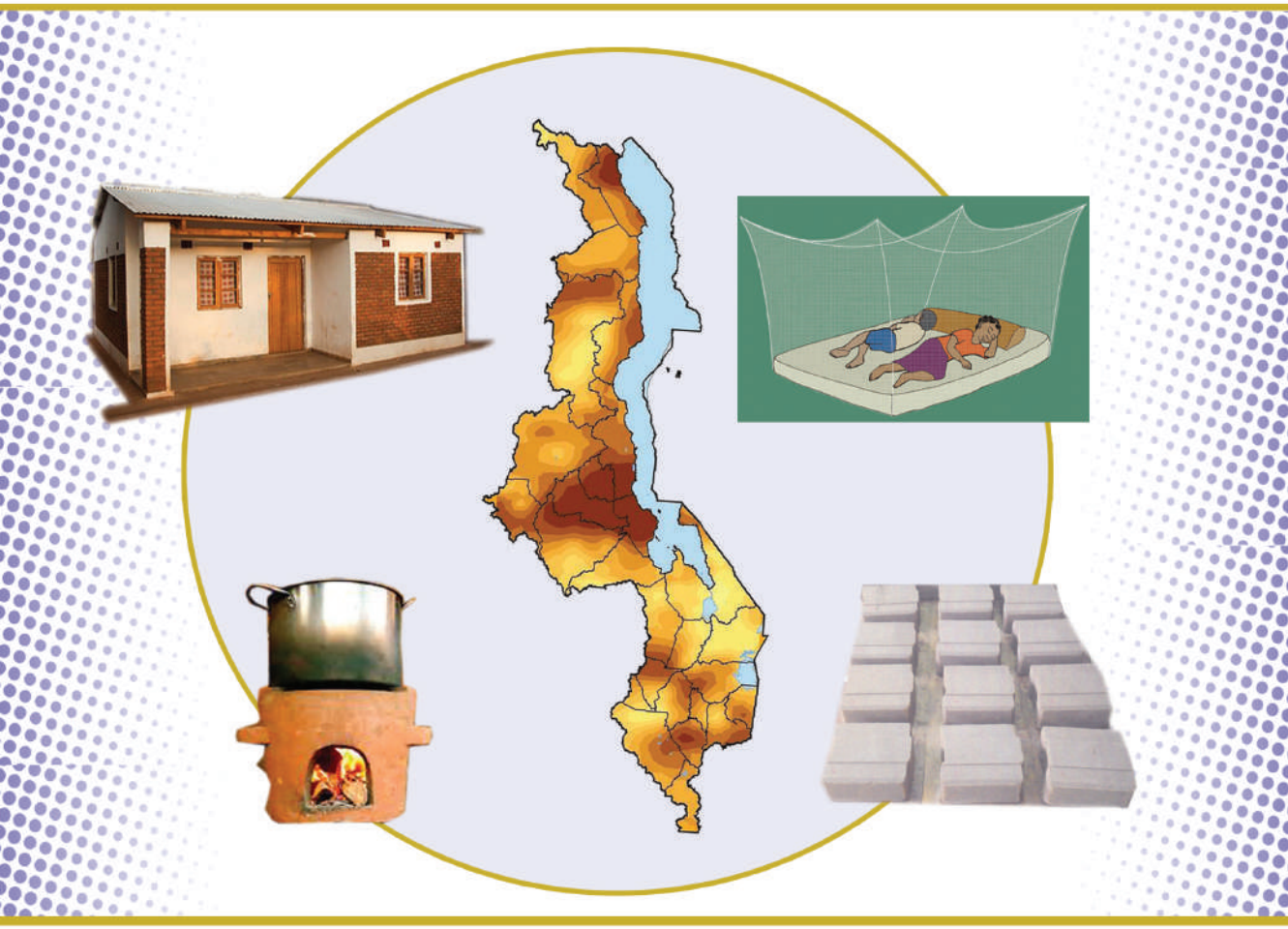
UNIVERSITY OF MALAWI

THE POLYTECHNIC

VOLUME 2 | ISSN: 2522-6878 | 2018



The Malawi Journal of Applied Sciences and Innovation

MJASI

Editorial

We at the Malawi Journal of Applied Sciences and Innovation (MJASI) are humbled to welcome our readers to this Volume 2 of 2018. The journal is indebted to the authors who continue to trust MJASI as a platform for disseminating their research findings and the reviewers who enhance the quality of our publications through peer review. MJASI recognizes the role of publications in bridging the gap among researchers, policy makers and practitioners. The contribution of research and innovation to social and economic development may not be fully realized unless there is appropriate interface among all stakeholders, which are researchers, drivers of policy, practitioners and the larger community. MJASI continues to play its pivotal role in this arena.