greater than 40% throughout the meteorological decades with the exception of decade number 16 and 17, which gave a corresponding probability value of 21% each while there is less probability of occurrence of the wet spell in the* ***belg*** *season during the entire years of record. In general, crop harvesting during the* ***Kiremt*** *season is less likely affected by moisture stress but the reverse is true for* ***belg*** *season.*

Introduction

Rain-fed agricultural is always dependent on the prevailing climate and weather variability phenomenon. The most important limiting weather element in agricultural sector is precipitation. Extreme climatic conditions and high inter-annual or seasonal variability of this weather element could adversely affect productivity [6] because rainfall governs the crop yields and determines the choice of the crops that can be grown. One of the reasons for low crop production in semi arid areas is marginal and erratic rainfall exacerbated by high run off and evapotranspiration losses. The in-field rainwater harvesting techniques has been shown to improve the yield of maize and sun flower on some benchmark ecotypes in South Africa [3]. Rainfall in terms of amount and frequency in a growing season is crucial for panning and management of agricultural practices. It is of some importance in adapting farming systems to supplementary water resources to know how long a wet spell is likely to persist, and what probabilities are experiencing dry spells of various duration at critical times during the growing season.

The analysis of rainfall records for long periods provides information about rainfall pattern and variability [5].Dry and wet spell analysis assists in estimating the probability of intra-seasonal drought and management practices can be adjusted accordingly [4]. A kind of work should not only focus to the semi-arid areas where rainfall is erratic but it is paramount important in the regions where rainfall seems good enough on annual scale while the temporal distribution through a growing season requires attention. Analysis of rainfall

probability on this particular time scale can only give a general in formation about the rainfall pattern of a certain location. Therefore there is a need of having specific information for critically planning agricultural operations for the benefit of increasing crop yields.

In this regard, dry and wet spell analysis at decadal time unit (tem day basis) more or less satisfies the required supportive information for decision making in rainfall water resource management and planning in agricultural sectors[1 and 7]. Like wise, in the central highlands of Ethiopia, rainfall persists relatively less erratic on annual scale, but what a limiting factor is the unexpected occurrence of the dry spell during some of the most important crop development stages and high intensity of rainfall in the middle of the season causing runoff and subsequently damaging the crops in the field. Thus understanding of those events is extremely important for reducing the adverse effects through appropriate planning and management of agricultural practices suitable to a certain pattern and characteristics of rainfall regimes in a growing season.

In this paper, an attempt was made to critically analyze the dry and wet spell probabilities for two growing seasons for a selected and agriculturally important district in the central highlands of Ethiopia based on the Markov chain probability model. The rainfall occurrence of dependable value at 80% probability level was also determined and subsequently a comparison analysis with FAO threshold reference evapotranspiration was a done for the selected district.

Materials and Methods

The bishoftu district is located in the central highland of Ethiopia, 45 Kms South East of the capital, Addis Ababa. The district is agriculturaly the most important one in the region. The district has two distinct seasons; the shorter (*belg*) lasts from March to end of May while the main rainy season (*kiremt*) is length of the period between June and September. The analysis of the work was entirely based on the thirty three years of meteorological records (1975-2007) obtained from Debre Zeit Agricultural Research Center's Weather Archive. The standard or meteorological decades (SMDs) are constructed in such a way that each month of a given year was divided in to three decades and subsequently the first two ten days are considered as the first and second decade for each month, respectively. The rest of days in each month again will be summed up to form the last or third decade.

Reddy [8] has already stated that a 3 mm rainfall depth per day is the minimum threshold value for crops to satisfy their crop water requirement. Accordingly, in this study, a 30 mm per decade of precipitation depth was taken as a threshold value for evaluating whether a decade is in a dry or wet spell. A decade with a depth of precipitation below this value was considered as dry and vice-versa for a decade with precipitation value of above the threshold level. The following expressions were used in the Markov chain analysis of dry/wet spells in the district [7]

$$P_D = \frac{F_D}{n} \quad (1)$$

$$P_W = \frac{F_W}{n} \quad (2)$$

$$P_{WW} = \frac{F_{WW}}{F_W} \quad (3)$$

$$P_{DD} = \frac{F_{DD}}{F_D} \quad (4)$$

$$P_{WD} = 1 - P_{DD} \quad (5)$$

$$P_{DW} = 1 - P_{WW} \quad (6)$$

Wet spell duration is defined as sequence of k wet decades preceded and followed by the dry decades and correspondingly the dry spell duration is the sequence of dry decades followed and preceded by the wet ones. The distributions of the spells by length or duration are found to be geometric [1] with the probability of wet spell of length *k* given by the following equation:

$$P(W = k) = (1 - P_1) P_1^{K-1} \quad (7)$$

$$P(W > k) = P_1^k \quad (8)$$

Similarly, Probability of a dry spell of length *m* and greater than *m* were calculated using the following equations respectively.

$$P(D=m) = P_O(1-P_O)^{m-1} \quad (9)$$

and

$$P(D > m) = (1 - P_O)^m \quad (10)$$

Where,

P_D is the probability of a decade being dry
F_D is the number of dry decades
P_W is the probability of a decade being wet
F_W is the number of wet decades
n is the number of observations
P_{WW} is the probability of wet decade followed by another wet decade
F_{WW} is he number of wet decades followed by other wet decades
P_{DD} is the probability of a dry decade followed by another dry one
F_{DD} is the number of dry decade followed by another dry one
P_{WD} is the probability of a wet decade followed by another dry decade
P_{DW} is the probability of a dry decade followed by a wet one.
P_1 is the probability that a decade is wet give that the previous decade is wet and denoted by P (W/W)

P_0 is the probability that a decade being wet given that the previous is dry and is a reference.
Evapotranspiration was calculated from meteorological records based on the Pen man-Months equation.
The Weibull frequency or probability formula of the following order was employed to obtain the probability of rainfall of each decade.

$$p = \frac{m}{n+1} * 100 \quad (11)$$

Where,
P Probability of Occurrences
m is the rank at which the value occurs when arranged in descending order
n is the total number of observation

Results and Discussions

The probability of a decade being wet in the *Kiremt (the main rainy season)* was found to be greater than 40% throughout the meteorological decades with the exception of decade number 16 and 17, which gave a corresponding probability, value of 21% each (Table 1). The probability of getting a wet decade after wet in the study district during the main rainy season was also found to be in the range of 14 – 100% with most of the meteorological decades skewed to the maximum. In general, the *Kiremt* season is having well above the threshold limit for most of the years during the study period.

However, the probability of getting a wet decade during *belg (smaller)* rainy season was limited in the range of 15 to 30 % (Table 2). The same table also showed that high probability of occurrence of dry spells was observed (greater than 70% in all decades), as expected. Further, the probability of getting a dry decade after dry in the study district during the *belg* season was also high (exceeded 65%) throughout the meteorological decades.

Table 1. Dry/wet spell probability distribution through the *Kiremt* rainy seasons

Dekade No	Pw	PD	Pww	PDD	PWD	PDW
16	21	79	14	92	8	86
17	21	79	57	88	12	43
18	42	58	29	89	11	71
19	64	36	52	75	25	48
20	88	12	69	25	75	31
21	88	12	66	0	100	34
22	91	9	87	0	100	13
23	94	6	90	0	100	10
24	94	6	100	0	100	0
25	88	12	100	0	100	0
26	61	39	90	8	92	10
27	52	48	53	56	44	47

Table 2. Dry-wet spell probability distribution of Belg based on the Markov Chain model (1975-2007)

Dekade No	Pw	PD	Pww	PDD	PWD	PDW
9	30	70	30	87	13	70
10	30	70	60	78	22	40
11	30	70	50	74	26	50
12	18	82	33	67	33	67
13	18	82	17	74	26	83
14	21	79	14	81	19	86
15	15	85	20	75	25	80

Further more, a relative high probability of occurrence of more than three consecutive dry decades was also showed up (Table 3) in this particular season as compared to the main season. This result suggests high chance of crop failure in the season and thus the season

needs to be out of the major cropping practices, sowing and planting but the moisture could be used for land preparation for early planting in the main rainy season.

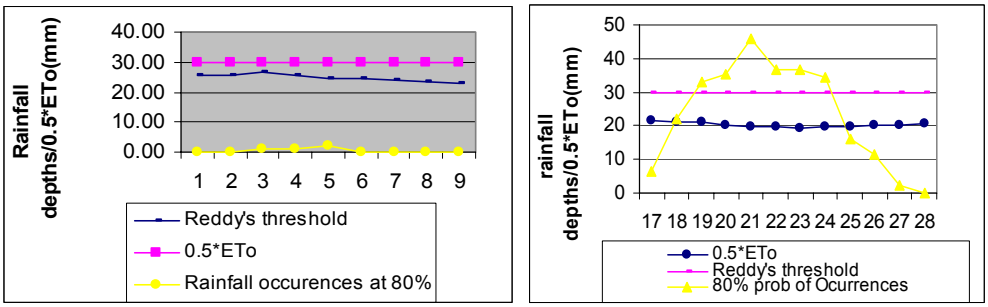
Table 3. Dry-wet spell duration distribution in the two seasons

k	Probability of wet sequences at least				Probability of dry spell > 3dek
	2	3	5	7	
Bega	0.13	0.048	0.0062	0.00082	0.58
Kiremt	0.43	0.28	0.12	0.01524	0.19

Therefore, crop harvesting during the main rainy season is less likely affected by moisture stress. This corresponds to high probability of run off and erosion hazard possibilities during the kiremt season (Reddy, 2008), and the results also indicated that there could be high risks of waterloging conditions which could affect the crops because of poor aeration and on the other hand, there might be damages in the down stream areas due to flooding in those decades that experience wet after wet conditions unless there have been strong soil and water management tecknologies in the study district.

The high consecutive wet week probability during 20th-25th decade of the main rainy season on the other hand hints for potential scope of harvesting excess runoff water for future supplemental irrigations and also drives attention towards soil erosion measures to be taken up for soil erosion control. However, one can infer from the presented tables that the belg season is getting below the threshold minimum requirement of rainfall and hence planting during *Belg* season is less likely.

Similarly, as illustrated in figure1 (a and b) below; the ratio between precipitation amount at 80% probability of occurrences and the average threshold reference evapotranspiration (0.5*ETo) showed that the main rainy season is still enjoying rainfall amount much higher than the minimum for most of the its decades while in *belg,* the rainfall amount remained much below the threshold of the crop water requirement at the same probability level of occurrences for all the decades.



. **a** **b**

Figure 1.Rainfall Occurrence at 80% probability and corresponding reference evapotranspiration during the growing seasons, *belg* and *kiremt* respectively

In general, the moisture from the rainfall during the shorter rainy season is extremely below the threshold level to support crop production. This is because rainfall amount below half of the corresponding evapotranspiration does not satisfy the crop water need and subsequently the crops are physiologically affected [1 and 2]. The results also indicated that maximum benefits should be derived from the ample moisture of the main rainy season. Besides this particular season holds some soil erosion and runoff possibilities, especially during decade 21st and thus it requires attention with respects soil and water conservation practices and also design of water harvesting structures.

Conclusions

Decisions in rain-fed agriculture always require detail analysis of the weather component. In the principle of the past gives a clue to the future, probabilistic analysis of the weather records of the past is an important step towards understanding and developing appropriate technologies that support crop growth under varying rainfall regimes. Some of the decisions: land preparation, crop and variety choice, fertilizer application rate, soil/water conservation measures and disease and pest control practices can be supported by the information obtained from the probabilistic analysis of the weather elements. But, for a kind of work is to be practical and applicable, a reasonable reliable data source and collection is crucial. Thus quality weather data handling is always paramount important for working out the analysis more informative for decision making. To sum it up, selection of appropriate technologies in agricultural development should always follow a detailed understanding and analysis of the climate, particularity the rainfall variability and pattern.

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Strategic Approach In Rehabilitation Of Tractor-Aggegations In Ghana

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Key Words: Tractor, Rehabilitation, Maintenance, Mechanization, Depreciation

Abstract

Ghana is an agricultural country and most of the 5000 tractors imported are for agricultural purposes. Tractor management in Ghana has been one of the most challenging to farmers and could be similar to most developing countries. Tractor repair and maintenance had a set back from the past. Most breakdowns of tractors could not be rectified immediately because farmers are less motivated or lack of repair funds. This has worsened the tractor situation with time and continues to put many tractors out of use. Different studies have revealed the problems and solutions for sustainability of managing tractors and ploughs.

A study conducted on the breakdown situation of tractor in Ghana revealed that most causes were attributed to incompetence of mechanics, tractor operators and neglect from tractor owners.

The level of broken down tractors was traced to the inability of farmers to rehabilitate their tractors due to incompetence in strategic management. Therefore, the strategy analyses were based on the integration of breakdown severity with support need and operational input cost of repair and maintenance relativity. The technical specifications and other literature review were studied using the farmtrac 70 tractor and its aggregations. Field Capacities were investigated and used to determine input cost.

The results of the study have revealed the tractor management strategy details in this study and recommendations were made strongly for implementation.

INTRODUCTION

Ghana has a total land area of approximately 24 million hectares of which 8 million are considered suitable for agricultural production using mechanical powered machines. However, due to the unavailability of farm tractors and also high breakdown levels, less than 20% of this productive area is actually cultivated MoFA[1]. If adequate farm power was available, increased production of food and cash crops could be realised. Consequently, industrial processing would also increase.

The current economic conditions many of farmers can no longer afford new machinery. Repair of existing machines could in certain circumstances, overcome this constraint by providing a cheaper replacement option. However, these repairs should be seen as a complementary activity to the importation and any local manufacture of new machinery. Moreover, new machinery will benefit from the creation of an environment conducive to encouraging and enabling repairs and maintenance to be carried out in a normal fashion. If not, premature degeneration will again occur. Tractors must be profitably used if they are to be considered a suitable power source. It must also be assumed that if a tractor becomes

inoperative and is not repaired or replaced, the area under cultivation will fall each year by the amount attributed to the tractor.

It is estimated that there are 5,000 two-axle agricultural tractors in Ghana, as well as the associated field implements, which were supplied with most of them. Unfortunately, a high percentage of the tractors are standing idle awaiting repair or rehabilitation work to be carried out. The broken down tractors can be economically put back into good working order, thereby protecting much of the investment made and at the same time providing farm power to boost and increase agricultural production. .

Although the farmers recognise that the process of restoring agricultural machinery to its former working condition is beneficial in terms of alleviating immediate equipment and power shortages, he also realises that a more important aspect is ensuring that rehabilitation programmes create an environment to support technology in the long term without the support of external funding agencies. Repair should aim to create an environment that encourages and allows machinery to be repaired and maintained in a normal manner without recurrent resort to formal repairs.

In management, cost of farm machinery operation should be controlled to minimize cost. Good maintenance also reduces cost (i.e. cost of wear and tear) since the factual rate of depreciation is slowed down. Mostly healthy machines get work done on time and also machines kept in good condition do better work.

Ghana has tractor makes such as the Massey Fergusson, Shangai, Swarag, Belarus, Lanbongini, Zetor, David Brown, etc. Most of the models from the various tractor makes are normally aggregated with three bottom disc ploughs.

One of the most important roles of a farmer is the rational use and economic management of farm machinery. The best strategy is to link machinery input cost to normal yield income and other option is to link to breakdown severity with tractors at old age. Some necessary factors to be considered in management of farm machinery are generally considered as follows will include the rational use, then the cost of operation and how to adjust the cost to improve income and rehabilitation.

OBJECTIVES

The overall objective is to link breakdown frequency to input cost of operation modality of management as many as possible of both the public and private sector owned broken down tractors in the country.

The objective of the study therefore is to find out the:
- Extent of the situation of tractor rehabilitation.
- Most needed tractor repair.
- Analysed input cost and repair need relativity;
- Present recommendation for implementation

A secondary objective through the study is to strengthen the private support services for mechanization (spare parts and repairs).

MATERIALS AND METHODS

The Massey Ferguson and Ford makes which form the majority of the old tractors in Ghana were focused for our studies to establish the extent of tractor breakdown situation. Questionnaires were administered with field inspections to address the problem. Below are the areas of attention in the questionnaire sections:

Information will be enquired on Tractor Owners, management, economics and environmental work capabilities. Physical inspections on the tractor were conducted to complete the exercise. Information on the workshops that give services to these tractors at their various areas of operation was visited and inspected the physical structure, Technical personnel and equipment.

For input costs, the farmtrac 70 was chosen as it represented the many newly tractor models imported into Ghana. The Farmtrac tractor is manufactured in India. The Escorts established the Escort Tractor Limited and commenced the manufacturing of Ford tractors in 1971 in collaboration with Ford .UK. Data collected by Gajendra Singh and S. R. Doharey [2] rated the Farmtrac tractor in India in 3rd position of preference after Mahindra & Mahindra and TAFE. This attest to the assumption that tractors developed from Ford tractors could be reliable with little frequency of breakdowns.

Fields of operations such as ploughing were carried out at the University Agricultural Research Centre (ARC) and on a private farm at Dodowa. Some mechanical properties of the soil at the experimental sites were defined to fall within the acceptable ploughing conditions that avoid the negative soil frictional effects.

The Theoretical Field Capacities were calculated in terms of quantity of operation output to time spent. Also the actual output was measured against the theoretical filed capacity.

Costs of mechanised operations were done with the combined methods of TIIAME transact [3] and Williams Edwards [4] on hourly basis and area productivity. Cost of operations had some few adjustments and assumptions to suit the Ghanaian situation.

Discussions and conclusions on findings in break down severity and input cost were done.

RESULTS AND DISCUSSIONS

Breakdown of Tractors on the Field of Operation

The study on breakdown situation in Ghana Mahama et al [5] revealed that all farmers maintained their machines on their farms and off farms in the towns. Breakdowns were relatively few with new tractors. The hydraulic and clutch systems had also frequent failures. Other crucial issue was the compatibility of the alternator, battery and the entire ignition system. Most of the tractors were observed to have lighting system and alternator breakdowns and the spares were regarded as not readily available. Spare parts were mostly obtained from the local market. The spares needed by farmers were inputs of routine maintenance for all tractors and tires for wheel tractors. The steering and hydraulic systems needed repair kits where possible for immediate correction when failures occur.

The most prevalent breakdowns so far on the tractor as revealed in the study were as follows in the order of severity on impact to management and functioning of operations: -

1 Tyres (rare)
2 Steering System
3 Front axle
4 Cooling System
5 Electrical System/Battery
6 Engine
7 Fuel system (Injection and lift pump)

It has been observed on the field that all the tractors inspected have any of the Nos 1-5 problem areas listed or even all the five. The breakdown becomes clearly severe when there is further addition of hydraulic, engine or fuel system problems, and then the tractor cannot in any way be serviceable to the owner as expected.

Those that are operational had weak engines, faulty fuel and hydraulic systems.The migration of tractor services from one area to the other with no servicing and maintenance support for some of the ailing tractors results to complete breakdown. Most tractors don't have greasing facilities and appropriate equipment for field adjustments as they trek from village to village or farm to farm.

The movement from farm to farm through bush paths and bushes resulted to blockage of radiator fins with weed seeds or leaves to cause ineffective cooling system and result to overheating of the system and consequently the breakdown of seals and rings.

Details on Observed Field Breakdowns

TYRES: The need for tyre replacement (especially rare) has been greatly attributed to frequent use of tractors as transport on the highway resulting to rapid wear. The lugs are hardly noticed.

STEERING*:* Steering problems have been very complicated as this could be traced to defects on many parts such as the front and sleeve half axle, kingpin, steering pot and the power system of operation. The worm gear steering box, which is force fitted on the steering shaft is tagged strongly on the shaft to avoid circular-play of the shaft. Power steering systems had leakage and bushing play problems

FRONT AXLE: -Pivot and the central axle are always subjected to wear and therefore a greasing nipple has been fixed to allow lubrication as at when it is deemed necessary but tractor operators hardly attend to this. The neglect results to excessive wear and steering control problems, promote breakage of the axle. The central pin is sometimes likely to move forward and allowing the tractor to fall on a dive.

SLEEVE HALF AXLE: -The tightening of this axle firmly will avoid play and alignment irregularity and the consequent problems. Steering can be very difficult to control under such circumstances. In the arrangement of the kingpin the spindle bushing and bearings may break after excessive wear.

Fuel: -Fuel handling on the field has not been the best on the part of cleanliness. There are instances of water getting into the fuel system.

Tractor Engine: Engine oil level increases as a result of lift pump valve failure that may be caused by the breakage of its diaphragm. The injection pumps end seal could also break and allow diesel to enter the engine. Most nozzles drip instead of spraying.

HYDRAULIC SYSTEM: - When an engine warms up and the hydraulic system starts to fail, it indicates that the hydraulic cylinder is severely worn out, seals broken or blockage in the

chamber valve. This normally happens when the cylinder is working with low-level hydraulic oil or when the hydraulic oil has loss it viscosity and appears soapy in colour; due to the absence of checking to change both hydraulic oil and filters, and this can bring about the rings been broken

ELECTRICAL SYSTEM: **-**It is also observed that the electrical system is not functional in majority of the tractors. Given the standard working hours to be eight (8) hours, it would have been possible to increase the working hours by having the lighting system on the tractor functioning.

Most of the tractors surveyed have no batteries on them simply because their alternators which did not receive proper maintenance were broken down which had resulted to their batteries always running down or the destruction of the cells of the batteries. Apart from starting inability, the absence of a battery will have also a great economic effect on the tractor because the tractors would be left running continuously unless a facility of a ground slope is available to allow pushing to start.

COOLING SYSTEM: **-**The tractor works continuously for less than eight hours a day due to the absence of the battery and coupled with other inefficiencies of the cooling system. Improper cooling system will shorten the life span of a tractor especially when the radiator is blocked or choked and the thermostat is faulty. It would be worse if the water pump functions badly. Most of the tractors had their radiator lid/cup removed to enable them top water as and at when they realized that the boiling water in the radiator is not pouring out and indication that the water level of the radiator has gone down.

Input Cost of the Tractor-Implement Aggregated Operations

Effective utilization of the Farmtrac tractor was measured in relation to the field capacity, time and with some comparison with theoretical provisions. Input cost as shown in Table 4 was published by Mahama et al [6] in which is hereby reproduced for analyses linked to the results.

Table 4. Results of Hourly Input Cost ($) of Operation of the Farmtrac 70 and Implements

ITEMS	**Farmtrac-70 Aggregations**			
	Idling Tractor	**Tractor +Plough**	**Tractor +Harrow**	**Tractor +Trailer**
Depreciation	1.102	1.221	1.186	1.356
Repair Maintenance Cost	0.812	0.918	0.870	1.048
Insurance & Housing	0.148	0.166	0.160	0.184
Interest on Capital	0.248	0.276	0.267	0.304
Fuel- Tractor plus	1.367	4.649	3.188	3.546
Lubrication (15% Fuel)	0.205	0.697	0.478	0.532
Salary of Operator	2.340	2.340	2.340	2.340
Sub-Total	6.222	10.267	8.489	9.310
Miscellaneous at 15%	0.933	1.540	1.273	1.397
Total Cost (TC)	7.155	11.807	9.762	10.707

Source: Mahama .A.A et al[6]

Further analyses were done on depreciation and repair to fuel consumption as illustrated in Table 5 to establish the impact of depreciation and repair cost with fuel consumption in connection with the aggregations and operations of the study (Operation fuel difference). The percentage of depreciation and repair cost compared to the total of input cost is stated in each operation. Given that the idling of a tractor without any operation will be considered as the base, then any further increase in consumption will be taken as the cost of consumption against the aggregation and operation after idling (operational cost difference).

The relativity index was arrived at by Mahama et al [6] to be 12 as the ratio was 2.25 and fuel consumption was 5.44 L/h.

Table 5. Depreciation and Repair (D&R) cost Impact Analyses on some field Operations in an hour

ITEMS	Farmtrac 70 Aggregations				
	Idling Tractor	Tractor + Plough	Tractor + Harrow	Tractor + Trailer	Ave
Depreciation: ($)	1.102	1.221	1.186	1.356	1.216
Repair and Maintenance ($)	0.812	0.918	0.870	1.048	0.912
Total of D& R	1.914	2.139	2.056	2.404	2.128
Operational Difference	--	0.225	0.142	0.490	0.214
Total Cost (TC) (Ref Table)	7.155	11.807	9.762	10.707	9.858
Depreciation Value to T C (%)	15.40	10.34	12.15	12.66	12.34
D & R to TC (%)	**26.75**	**18.12**	**21.06**	**22.45**	**21.59**
Fuel-Cost of operation	1.367	4.649	3.188	3.546	3.188
Dep. & R to Fuel ratio	**1:0.7**	**1:2.17**	**1:1.55**	**1:1.48**	**1:1.50**

To stay updated for some time before a review, the calculation done with Table 5 can be considered appropriate on relativity basis and be applied for strategic purposes for maintenance of farm aggregates with wheel tractors through fuel consumption. As shown in Table 5, the relativity of fuel consumption to the other input cost such as the depreciation whose mandate is to renew the machine plus the maintenance input could serve as the fund for tractor repair and maintenance management. The ratio of depreciation repair and maintenance to fuel consumption rate is indicated as 1:1.5. Therefore the amount needed to be put into the repair and maintenance fund should be 66% or two thirds of fuel cost.

CONCLUSIONS

Conclusions have been drawn from the survey and summarised below: -

1. Repair outlets are located at mainly in the regional capitals.
2. There is the monopoly of the existing tractor companies who have played very little role in sustaining the ailing tractors that are now requiring repairs.
3. Training programmes for personnel in the tractor Management, Mechanics and Operators have been few and not regular. This has played a major role in the numerous problems usually encountered in bringing down revenue and the unexpected breakdowns
4. Repair planning activities does not consider the depreciation value of various parts and therefore repairs/replacement of some vital parts such as tyres, electrical system (starting and lighting) and second counter gear does not get the appropriate attention timely.
5. The back wheel tyres, steering box, hydraulic system, gearbox and electrical system were in deplorable situation.
6. The worse of all these that needed attention in terms of strategy the back tyres

RECOMMENDATIONS

1. Refresher training should be part of the maintenance exercise.
2. A monitoring team should be constituted to coordinate the exercise.
3. Care should be taken to avoid the monopoly of the existing tractor companies who have played very little role in sustaining the ailing tractors that are now requiring repairs
4. Repair outlets should be close to farmers strategically distributed with emphasis on village or district, activity, etc.

5. Special attention should be given to tyres replacement. All tractors need regular servicing of the electrical system (starting and lighting).
6. Depreciation values of 66% of fuel cost should be deducted into a fund to support the replenishing of the tractors as at when they need capital repair attention.
7. Regional workshops should be organized for farmers on tractor aggregation and economic application.

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FACTORS ASSOCIATED WITH ADOPTION OF WEED CONTROL TECHNOLOGIES AMONG FOOD CROP FARMERS IN NIGERIA

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Key Words: Weed control, Food crop, Adoption, Best Management Practices (BMP)

Abstract
Weeds are the tropical farmers' major problem and it has affected their socio-economic well-being. A substantial amount of available time and labour resources are being committed to control these weeds and this translates to increased cost of production and inefficiencies. This would affect the farmers' food production decisions and consequently lead to overall food shortage in the economy. In this study, available methods of weed control techniques, the extent of adoption of the weed control technologies and the associated determining factors among food crop farmers in Akinyele local government area of Oyo state were examined. Using a 2- stage proportionate random sampling procedure, relevant primary data were obtained from 65 farming households. Descriptive statistics and Tobit model were the analytical tools. The study revealed that both traditional (mostly hand weeding) and improved (technologies) were employed by the farmers. These include pre-emergence and post-emergence herbicide, increased crop density, use of cover crops among others. About 23 percent of the farmers use only traditional methods to control weeds while 68 percent combine the two methods at varying proportions. The use of solely improved technologies was practiced by only nine percent of the farmers. The farmers in this category were also found using selective herbicides. The Tobit analysis showed that, number of years spent in school, crop enterprise cultivated, membership of farmers' cooperative, access to training on weed control and volume of credit received were the significant variables affecting adoption of weed control technologies. Farmers should be encouraged to form themselves into groups as this would improve the degree of connectedness. Hence information of alternative technologies would be disseminated freely among the farmers. Policy intervention towards enhancing farmer's performance should also be re-directed at staging extension training on weed control technologies.

Introduction
The productivity of small scale farmers in Nigeria has always been described by various studies to be very low. This category of farmers represents 95 percent of the total food crop farming units in the country and produce about 90 percent of the total food output [7]. Consequently, the low productivity status of these farmers has persistently locked them in a poverty cycle over years that seem to have no outlet. One of the major reasons for the poor performance of the sector according to those studies [2] and [11] is seldom use of modern inputs especially agrochemicals such as herbicides in the control of weeds. Weeds are generally referred to as unwanted plants in a farm land or plant in an undesired place. Weeds can compete with productive crops or pasture, or convert productive land into unusable scrub. Weed are also often poisonous, distasteful, produce burrs, thorns or other damaging body parts or otherwise interfere with the use and management of desirable plants by contaminating harvests. They provide competition for space, nutrients, water and light,

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although how seriously they will affect a crop depends on a number of factors [14]. The study of [3] confirmed that smallholder farmers manage weeds in upland rice by hand weeding with hoes and machetes but are faced with high labour cost as a result of labour shortage. Available submissions have revealed that adoption of herbicide contributes to profit made by the farmers base on the cost-benefit analysis. For instance; productivity of herbicides used in corn and soybeans was investigated where combinations of preplant incorporated and pre-emergence treatments (herbicides) were selected and were evaluated to determine their effect on crop yield. Corn and soybean yields increased with herbicide use, thereby resulting in a positive net benefit to growers. Benefit/cost ratios for herbicide use in corn and soybeans were calculated to be 2.8/1 and 2.6/1, respectively [6].

Problem Statement and Objective of the study

Weeds are the tropical farmers' major problem and it has affected their socio-economic well-being. A substantial amount of available time and labour resources are being committed to control these weeds and this translates to increased cost of production and inefficiencies. This would affect the farmers' food production decisions and consequently leads to overall food shortage in the economy. The food production decision of the farmers is governed by safety first rule and multiple objectiveness [10]. They are primarily concerned with household survival, food security and as a result; they are risk averse. According to [1], the savanna zone of Africa, including Nigeria, weed is a number one pest, which farmers must contend with, in 25 out of 30 common crops. The perennial incidence of weed on farming activities has led to increasing soil degradation, cereal specific soil borne problems, negative micronutrient balance, decimation of crop yields or even land abandonment and consequently severe poverty incidence among farm families in Nigeria [5]. Investment in relevant and appropriate method of weed control thus becomes an important issue for discussion. Eliciting information on factors associated with the use of weed control technologies would definitely provide insights for the stakeholders in the policy arena. Several studies have extensively exposed the potential damages by weeds on food crops while others have empirically revealed the cost benefit analysis of the use of appropriate weed technologies. The studies are however incapable of providing relevant information such as extent of herbicide use and the determinants of adoption that this study seeks to reveal.

The foregoing therefore permits us to pursue the following objectives:

1. The available weed control technologies and adoption extent employed by the farmers
2. The associated determining factors for the adoption among the farmers

Material and Methods

The study was carried out in Akinyele local government area of Oyo state, Nigeria. The data for this study were obtained mainly from primary sources. Using a 2-stage proportionate random sampling; with farming communities at the first stage and farming households at the second stage. Primary data were collected from 79 farming households in the study area with the aid of structured questionnaire. However, data from 65 households were eventually used in the analysis owing to inconsistencies in others. Data collected included socio-economic, demographic and farm characteristics, available weed control technology in the area and use. The analytical framework for this study includes descriptive statistics and the Tobit regression analysis. The descriptive statistics were frequency count, percentages and means. Adoption in this study is with respect to farmers responses to herbicide usage in weed control based on Weed Best Management Strategies (BMP) as used

by [4]. A 'Yes' or 'No' response to observance of each of the listed practices in Table 1 below is used to generate an adoption index for the respondents. Thus a respondent has maximum of 10 points if he observes all and a minimum of 0 if none of the practice is observed.

Table 1: Weed Best Management Practices

Serial Number	Weed Best Management Practices
1	Scout fields before an herbicide application
2	Scout fields after an herbicide application
3	Start with a clean field, using a burndown herbicide application or tillage
4	Control weeds early when they are relatively small
5	Control weed escapes and prevent weeds from setting seeds
6	Clean equipment before moving between fields to minimize weed seed spread
7	Use new commercial seed that is as free from weed seed as possible
8	Use multiple herbicides with different modes of action during the cropping season
9	Use tillage to supplement weed control provided by herbicide applications
10	Use the recommended application rate from the herbicide label

Tobit model was used to identify the factors associated with adoption of weed technology. The Tobit regression, a hybrid of the discrete and continuous dependent variables, was used to determine the effects of the explanatory variables (socio-economic, demographic and farm characteristics) on adoption of herbicide technology among the farmers. The model is expressed below following [13] and [8].

$$Y_{i*} = BX_i + e_i$$
$$Y_{i*} = 0, \; if \;\; Y_i = 0$$
$$Y_{i*} = Y_i \; if \;\; 0 < Y_i \leq 1$$

Where Y_i^* is the limited dependent variable, which represent the farmers Adoption indices

Y_i is the observed dependent (censored) variable
X_i is the vector of independent variables,
B is a vector of unknown parameters,
e_i, is a disturbance term assumed to be independently and normally distributed with zero mean and constant variance σ; and
$i = 1, 2,...n$ (n is the number of observations =65).

The independent variables specified as determinants of the Adoption levels were defined as follows:

The following socio-economic, demographic and farm characteristics (independent) variables were considered

AGE	=	Age of farmer in years
EDUCATIO	=	Number of years of formal Education of the farmers
FARMEXP	=	Number of years of food crop production
MCOOP	=	Member of Cooperative Societies (D=1 if yes, otherwise D=0)
HOSIZE	=	Household size
TFSIZE	=	Total farm size in hectares
INDIVERS	=	Income source diversification index (Estimated by Simpson index)

TRAINING = frequency of extension agents' visit
CREDITVL = Credit volume in Naira
MAIZE = Enterprise (D=1 if Maize, otherwise 0)
CASSAVA = Enterprise (D=1 if Cassava, otherwise 0)
COWPEA = Enterprise (D=1 if Cowpea, otherwise 0)
YAM = Enterprise (D=1 if Yam, otherwise 0)

If Y_i^* is assumed to be normally distributed, then consistent estimates can be obtained by performing a Tobit estimation using an iterative Maximum Likelihood algorithm. The use of maximum likelihood estimation guarantees that the parameter estimates will be asymptotically efficient and the appropriate statistical tests can be performed. This means that all the parameter estimators are asymptotical normal, such that test of significance analogous to the regression t- test can be performed [9].

Results and Discussion

Available Weed Technology in the Study area and Usage among the Respondents

The study revealed that about 23percent of the farmers existed mainly on weed control using hand and hoe weeding alone (Table 2). A total of 68percent of them were combining other weed control options with usual hand weeding. These were pre-emergence herbicides and tillage (18.46 percent), post emergence herbicides and increase in crop density (20.00percent), cover cropping and solarizing (4.6 percent) among others as detailed in the table. However, 9.23 percent of the respondents were discovered controlling the weeds with aid of herbicides only. An important note from the result is that more farmers were still operating only on hand or hoe weeding only; an option that would not only easily bring about drudgery especially on a relatively large area of land, but inefficiency of labour use. Given that herbicides were used by 68 percent of the respondents (either fully or combined) than other methods probably implies the acceptance and effectiveness of herbicides among them.

Table 2: Available Weed Control Technology in Use in the Study Area

Available Weed control Technology in the study area	**Frequency**	**Percentage**
Hand/hoe Weeding only	**15**	**23.08**
Pre-Emergence Herbicides + Tillage	**12**	**18.46**
Post-Emergence Herbicides + Increase Crop Density	**13**	**20.00**
Cover cropping + Solarizing	**3**	**4.60**
Solarizing + Post Emergence Herbicides	**13**	**20.00**
Cover Cropping + Crop Rotation	**2**	**3.00**
Tillage + Crop Rotation	**1**	**1.50**
Herbicides only	**6**	**9.23**
Total	**65**	**100.00**

Adoption of Herbicides among the Respondents using Weed Best Management Practices (BMP) Approach

Adoption index for the respondents was generated using Best Management Practices (BMP). The BMP is a ten point statements based on the necessary operations involved in herbicides usage before an adoption could have taken place (Table 3). A point is awarded for

the farmer with a "Yes" response to a statement while a "Nil" is awarded otherwise. In any case, ten points was the highest mark and zero; the lowest and this gives the index of adoption among the respondents. The response of the farmers is as presented in Table 3 below for the 44 farmers (68 percent) using herbicides. "Scout field after an herbicide application" has the highest "Yes" response (43 percent) while "use new commercial seed that is as free from weed as possible" has zero "Yes" response (0.00percent). A relatively less than average "Yes" response were recorded in others statements as shown in the Table thus the average adoption index was estimated at 0.34 This implies that an average food crop farmer in Nigeria only involved in three of the ten practices involves in order to record a whole success of the herbicide usage based on BMP.

Factor Associated with adoption of Herbicides usage in Weed Control

The factors associated with adoption of herbicide usage were captured using Tobit model, as specified in the methodology. The regression parameters and diagnostic statistics were estimated using the maximum-likelihood Estimate (MLE) technique (Table 4). The result shows that the sigma (σ) is 0.0676 with a t-value of 12.422; hence sigma is statistically significant ($P < 0.01$). This indicates that the model had a good fit to the data. The computed chi- square statistic, 59.34 was not significant ($P > 0.05$). This shows that there is no significant multi-colinearity in the model. In the analysis, seven of the thirteen (13) coefficients, estimated in the model were statistically significant at different levels between one percent ($P < 0.01$) and ten percent ($P < 0.1$) levels of significance. The intercept is 0.2442 and this represents the autonomous adoption index coefficient for the farmers in the study area. The variables that significantly influence adoption of herbicides were Years spent in school (0.0144, $P<0.01$), Membership of farmers' cooperative group (0.6112, $P<0.01$), Training (0.0728, $P<0.01$), Credit volume (0.1824, $P<0.01$), Cultivation of Maize enterprise (0.3327, $P<0.01$), Cassava enterprise (0.0022, $P<0.05$) and Yam enterprise (0.0921, $P<0.1$). All the significant variables have positive coefficients hence would lead to adoption of herbicide usage. For instance, if the farmer is literate enough; with years spent in school as proxy, would enable him to read, understand and apply the recommended application rate from the herbicide label. Improvement in the credit volume received would also enable the farmer to have a high degree of freedom in investing in herbicides since it has been proved to have more incremental benefits than the incremental costs.

Conclusions and Recommendations

The study concludes that the herbicides were used by the food crop farmers along with other weed control technologies. However, the BMP adoption rating scale shows that average adoption of the herbicide is well below average. Years spent in school Membership of farmers' cooperative group, Training/Extension visit, Credit volume received, Cultivation of Maize enterprise, Cassava enterprise and Yam enterprise influence adoption of herbicides among the food crop farmers in the study area. Farmers should be encouraged to form themselves into groups as this would improve the degree of connectedness. Hence information of alternative technologies would be disseminated freely among the farmers. Policy intervention towards enhancing farmer's performance should also be re-directed at staging extension training on weed control technologies while a well coordinated adult literacy programme should be embark upon.

Table 3: Distribution of Respondents by Adoption of Weed Best Management Practices (BMP)

Practice	Yes	No	Total
Scout fields before an herbicide application	24(54.55)	20(45.45)	44 (100)
Scout fields after an herbicide application	28(43.08)	16(56.92)	44 (100)
Start with a clean field, using a burndown herbicide application or tillage	9(13.85)	35(86.15)	44 (100)
Control weeds early when they are relatively small	20(45.45)	24(54.55)	44 (100)
Control weed escapes and prevent weeds from setting seeds	10(15.38)	34(84.62)	44 (100)
Clean equipment before moving between fields to minimize weed seed spread	19(29.23)	25(70.77)	44 (100)
Use new commercial seed that is as free from weed seed as possible	0(0.00)	44(100)	44 (100)
Use multiple herbicides with different modes of action during the cropping season	6(13.64)	38(86.36)	44 (100)
Use tillage to supplement weed control provided by herbicide applications	12(18.46)	32(81.54)	44 (100)
Use the recommended application rate from the herbicide label	19(29.23)	25(70.77)	44 (100)

Table 4: Tobit Model Estimation of Factors Associated with Herbicide Adoption

Variable	***Coefficients***	***t- value***
Constant	0.2422	1.7995
Age	-0.0452	-0.6234
Years spent in school	0.0144***	2.9338
Household Size	-0.0406	-0.4512
Farming Experience	-0.0327	-0.5682
Membership of Cooperative	0.6112***	2.8472
Farm size	0.0921	0.8991
Income diversification	0.0431	1.0397
Extension Visit/Training	0.0728***	3.0142
Credit Volume	0.1824***	3.2213
Maize	0.3327***	4.1654
Cassava	0.0022**	2.2335
Cowpea	0.0019	0.0953
Yam	0.0921*	1.7457

***= significant at P< 0.01, **= significant at P< 0.05 and *= significant at P<0.1
Sigma = 0.0676; (t = 12.4722) significant at p <0.01
Computed Chi square statistic = 59.34

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Economic Analysis Of Small- Scale Catfish Farming In Ido Local Government Area Of Oyo State, Nigeria

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Key Words: Economic Analysis, Small- scale, Catfish.

ABSTRACT

This study analyzed the economics of small-scale catfish farming in Ido Local Government Area of Oyo State. Sixty small-scale catfish farmers were selected using simple random sampling technique. Structured interview schedule was used to collect information from the respondents. Descriptive analysis revealed that the average age of respondents was 45.07 years. Average year of schooling was 9.5 years and 90% of them use earthen ponds. The major problems faced by the catfish farmers were predators, high cost of inputs and finance. Per harvest cost and returns analysis revealed the gross margin as N428, 917. 78, net revenue as N370, 154.40 and the benefit-cost ratio (BCR) as 2.173. This result shows that catfish farming is a profitable enterprise. Regression analysis was employed to determine the relationship between cost of production and returns. Adjusted R^2 of 89.6% revealed that rent on land, Pond construction cost, Cost of fingerlings, feed cost, transportation, as well as salary and wages were significant factors affecting total revenue of respondents.

INTRODUCTION

Fish farming is the sub-set of aquaculture that focuses on rearing of fish under controlled or semi-controlled conditions for economic and social benefits. Aquaculture is the rearing of aquatic organisms under controlled or semi-controlled conditions for economic and social benefits. Aquatic organisms include fishes, molluscs, crustaceans and aquatic plants. Culture implies some forms of intervention in the rearing process to enhance production such as regular stocking, feeding, protection from predators etc. [2].

Fishing, like any other hunting activities has been a major source of food for human race and has put an end to the unsavory outbreak of anemia, kwashiorkor and so on. Fish is one of the most diverse groups of animals known to man with more than 20,500 species in existence [3]. It accounts for about one fifth of world total supply of animal protein and this has moved up five folds over the last forty years from 20 million metric tons to 98 million metric tons by the year 1993 and projected to exceed 150 million metric tons by the year 2010. Fish farming also generates employment directly and indirectly in terms of people employed in the production of fishing output other allied business [6]. An estimated 43.5 million people were directly engaged (part time or full time) in primary production of fish either in capture from the wild or in aquaculture representing 3.2 percent of global 1.37 people in active agriculture and a further 4 million people were engaged on an occasional basis [4]. According to [8], small-scale and home-use catfish farming are significantly more sustainable than intensive production. Because inputs are minimized, small-scale practices can substantially reduce production costs. The savings realized by producing fish for direct consumption reduce the farm family's cost of living and improve their quality of life. Small-scale catfish production offers Kentucky's farm families quality food at wholesale prices, a source of supplemental income, and a means of diversifying farm enterprises. These home-use techniques broaden Kentucky's farm culture and enhance opportunities in rural areas overall. When compared with livestock, it requires less space, time, money and has a higher

feed conserving rate. In further production of animal meat and other production in Nigeria and in world at large, the fish serve as an additive and good nutritive supplement (ingredient) for the production of various animal meals and other products [7].

Clarias specie has wide acceptability as a food in Nigeria and because it is a fast growing specie that adapts well to culture environment and also because it can be retailed live and attracts premium price. Channel and blue catfish are both suitable for stocking in ponds. However, channel catfish are more readily available from private hatcheries and tolerate low dissolved oxygen better than blue catfish. Blue catfish grow larger than channel catfish after the second year post-stocking. There is no difference in taste or flesh texture between the two species [6]. Catfish is highly nourishing. It contains lysine as well as vitamins A that are necessary for healthy growth. It also contains some quantities of calcium, phosphorus, fat and other nutrients needed for human growth and health. Catfish is a major source of protein to an average Nigerian home and through small-scale production, it is expected that there would be an increase in the supply of catfish which directly would mean an increase in the protein supply to an average Nigerian family, and this would definitely have a positive effect on the national income as healthy people tend to work harder [5].

Most of the past studies in Nigeria focused on large scale fish farming. Some others have their focus on the nutritional aspect. To this end, an economic analysis of small-scale catfish farming, which is the focus of this study, would serve as a guide for investment decision to both current and potential farmers. Information on the various inputs that contribute significantly to output would be of much benefit to intending catfish farmers.

Objectives of the study

The major objective is to analyze the economics of small-scale cat fish farming in the study area. The specific objectives are to;

- Identify the socio- economic characteristics of catfish farmers in the study area.
- Investigate the inputs employed in catfish farming in the study area.
- Analyse the cost ant returns to catfish farming in the study area
- Identify the problems militating against catfish farmers in the study area.

Hypothesis of the study

There is no significant relationship between the cost of inputs used and total revenue generated by small-scale cat fish farmers.

METHODOLOGY

Study Area

The study area is Ido Local government area of Oyo State. It is one of the local government areas located in Ibadan, the state capital. Ido area is well drained with some rivers which the indigenes of the area used for domestic purpose and fish cultivation. There are two main seasons; the rainy season, and dry season. The rainy season is from April to October, the dry season is November to March. The major occupation of residents in the area is farming. Population size of the area is two hundred and sixty seven thousand, eight hundred and sixty five (167,865).

Method of data collection

A list of registered catfish farmers was collected from the local government headquarters. The list of small-scale catfish farmers were extracted from the register and a random sampling technique was used to select 60 catfish farmers (40%) from the list. According to [1]'s classification, Nigerian farmers fall in to three broad categories, namely, small scale with 0.10 to 5.99 hectares, medium scale with 6 to 9.99 hectares and large scale

holdings with 10 hectares upward. Structured interview schedule was administered to the selected catfish farmers. Information was collected based on the objectives of the study.

Data analysis

Data collected were analyzed using both descriptive and inferential statistics. Cost and returns analysis was also carried out to investigate the profitability of the enterprise. Descriptive analyses involve the use of tables, percentages, frequency and mean. Inferential statistics involve the use of regression analysis to establish the relationship between the dependent variable and independent variables.

This is implicitly expressed as:

$Y = f(x_{1.....}, x8)$

Where Y= Total Revenue generated by respondents

X = [Rent on land(X1), Stocking density(X2), Pond construction cost(X3), Cost of fingerlings(X4), Feed cost(X5), Cost of veterinary services and drugs(X6), Transportation cost(X7), Level of education(X8), Year of experience(X9), Salaries & wages(X10)]

The a priori expectation of this study is that an inverse relationship exists between revenue and cost of production.

Cost and returns analysis investigates the profitability of the business:

Total Revenue = Output * Unit price

Total cost = Total variable cost + Total fixed cost

Gross margin = Total Revenue – Total Variable Cost

Profit = Gross Margin – Total fixed cost (depreciated value)

$$\text{Benefit cost Ratio} = \frac{\text{Total Revenue}}{\text{Total Cost}}$$

RESULT AND DISCUSSION OF FINDING

Socio-economic characteristics of respondents

Data collected showed that both male and female were involved in catfish production as 78.3% of the respondents were males while 21.7% were females. It revealed that 50% of the respondents were between the age range 41-50 years, and they constitute the largest population of the catfish farmers. Mean age for the respondents was 45.07 years.

Education is important in achieving high level of management capabilities. Findings showed that a good number of the farmers in the study area received some level of formal education. About 33 percent of the respondents claim to acquire tertiary education. On the average, the respondents spent 9.5 years in school. Eighty-three percent of the respondents claimed between 1-6 members within household. The average household size was 6. Finally, the average years of fishing experience by the farmers was 5.88 years.

Inputs employed in catfish farming

Table 1 depicts different types of inputs employed by the respondents in there production activities. Most (90%) of the farmers employed earthen ponds while only10% use catfish tanks. There are variations in pond sizes of respondents .According to them, large ponds are economical but can not be easily managed. Smaller ponds are easily managed and more suitable for those just venturing into the enterprise. Average pond size in the study area was 482 meter squared, with an average depth of 3 meters. This conforms to [8]'s submission that ponds as small as 0.25 acre or as large as 20 acres are suitable. However, ponds in the 1-to 5-acre range are more practical. The table also shows the stocking schedule of fingerlings by the farmers in the area. Average stocking rate for the respondents was 1640 fingerlings. Fertilizer is an important input to catfish farming in the study area. Eighty-six percent (86.7%) of respondents claimed to use poultry waste, 10% use cattle dung while 3.3% use NPK in the study area. Thirty three percent of respondents claimed to depend on family

labour while 67% use hired labour. Other inputs used by the respondents are: land, water, feed, shovels, fishing nets, veterinary services and drugs. The average land area allotted to fishing activities by respondents was1.37 hectares. This conforms to [8]'s finding that fish farming requires less land area compared to crop and livestock production. Underground water and rain water are major sources of water for fishing activities in the study area.

Table 1: Inputs employed by respondents

Fish pond (type)	**Frequency**	**Percentage**
Earthen pond	54	90.0
Concrete tank	6	10.0
Total	**60**	**100**
Fingerlings (stocking rate)		
1000-2000	36	60.0
2001-3000	24	40.0
Total	**60**	**100**
Fertilizer & Lime		
Poultry waste & lime	52	86.7
Cattle dung & lime	6	10.0
NPK & lime	2	03.3
Total	**60**	**100**
Labour (type)		
Family	**20**	**33.3**
Hired	**40**	**66.7**
Total	**60**	**100**

Source: Field survey, 2009

Cost and Returns Analysis per Harvest

According to the respondents, harvesting is carried out twice in a year, that is, six months interval. The following analysis is done based on per cropping operation. The average values for the sixty respondents were used.

Variable cost components for the respondents include fingerlings cost, fish meal, fertilizer and lime, vetenary services and drugs, transportation, salary and wages.

Average variable cost = # 256,930.55

Fixed cost components for the respondents include rent on land, pond construction, fishing-net, shovel, e.t.c.

Average fixed cost = #58,763.43

Average total cost = Average variable cost + Average fixed cost
= # 256,930.55 + #58,763.43
= #315,693.98

Revenue = quantity harvested (kg) * price per kg
=1,558.74 * # 440
= # 685,848.33

Benefit Cost Ratio (BCR): which is total revenue divided by total cost i.e. TR/TC.

$$BCR = \frac{TR}{TC} = \frac{685848.33}{315693.98} = 2.173$$

An investment is profitable if the BCR is greater than 1.

Gross Margin: This is calculated as revenue minus variable cost

GM = R-VC

= ₦685848.33- ₦ 256,930.55
= ₦ 428,917.78k
This shows that catfish production is profitable.

Profit**:** This is the net benefit of doing business.
Profit = Gross margin – FC (i.e. revenue – cost)
= ₦428, 917.78 – ₦ 58,763.43
= #370,154.40 k

Going by the above analyses, a catfish pond of 482 meter squared, stocked with 1640 fingerlings, within the next six months will yield 1,558.74kg of catfish to give a profit of #370,154.40k to the investor. This finding agrees with [6] and [8] that small-scale catfish farming is a profitable enterprise.

Problems faced by catfish farmers in the study area

It is clearly shown from table 2 that catfish farmers encounter diver problems in the course of their production activities. The major ones include high cost of input, predators and finance. According to the respondents, most of sources of credits demand for collaterals they could not afford, while others delay such that it does not meet up with the purpose it was meant for.

Table 2: Problems faced by the catfish farmers

Problems	Frequency	Percentage
High cost of input	47	78
Limited market sales	26	43
Inadequate extension visits	33	55
Flood problem	16	25
Predators	57	95
Finance	44	73

Source: Field survey, 2009.
* Percentage greater than 100 due to multiple responses

Result of regression analysis

The analysis determined the relationship between dependent and independent variables. The R-squared of 0.896 indicated that the estimated independent variables explained 89.6% of the variations in revenue to catfish farmers in the study area, while the remaining 10.4% are exogenous to the system. From table 3, the result showed that rent on land, pond construction cost, feed cost, transportation cost, as well as salary and wages have negative significant relationship with revenue. The negativity indicated that the variables and revenue move in opposite directions i.e. the higher the cost of negatively signed variables, the lower the revenue. This agrees with the a priori expectation of the study.

However, contrary to a priori expectation, cost of fingerlings was found to be proportionally related to revenue. This could be accredited to the fact that high quality fingerlings cost more. But at the end of the day, they produce better yield which results to higher revenue.

Conclusion

This study concluded that small-scale catfish farming is a profitable enterprise, especially when there is proper management of inputs, absence of predators, and when timely source of loan is available. The study concluded that there is significant negative relationship between cost of production and total revenue made by catfish farmers in the study area.

Based on the findings and conclusion of the study, the following recommendations are made: Catfish farmers should form themselves into cooperative groups or association and

purchase inputs in bulk for the use of members so as to reduce per head cost of production. The cooperative groups can also provide timely loans to its members at a much reduced interest rate; as well as constitute an avenue for the farmers to share improved management information.

Table 3: Result of regression analysis

Variable	Coefficient (b)	t- ratio	significance
Constant	6447.227	0.185	0.854
Rent on land	-0.928	-8.253	0.000
Stocking Density	0.315	0.053	0.958
Construction cost (Pond)	-1.010	-7.813	0.000
Cost of fingerlings	36.466	99.474	0.000
Feed cost	-0.725	-5.280	0.000
Vet. Services & Drugs	-0.331	-0.506	0.615
Transportation	-1.133	-5.046	0.000
Level of education	2.884	0.365	0.717
Year of experience	-10.192	-1.240	0.221
Salary and wages	-0.957	-2.304	0.026

Adjusted R- squared =0. 896 F-value = 83.313 (0.000)

Source: Data analysis, 2009.

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Comparative Economics Analysis Of Maize Production Under Furrow And Sprinkler Irrigation In Ogun–Oshun River Basin Development Authority

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Key words: maize, sprinkler, furrow, rain-fed production function.

Abstract

*Irrigation is an artificial application of water to the soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost,*http://en.wikipedia.org/wiki/Irrigation - cite_note-0 *suppressing weed growing in grain fields and helping in preventing soil consolidation. This study compares maize production under furrow and sprinkler irrigation system in Ogun- Oshun River Basin Development Authority in Nigeria. Primary data were collected using purposive sampling technique to elicit information from 120 maize farmers under sprinkler, furrow irrigation and rain-fed system. The socio- economic characteristics of the respondents reveals that majority of the respondents were male, married, had formal education and between the age of 30 and 39 years. From the gross margin analysis, maize production under sprinkler irrigation is more profitable than furrow irrigation. The result of the regression analysis revealed that all variables that are statistically significant at their various levels of significance carry positive sign which conform to a priori expectation. The result revealed that all the resources were not used efficiently hence not to optimum economic advantage.*

INTRODUCTION

Maize is a major cereal consumed by nearly all Nigerian households. It has great dietary and economic importance. Since the 19th century, maize has become the prime source of grain for feeding monogastic animals especially in those parts of the country where cassava cannot be grown (1). Apart from animal feeding, it is the key to agro-allied industrial raw materials from which many products are manufactured. With regards to food, processed maize is used in several ways-'ogi', 'Eko' (wrapped semi-solid pap), 'moinmoin'. It can be eaten as roasted or boiled; it can also be cooked along with beans. In some local areas, it can be pounded along with yams, cocoyam and water-yams. As a result of the different uses into which maize can be put, there has been an increase in its demand over the years. (2) reported that the domestic demand of 3.5 m metric tones far outstripped domestic production of 2.0 m metric tones, hence the increase in its price. To increase domestic demand, various efforts were made by various governments to raise the level of production but with limited success. According to (3), price fluctuations, disease and pests, storage facilities and efficiency of resource utilization are the identified causes of low maize production in Nigeria.

Until recently, most of the production of maize has been restricted to the rainy season. However, the introduction of irrigation facilities through the provision of dams and reservoirs and the development of fadamas has necessitated the need for increased maize production in the dry season. Irrigation is an artificial application of water to the soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost

(4),http://en.wikipedia.org/wiki/Irrigation_-_cite_note-0 suppressing weed growing in grain fields (5) and helping in preventing soil consolidation.

Three main categories of irrigation development that exist in Nigeria are; Public irrigation schemes which are systems under government control; the farmer-owned and operated irrigation schemes that receive assistance from government in form of subsidies and training and residual floodplains and fadama, where no government aid is supplied and based on the traditional irrigation practices. (6). Efficient water management largely depends upon selecting the method best suited to local conditions because irrigation management systems differ from region to region in a country. Water is one of the primary inputs for crop production. Proper timing and a judicious amount of use of this input along with scientific methods of application are important for achieving a good yield when properly combined with other input. One aspects of the poor performance of irrigation schemes has been defective methods of water distribution between the farmers at the head and the tail ends of the water courses and inefficient management of the irrigation department, (7).

Therefore, this study is aimed at comparing the economics of maize production under furrow and sprinkler system of irrigation in Ogun-Oshun River Basin Development Authority. Specifically the objectives of this study are to identify the socio-economic characteristics of maize farmers under furrow and sprinkler system, determine the cost and returns to maize production, identify factors affecting maize production, and to examine resource- use efficiency in furrow and sprinkler system.

MATERIALS AND METHODS

Abeokuta irrigation scheme and Itoikin irrigation project were specifically chosen as the study area for this research work. Sampling procedure adopted is purposive sampling technique to select the sampling size of 120 farmers which comprises of 40 farmers with furrow system of irrigation. 40 farmers with sprinkler irrigation system and 40 farmers with rainfall system as control for the research.

The data were analyzed using descriptive statistics, gross margin analysis and the production function.

The implicit form of the production is given as:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6)$

Where Y = Total output in kilogrammes and X_1, X_2, X_3, X_4, X_5, X_6 are Farm size (ha); Labour used (mandays); Fertilizer(kg); Herbicide(litre); Seed(Kilogram) and irrigation charge (₦) respectively. The production function was fitted using three functional forms, which are linear, semi-logarithms and Cobb Douglas. Chow test analysis was used to test if there is a significant difference in the inputs used and total output under sprinkler and furrow irrigation system.

RESULTS AND DISCUSSION

Socio- economic characteristics of the respondents

The selected socio-economic characteristics in Table 1 reveal that most of the respondents in the three systems were male. The attitude of the respondents in all the three systems was not in consonance with earlier findings by (8) that 48.7% of maize farmer were male. This implies that maize production under the three systems were male dominated

enterprise. In all the three system, a higher percentage of the respondents fall within the age bracket 30 – 39 years. The mean age was 35.9years, 37.years and 37.95years under sprinkler, furrow and rain-fed respectively. This indicates that most of the respondents were in their prime age. Majority of the respondents were married. In essence married people were more involve in maize production under the 3 systems in order to earn more income to cater for their household. This finding agrees with that of (9) who reported that 83% of maize farmers in rural Nigeria were married. Table 1 also shows that most of the respondents from the three systems are primary six certificate holder. This is an indication that majority of maize farmers in Oyo State had at least primary School education. This finding agrees with that of (8) who reported that 26.6% of maize farmer in River state had no formal education. The mean years of maize production were sprinkler (8.83 years), furrow (12.02 years) and rain-fed (11.30 years). This implies that most of the respondents in all the three systems are well experienced in maize production. The major occupation of the respondents in the three Irrigation systems are farming (sprinkler 60%, furrow 72.5%, and rain-fed 65%) This indicates that most of the respondents rely on maize farming for their livelihood.

Cost and Return Analysis

The total variable cost is the costs that vary with the scale of production. For this study, these include seed, fertilizer, chemical, tractor rent, irrigation charge, land rent and payment of labour. From table 2 the highest total cost of ₦102, 675.38 were recorded from sprinkler irrigation system followed by ₦ 78,969.10 from furrow system and the least cost of producing maize came from rain-fed with N 45,242.21. Table 2also reveals that the gross margin of ₦91, 405.57, ₦ 50,987.77 and ₦27, 321.97 were obtained from sprinkler, furrow and rain-fed respectively. It was observed that the total fixed cost obtained from sprinkler irrigation system surpassed other fixed cost obtained from furrow and rain-fed system. This indicates that sprinkler system had higher investment cost than furrow and rain-fed. The Net farm income of ₦ 90,629.74 obtained from sprinkler irrigation was higher that from furrow (₦50, 317.98) and rain-fed (₦26, 991.8). This indicated that production of maize under sprinkler is more profitable and productive than furrow and rain-fed system. The attitude of the respondents in all the three systems is in consonance with earlier findings by (10) and (11). (12) reported that irrigated farms are more profitable than non irrigated farms. The analysis of the profitability ratio in table 3 reveals that maize production under the three systems is profitable.

Table 1: Socio- Economic Characteristics of the Respondents

Characteristics	Sprinkler	Furrow	Rain-fed
Sex			
Male	36(90)	35(87.5)	36(90)
Female	4(10)	5(12.5)	4(10)
Age			
20-29	10(25)	7(17.5)	4(10)
30 – 39	20 (50)	22 (55)	22(55)
40 –49	5(12.5)	7 (17.5)	8(20)
50-59	4(10)	2(5)	4(10)
60-69	1(2.5)	1(2.5)	2(5)
70-79	0(0)	1(2.5)	0(0)
Marital status			
Married	36(90)	32(80)	40(100)
Single	3(7.5)	3(7.5)	0(0)
Widow(er)	0(0)	4(10)	0(0)
Divorced	1(2.5)	0(0)	0(0)
Separated	0(0)	1(2.5)	0(0)
Educational Level			
No formal education	7(17.5)	11(27.5)	12(30)
Primary Six	20(50)	17(42.5)	20(50)
SSCE	8(20)	11(27.5)	4(10)
Tertiary	5(12.5)	1(12.5)	4(10)
Experience			
1-10	32(80)	24(60)	26(65)
11-20	6(15)	12(30)	8(20)
21 – 30	2(5)	3(7.5)	6(15)
31-40	0(0)	1(2.5)	0(0)
Main Occupation			
Yes	24(60)	29(2.5)	26(65)
No	16(40)	11(27.5)	14(35)

Source: Field Survey .2009

Table 2: Cost and Return Analysis

Characteristics	Sprinkler	Furrow	Rain-fed
Variable cost(V.C)			
Seed	9152.50(8.9)	7359.38(9.3)	2878.75(6.4)
Fertilizer	34515(33.6)	26085(33.03)	9909(21.9)
Chemical	16972.05(16.5)	9650(12.2)	6100(13.5)
Tractor rent	8000(7.8)	6596.77(8.4)	4000(8.8)
Land rent	3350(3.3)	2084.85(2.6)	514.29(5 .6)
Payment of labour	19400(18.9)	20210.81(25.6)	9510(3.1)
Irrigation charge	10510(10.2)	6312.50(8.0)	-
Total V.C	***101899.55(99.2)***	***78299.31(99.1)***	***44912.04(99.3)***
Total fixed cost			
Cost of equipment	*775.83(0.8)*	*669.79 (0.9)*	*330.17 (0.7)*
Total cost	***102675.38***	***78969.1***	***45242.21***
Total revenue (TR)	193,305.12	129,287.08	72,234.01
Total variable cost (TVC)	101,899.55	78,299.31	44,912.04
Gross margin (GM)	91,405.57	50,987.77	27,321.97
Total fixed cost (TFC)	*775.83*	*669.79*	*330.17*
Net farm income	90,629.74	50,317.98	26,991.8
BCR = TR/TC	1.88	1.64	1.60
ROR = $\frac{TR-TC}{TC}$	0.88	0.64	0.60
GRR = TC/TR	0.53	0.61	0.63

Source: Field survey, 2009

C. Regression Analysis

Of all the model fitted for the three systems, linear equation was chosen as the lead equation based on statistical measures of performance such as the F-statistics, R^2 (adjusted coefficient of multiple determination), significance of individual coefficient and the appropriation of the signs of the regression coefficient. The result in Table 4 shows that all the variables that are statistically significant at their various levels of significance carry positive sign which conform to *a priori* expectation. The results indicate that farm size was a significant and positive determinant of the output in the three systems at 1 percent level. This means that output is greatly affected by farm size. Hence an increase in this variable will lead to a substantial increase in the output of maize. This corroborates a study by (9) who reported a positive and significant relationship between farm size and output. Labour and herbicide are only significant under furrow irrigation system at 1% and 10% level of significance respectively. Fertilizer is positive and significant under furrow irrigation system and rain-fed at 1% and 5% level of significance respectively. Seed is only significant under the rain-fed at 1% level of significance.

About 93.8%, 94% and 92.4% of variability in the dependent variable was accounted for by the independent variables under sprinkler, furrow and rain-fed respectively. The F

value was found to be significant at 1% level of significance in all the system and it implies that all the explanatory variables taken together have a significant effect on the total output.

Table 4: Regression Analysis

Variable	*Sprinkler*	*Furrow*	*Rain-fed*
Constant	283.571 (2.014)**	27.988 (0.252)	23.124(0.331)
Farm size (Ha)	394.036 (3.288)***	15.091(2.599)***	347.772 (5..020)***
Labour (Man-days)	0.639 (0.933)	0.426 (3.095)***	0.163 (1.631)
Fertilizer (kg)	4.109 (0.227)	65.814 (5.740)***	6.620 (2.503)**
Herbicide (litre)	1.43 x10-^{8} (0.422)	11.326 (1.817)*	17.177(1.218)
Seed (kg)	7.240 (1.638)	0.899 (0.614)	13.004(2.675)***
Irrigation charge (₦)	0.001 (0.100)	0.00198 (0.108)	-
R^2	0.938	0.941	0.924
F	64.659***	68.424***	60.788***

Source: Field Survey, 2009

Figure in parenthesis represent t – value

*Represent coefficients that are significant at 10%; **represent coefficient that are significant at 5%; *** represent coefficient that are significant at 1%;

Resources used Efficiency in the three Systems

The marginal value productivity (MVP) and marginal input cost (MIC) is the yardstick for judging the efficiency of resource used. A given resource is optimally allocated when there is no divergence between its marginal value productivity and marginal input cost. A positive MVP implies that output could be raised by using more of a given resources but the magnitude of MVP must be compared with the MIC in order to determine the worthwhileness of increasing output given the level of resource used.

Table 5 shows that, the ratio of MVP to MIC is less than one for labour and seed in all the three systems. This indicates that there is over-utilization of these resources in the study area. Hence, in order to increase output of maize under the three systems, the use of labour and seed must be reduced. Fertilizer is over – utilized under the sprinkler and ran-fed and under-utilized under the furrow irrigation system. However, herbicide has the ratio of MVP to MIC greater than one in sprinkler and furrow irrigation system showing that they are under-utilized. Thus, in order to increase the output, the quantity of herbicide must be increased whereas it is over-utilized under the rain-fed. Since the ratio of MVP to MIC for all the input in the 3 system are not equal to one, therefore maize farmers are inefficient in their resource use under furrow and sprinkler irrigation system.

Table 5: Resources Used Efficiency in the three Systems

	MVP	MIC	MVP/MIC
Sprinkler System			
Labour	*1186.94*	*19400.00*	*0.061*
Seed	0.000027	16972.05	$1 X10^{-9}$
Fertilizer	7632.47	34515.00	0.22
Herbicide	13448.30	9152.50	1.47
Furrow System			
Labour	*430.79*	*20210.81*	*0.021*
Seed	909.11	7359.38	0.12
Fertilizer	66554.41	26085.00	2.55
Herbicide	11453.42	9650.00	1.19
Rain-fed			
Labour	*66.59*	*19805.41*	*0.0033*
Seed	2704.27	2878.75	0.94
Fertilizer	7016.80	7909.00	0.89
Herbicide	5312.13	10904.83	0.49

Source: Field Survey, 2009.

CONCLUSION

The result of analysis carried out in this study shows that maize production under sprinkler system had the best and highest gross margin and net farm income than furrow irrigation system. Therefore, maize production under sprinkler system is more profitable and productive than furrow irrigation system in the study area. Since maize production under sprinkler system is the best and profitable, it is now suggested that Government and Ogun-Oshun River Basin Development Authority should introduce sprinkler system in their project that do not have sprinkler system in order to boost food production in Nigeria.

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Women's Preference For Credit Sources On Small Scale Poultry Production In Egbedore Local Government, Osun State

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Keywords: preference, small scale, cooperative society, poultry products

Abstract

Small scale poultry raising is a popular activity among women in most countries. It can provide meat and eggs for the family, a small and fairly regular source of cash, manure for crop production, items for traditional rituals and gift for friends. Also women control the marketing of poultry and poultry products with resulting income theirs to use [6]. The study examined the women's preference for credit sources available on small scale poultry production in Egbedore Local Government area of Osun State. To achieve this, the study identified the socio-economic characteristics of the poultry farmers, examined the effect of credit on poultry production and investigated the problems faced by the poultry farmers. The population for the study comprises women poultry farmers within the local government. Structured Interview schedule was used to collect information from eighty (80) women farmers in the study area, while Simple random sampling technique was used to select respondents from the compiled list of farmers. Data analysis was carried out using frequency counts, percentages and chi-square. The results of the analysis revealed that most of the respondents preferred to obtain credit from cooperative societies which is due to its easy accessibility, lack of collateral and availability of credit facilities when needed. Empirically, the Chi-square test indicates that a significant relationship exist between the age, marital status, household size, educational level, years of experience and preference for credit sources at 0.05 level of significance . The findings of the study revealed that the major constraint faced by small scale poultry farmers is high cost of feed. Therefore, it is recommended that farmers should be encouraged to form more cooperative societies or strengthen the existing ones, so as to purchase feed in bulk at a reduced price.

INTRODUCTION

The complexity of forces working against poor women in developing countries is now greater than ever as the worldwide recession and the severe food crisis throughout most of sub- Saharan Africa have particularly intensified the burden on poor women. They now increasingly contribute to and often as sole responsibility for the welfare of their families, where the men are forced to migrate to cities, mines or abroad [5]. Lack of credit for use as working capital has always been a problem for women in all aspects of Agriculture including poultry. Women were of a significant disadvantage in gaining access to credit, as women general have lower saving level than men and therefore obtained lower return on saving due to minimum balance requirements in banks. According to [3], womens' production capacities in Nigeria seems to be constrained as a result of lack of access to productive resources due to discriminations in property ownership and gender division of labour in unpaid productive and reproductive activities. Also, lack of access to labour as a result of norms of gender hierarchy/ separation and lack of access to markets due to their exclusion from the most lucrative markets, as highlighted by [1]. According to [4], high cost of agricultural inputs where available and in availability/ inaccessibility of capital and credits to landless farmers with hardly any form of collateral security constitute some of the barriers that inhibit active

female participation in agriculture and Industry in Nigeria.[2] defined credit as the monetary or financial aspect of capital resources. According to him credit can take such forms as (i) money in cash or bank draft and (ii) in kind as forms of biological and physical capital purchase and supplied to producers. In these two main forms, credit is often classified into short, medium and long term. Short term credit means loans for period as one cropping season and not exceeding one or one and a half years. Medium term is for two to five years, while long term credit is for longer periods. In the same vein, [8] stated that agricultural credit encompasses all loans and advances granted to borrowers whether beneficiaries of agricultural or other reforms of finance and service production activities relating to agriculture. Therefore [9] emphasized the need to design special programmes to improve women's cooperative farming and poultry through informal credit source such as the traditional credit groups like the ajo, esusu, and co-operative societies. It has been reported that inadequate information about the improved technologies was one of the constraints in poultry production, as well as women's little access to agricultural credit and control of land. Hence, for women poultry farmers to practice farming with ease and contribute their own quota to improve productivity, women's sources of credit should be ascertained. Thus, the problem of this study is centered upon the following questions: i. What are the socio-economic characteristics of the poultry farmers, ii. What are the effects of credit on poultry production, iii. What are the constraints to small scale poultry production.

Objective of the Study

The main objective of the study is to determine women's preference for credit sources on small scale poultry production in Egbedore Local Government of Osun State.

The specific objectives are to: i. identify the socio economic characteristic of the respondents, ii examine the effect of credit on poultry production, and iii. Investigate the constraints to small scale poultry production.

Hypothesis of the Study

HO1: There is no significant relationship between the socio-economic characteristics of the respondents and their preference for credit sources.

METHODOLOGY

The study was carried out in Egbedore Local Government Area of Osun State, which was purposively selected due to the fact that majority of the women were engaged in small scale poultry production. Respondents were selected from eight agricultural cells, after which simple random sampling technique was used in selecting ten respondents from each cell from the list of registered poultry farmers in the Local Government headquarter. In all we have eighty respondents for the study. This study used primary data generated through structured interview schedule, and information was obtained on socio- economic characteristics of the poultry farmers, effects of credit obtained on poultry production and constraints to small scale poultry production. The independent variables are age, marital status, household size, farm size, years of experience and educational level, while the dependent variable was determined by choice of sources of credit. Data collected was analyzed with the use of descriptive statistics for the objectives and the use of chi square analysis for determining the relationship between the variables.

DATA ANALYSIS AND DISCUSSION

Socio-economic characteristics of the respondents

Result of the table 1 showed that about half(48.8%) of the respondents are young farmers between the ages of 21 and 40 years. The mean age of the respondent was estimated

to be 43 years, indicating that majority of the respondents were within the middle age of 41 – 50 years with the tendency to utilize credit obtained judiciously. Table 1 also showed that majority of the respondents are married (65%). This implies that married women are more involved in poultry production. 53.9% of the respondents have between 5 and 8 members in their household, The average household size is about 5 members. 76.2% of the respondents were literate. This conforms with the findings of [7], that high literacy level of respondents would afford them the opportunity to easily understand and adopt information on modern farm practices thereby enhancing their productivity. The average poultry farm size in the study area is about 242 birds. It can also be revealed from table 1 that majority of the respondents (56.3%) have only been in poultry farming for about 3years. This suggest that majority of the respondents are new in the business.

Table 1: Socio economic characteristics of respondents.

Variable	Frequency	Percentage
Age		
21 -30	16	20.0
31 -40	23	28.8
41 -50	24	30.0
51 -60	10	12.5
Above 60	7	8.9
Marital Status		
Single	11	13.8
Divorced	8	10.0
Widowed	9	11.3
Married	52	65.0
Level of Education		
Non-formal	19	23.8
Pry uncompleted	7.5	7.5
Pry completed	4	5.0
Sec uncompleted	7	8.8
Sec completed	23	28.8
Tertiary	21	26.3
Year of Experience		
1-3	45	56.3
4-7	22	27.6
7-9	9	11.4
>10	14	5.0
Household size		
1-4	34	42.6
5-8	43	53.9
9-12	3	3.8
Stock size		
1-100	37	41.3
101-200	22	27.6
201-300	5	6.3
301-400	2	2.6
401-500	5	6.3
>500	9	11.5

Source: Field survey 2009

Effect of Credit on Poultry Production

The table 2 below shows that 38.8% of the respondents utilize credit for improved feeding quality, 37.5% for increasing stock size and to 16.3% credit gives the opportunity to have access to modern equipment. Also 6.3% of the respondents agreed that credit gives access to adequate technology. While to 2.5% of the respondents, credit helps to provide

health facilities for the poultry birds. It can be revealed from the table that access to credit have a great impact on the feeding quality, stock size and modern equipment.

Table 2: Effect of credit on poultry production

Effect of Credit	*Frequency	Percentage %
Increase in stock size	70	37.5
Access to modern equipment	50	16.3
Improved feeding quality	31	38.8
Access to improved technology	5	6.3
Improved health facilities	2	2.5

Source: Field Survey 2009
***multiple response**

Constraint to small scale poultry production

Seven possible constraints to poultry production were itemized for the respondents to identify one as the main pressing problem. They included high cost of feed, gender factor, low level of literacy, pest and diseases, high mortality rate and poor market. High cost of feed was identified to be the major problem facing poultry production as 75% of the respondents considered it as the most pressing problem. This was followed by poor market (72.5%), high mortality rate (68.8%), stock procurement (50.0%), pest and disease (37.5%), gender factor (13.8%) and low level of literacy (12.5%). The majority of the farmers considered high cost of feed and poor market as the major problem militating against poultry production. These findings are in agreement with the findings of [9] that poultry enterprise in Nigeria is constrained by some factors, major among which is the high cost of production inputs.

Table 3: Distribution of respondents by Problems faced

Problems	Frequency	Percentage
High cost of feed	60	75.0
Gender factor	11	13.8
Low level of literacy	10	12.5
Pest and diseases	30	37.5
High mortality rate	55	68.8
Poor market	58	72.5
Stock procurement	40	50.0

Source: Field Survey, 2009

Preference for Sources of Credit

The table below shows the different sources of credit available to the respondents in financing poultry production. The preference of farmers for credit sources was measured on a three point scale most preferred, preferred and not preferred with assigned weight to each point. The preference score was ranked and it was revealed that cooperatives society was ranked first among others. This might be due to the fact that loan from this source does not involve collateral, high rate of interest, and also loan can be obtained at any particular time when needed for poultry production.

Table 4: Distribution of respondents by preference for credit source

Credit Source	Most preferred	Preferred	Not preferred	Score	Rank
Commercial Bank	5(6.3)	10(12.5)	65(81.3)	20	4
Relatives and friends	30(37.5)	20(25.0)	30 (37.5)	80	2
Money lenders	20(25.0)	10(12.5)	50 (62.5)	50	3
Cooperative society	60(75.0)	20(25.0)	0 (0.	140	1

Source: Field Survey 2009

Test of hypothesis

Chi-square test

The table below indicates that a significant relationship was found between preference for sources of credit and all the socio economic characteristics of the respondents' at 0.05% level of significance. This implies that age, marital status, Household size, educational level and years of experience have effect on the women's preference for the available credit sources.

Table 5: Relationship between socio-economic characteristics and preference for credit sources

Socio economic xtics	x2 value calculated	Degree of freedom	x2 tabulated	Decision
Age	16.82	2	5.99	sig
Marital Status	28.71	2	5.99	sig
Educational Status	26.63	4	9.49	sig
Household Size	48.77	5	11.07	sig
Years of Experience	87.76	4	9.49	sig

Level of sig = 0.05

SUMMARY, CONCLUSION AND RECOMMENDATION

A total of eighty poultry farmers were interviewed, It was revealed that majority of the respondents are in their active age. Married women are more involved in poultry production while majority of the respondents in the study area can read and write. Based on the findings, it could be observed that most of the respondents are constrained with high cost of feed, while majority of the respondents preferred to obtain credit from cooperative societies. This might be due to the fact that credit obtained from this source is easily accessible, no collateral is involved and there is little or no interest involved. The chi-square test indicates that there is a significant relationship between the socio-economic characteristics of the respondents and their preference for sources of credit.

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Integrating Appropriate Architecture and Food Production in Rural Nigeria: Cassava, Adobe, and Education

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The project I will discuss presents a design solution I am developing in Igbogun, Nigeria to tackle water related issues through education and training vis-à-vis (1) the processing of cassava, a major food source and (2) climate specific architecture to improve upon unsustainable building practices. Current processing techniques of both cassava and concrete have led villagers to mismanage their water resources in pursuit of economic interest. Subsequently, the quality of water in Igbogun is poor and inadequate for a village with over 600 people. To implement this project (3), I will teach villagers ways to make money using sustainable farming and construction practices.

Almost all of the villagers are subsistence farmers and (1) processing cassava is one of their main sources of income. Unfortunately, the main issue affecting well water quality is the method for processing cassava during food preparation. Cassava must be peeled then soaked before it can be consumed. Waste water produced during this process infiltrated nearby ground water which affected the quality of well water downstream. Five out of six wells in the village have been rendered useless as a result. Well water is no longer potable and can not be used for irrigation due to high levels of turbidity and arsenic. It is also inadequate for cleaning purposes because the water became too hard and can not be used to form a soapy lather.

Water is available from a nearby stream, but this source has also been mismanaged in pursuit of economic interest. Local concrete brick manufactures (2) excavated soil along the stream to make and sell concrete blocks in local building material markets. This led to erosion along the banks of the stream, and eventually pockets of standing water began to collect and fill after heavy rains which facilitated an increase in malaria infections. Ironically, concrete blocks are not the most appropriate building material for this climate. Utilization of adobe brick would be more appropriate and could mitigate the environmental impact of using concrete blocks for construction.

A design solution (3) which I am developing to address the water related issues integrates education and training on processing cassava in a facility built to encourage and promote the use of adobe brick and bamboo as appropriate building materials. This educational facility will be a mixed use primary school/community and college resource center. I want to teach villagers how to make money using techniques that do not jeopardize the quality of their water supplies. I look forward to sharing my ideas and learning from others so that we can integrate methods on how to best implement appropriate water technologies in areas of need throughout Sub-Saharan Africa.

Water Management for Pharmaceutical Manufacturing in a Resource-Constrained Environment

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Abstract
A water purification system, using a 52 M deep underground water source, has been designed and installed to provide a reliable source of water for pharmaceutical manufacturing at LaGray. The system delivers water with pH of 6.7, total dissolved solids (TDS) =of 11.7 mg/L, total hardness = 12.5 mg/L and with no viable microbial counts. These parameters meet internationally (WHO) acceptable criteria for pharmaceutical GMP. Similarly, a comprehensive self-sufficient aqueous effluent treatment system has been designed and installed for the purification of wastewater from the plant. Treated effluent from the system meets all criteria stipulated by the Ghana Environmental Protecting Agency (GEPA) for safe discharge into the environment, except for phosphate content (2.9×10^{-4}), which is slightly above the limit (2.0×10^{-4}). Approaches to reducing the phosphate content further include improving the level of aeration and increasing the amount of aquatic plants in the final aerobic pond.

Introduction
The importance of local manufacturing of pharmaceuticals in developing countries cannot be overemphasized. Local manufacturing improves access to affordable medicines, thereby reducing the disease burden in these parts of the world. However, with the introduction of new technologies and new processes come new challenges that must be faced. One such challenge is the management of water used in such manufacturing facilities. There is first the supply of water for manufacturing and then the handling of effluent water. These fundamental requirements for the operation of a pharmaceutical manufacturing plant, which may be taken for granted in a resource-endowed setting, could pose debilitating challenges in a resource-constrained environment such as Ghana.

a. Supply water
As dictated by principles of good manufacturing practices (GMP) for pharmaceuticals and mandated by medicine regulatory agencies, water for pharmaceutical manufacturing must meet certain minimum standards. It must first be derived from a potable water source and purified to meet strict specifications for total dissolved solids (TDS), pH, hardness and microbial contamination. Storage and distribution of the purified water must be such that re-contamination, especially by microorganisms is prevented.
In a developed environment, these requirements are attained by connecting to municipal pipe-borne water, which is typically potable, passing the water through a reverse osmosis system, storing in a stainless steel tank, heating and circulating at 80°C to discourage microbial growth in the storage vessels and to prevent build up of biofilm in the supply lines. Distribution outlets are typically fitted with cooling devices to bring the temperature of the circulating hot water to ambient temperature for immediate use in manufacturing or as required.

In a resource constrained environment of a developing country, such as Ghana, the problems that these requirements pose are the following: 1) Pipe-borne water supply is not readily available or reliable, hence some manufacturers rely on water of questionable quality delivered by tankers as the starting point. 2) Water, where available, usually contains high amounts of dissolved solids and is quite often also high in microbial contamination thereby posing challenges to the water purification process. 3) The supply of electricity is unreliable and utility costs are high. Hence continued maintenance of stored water at 80°C and subsequent rapid cooling to ambient temperature is prohibitive at best and mostly impractical.

b. Effluent water

There are strict environmental requirements in Ghana for the discharge of industrial aqueous effluent into the environment. Such effluent must be treated to a certain minimum standard for biological oxygen demand, conductivity and phosphate content before discharge. In highly industrialized countries, efficient sewer systems exist into which industrial waste is discharged after minimal treatment. The effluent is then subjected to communal treatment to the required level of acceptability and discharged into large bodies of water.

There are no centralized sewage systems in Ghana for either household or industrial waste. Hence the only legal way of handling industrial aqueous effluent is to design and operate an independent waste treatment system.

System Design

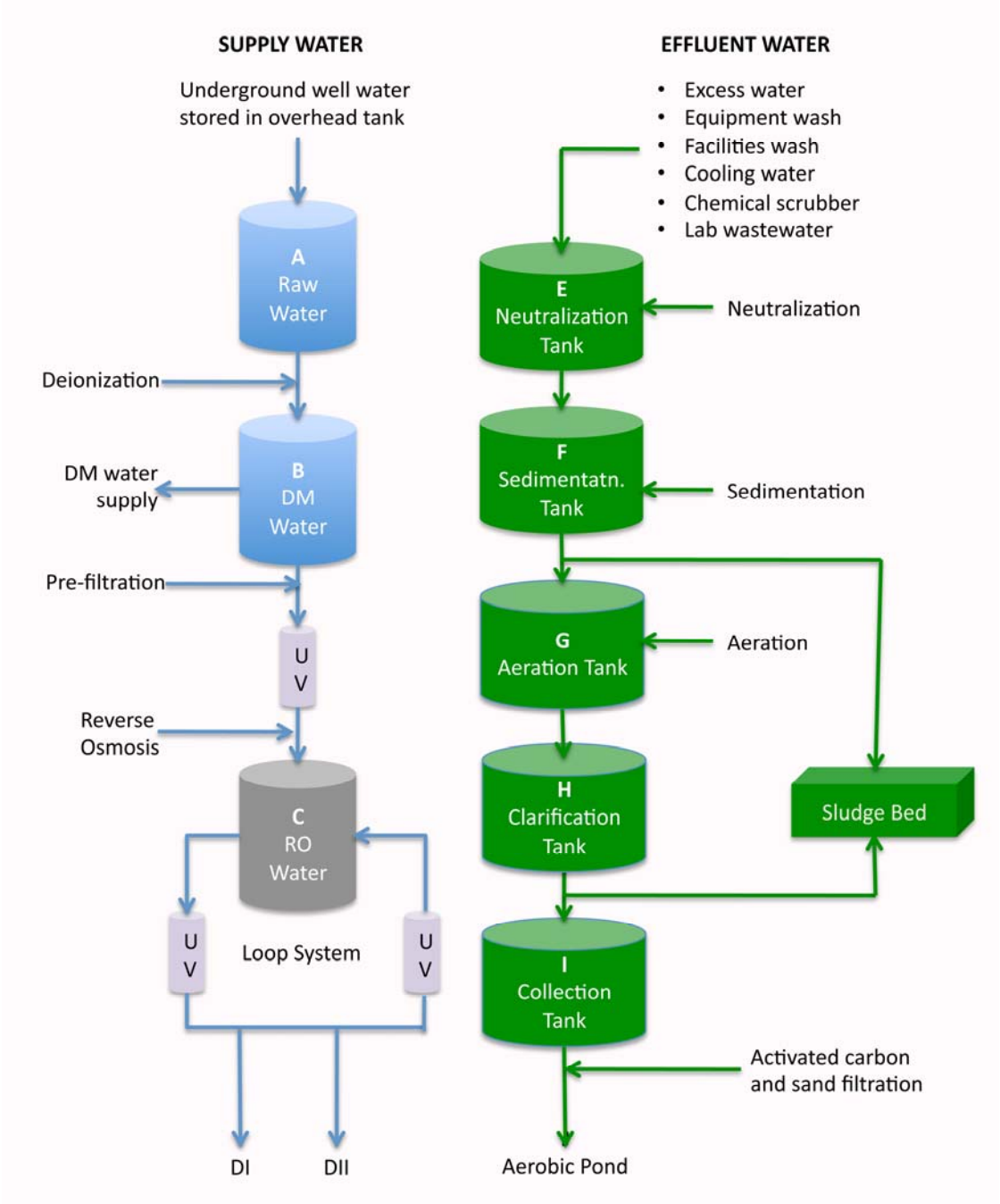
LaGray is a fully vertically integrated manufacturer of pharmaceuticals, with the capacity to manufacture active pharmaceutical ingredients as well as finished dosage forms. The facility is therefore both a fine chemicals manufacturing plant as well as a finished dosage plant that produces capsules, tablets, creams, liquids and powders. It is the first of its kind in West Africa and operates in compliance with international standards of GMP. The company conducted a comprehensive environmental impact study in association with project implementation and undertook a commitment to GEPA to comply with guidelines and stipulations for safe wastewater. In this paper, we describe how GMP requirements for pharmaceutical water, as well as GEPA requirements for wastewater are both met by the company, in spite of challenging resource constraints.

a. Supply water treatment system

The design concept of the water management system is as shown in Figure 1. The source of primary raw water is an underground well 52 M in depth and with a capacity flow rate of 120 gallons per minute. This provides an independent and reliable source of water that is relatively free of microbial contaminants compared to what occurs in fresh surface water sources. The underground water is pumped into a 50,000 L galvanized overhead tank for storage. The water flows by gravity to a 2,500 L HDPE tank in the utility block for further treatment.

The raw water is subjected to demineralization by sequential passage through a cation and anion exchange resin. The resins are regularly monitored for efficiency and regenerated as needed. The demineralized (DM) water is stored in a 5000 L capacity HDPE tank. Supply lines from this tank provide DM water for use in a number of functions including boiler feed, equipment washing and most laboratory use.

Figure 1, Water management system



The DM water is passed through a UV sterilizer and subjected to further purification by double passage through a reverse osmosis (RO) plant. The RO water is then stored in a 500 L RO water storage tank. The tank is constructed from No 316 stainless steel and is equipped for heating. The system, including piping, after the RO plant is entirely constructed out of No. 316 stainless steel.

The RO water is constantly circulated through a loop system. The recirculation flow rate of 2.5 m^3/hr produces turbulent flow that minimizes formation of a bio-layer in the tank and piping. Other features that reduce microbial contamination include three UV sterilizers at

vantage points in the system. One is before the DM water storage tank. The second is before the loop system's outflow and the third is at the return point of the loop system.

The water in the storage tank is intermittently heated to 85-90°C and circulated through the loop system for sterilization. Further, the membranes in the filters and RO cartridges are sanitized with 10% hydrogen peroxide on a quarterly basis. The system as set up and operated in this manner, adequately and consistently provides water that meets the specifications for pharmaceutical manufacturing and is free from microbial contamination without the need for continued circulation of the water at high temperatures and the need to install cooling systems at the usage points.

b. Effluent water treatment system

The sources of effluent water are the following: 1) Excess process water, 2) water from cooling and heat exchange equipment such as condensers, 3) water from chemical processing, including waste water from organic extractions, 4) water used for equipment wash, including water used after production of both API and finished dosage forms, 5) water from the gaseous effluent scrubber and 6) water from regeneration of the cation and anion exchange resins used for process water purification. All effluent water is directed into a neutralization tank (E). As shown in Figure 1, the collected effluent is neutralized by addition of either HCl or NaOH solution.

In the next stage of treatment, the neutralized effluent is pumped into an aeration tank (F) and actively agitated to increase its oxygen content. The aerated mixture is subsequently pumped into a sedimentation tank (G) and separated solids allowed to settle. The settled solids are pumped into a sludge bed and allowed to dry as solid waste. The clarified effluent is pumped through a sand and activated charcoal polishing system to remove trace organic material and then discharged into an aerobic pond.

The aerobic pond is 1.5 M deep and has a surface area of 100 $M.^2$ The pond is constantly aerated by pumping the treated effluent through UV sterilizers, to help reduce excessive algae bloom, and discharging it back into the pond.

Methodology

Supply water monitoring

Samples are tested for total dissolved solids (TDS),
pH, and heavy metals. The sampling points are A, B, C and D as shown in Figure I. Points DI and DII represent two different points of use in the loop system. Chloride content, alkalinity, total calcium and magnesium hardness are determined by standard methods [1]. Physical parameters such as TDS, pH, conductivity and temperature were measured with a composite meter for water sample analysis. Standard buffer solutions of pH 4.0 and 10.0 and standard 0.01 M KCl solutions were used to calibrate the instrument prior to analysis.

Viable counts are performed by placing an aliquot of sample onto pre-poured agar plated, spreading and incubating overnight. Viable counts are determined as colony forming units.

Table 1: Properties at key points in the water supply system

Parameter	Guidelines	Sampling Points			
		A	B	C	D
pH at 25°C	6.5-8.5	7.35±0.71	7.15±0.21	6.70±0.14	6.70±0.04
TDS (mg/L)	≤1000	464.76±6.43	316.32±2.43	20.98±0.13	11.69±0.52
Chloride (mg/L)	≤250	87.89±2.64	57.97±2.64	9.35±2.6	8.11±0.88
Total Hardness (mg/L)	≤500	261.53±2.12	125.51±0.71	13.00±1.41	12.50±0.24
Total Alkalinity (mg/L)	-	275.14±8.15	163.22±6.60	39.64±3.30	40.06±0.78
Ca^{++} Hardness (mg/L)	-	164.02±2.83	73.50±0.71	7.00±1.41	6.50±0.071
Mg^{++} Hardness (mg/L)	-	97.51±0.71	52.01±0.01	6.50±0.71	5.67±0.94
Microbial content (CFU/mL) I	100	-	-	-	0.00
Microbial Content (CFU/mL) II	100	-	-	-	0.00

Table II: Properties at key points in the effluent treatment system

Parameter	GEPA Limits	Compartment					
		E	F	G	H	I	J
pH at 25°C	6-9	7.00 ±0.14	6.95 ±0.07	8.10 ±0.14	8.00 ±0.14	7.55 ±0.35	8.40 ±0.14
Temperature (°C)	<3°C + Ambient	26.00 ±0.14	25.95 ±0.07	26.30 ±0.57	26.25 ±0.49	25.35 ±0.64	25.90 ±1.13
TDS (mg/l)	≤1000.0	518.80 ±3.96	639.90 ±3.11	493.75 ±6.29	498.40 ±3.96	496.35 ±9.97	460.50 ±6.22
Conductivity (µS/cm)	≤1500.0	759.65 ±4.17	920.90 ±2.83	508.75 ±14.91	729.00 ±6.65	728.75 ±9.97	675.60 ±11.03
Cl^- (mg/l)	≤250.0	132.77 ±2.64	117.81 ±13.22	147.73 ±2.64	95.37 ±2.64	95.37 ±2.64	72.93 ±2.64
Total Hardness (mg/L)	≤500.0	159.52 ±2.12	228.02 ±2.83	229.51 ±2.11	235.01 ±1.40	213.515 ±2.11	238.52 ±0.68
Ca^{++} Hardness (mg/l)	-	91.01 ±2.83	91.52 ±2.13	100.51 ±3.53	110.01 ±1.41	96.505 ±2.11	98.01 ±1.41
Mg^{++} Hardness (mg/L)	-	65.51 ±0.71	136.51 ±4.96	129.01 ±1.42	125.01 ±0.01	117.01 ±0.00	140.51 ±0.71
BOD (mg/l)	≤50.0	-	-	1.56 ±0.55	2.34 ±1.10	2.35 ±0.57	1.755 ±0.83
$PO_4^=$ (mg/L)	≤0.0002	-	-	0.0007 ±0.00	0.00067 ±0.00	0.0006 ±0.00	0.00029 ±0.0
NO_3^- (mg/L)	≤0.0050	-	-	0.0017 ±0.00	0.00076 ±0.00	0.0007 ±0.00	0.0007 ±0.00

Effluent water monitoring

The sampling points for the effluent treatment system are E, F, G and H as shown in Figure 1. Additional methods needed for effluent tests are total phosphate, nitrate, chemical oxygen demand (COD) and biological oxygen demand (BOD). These are also determined using standard methods [1,2].

Results

A sample of data collected in …is as shown in Tables 1 and 2. The results of pH, Total Dissolved Solids (TDS), Electrical Conductivity, total, calcium and magnesium hardness, total alkalinity and chloride for purified water (Table 1) recorded were within the World Health Organization (WHO) guidelines for drinking water and for pharmaceutical use. The microbiological data indicated that the purified water met the standards for production.
In case of the treated effluent, the data (Table 2) shows a progressive improvement in effluent quality from stage to stage of purification. All parameters at the final point, the aerobic pond, are well within the range of EPA guidelines, except for phosphate, which is slightly above the recommended limit. This may be due to inadequate aeration of the pond. Approaches being taken to bring the phosphate levels down further include installation of additional pumps for aeration and introduction of more aquatic plants into the pond.

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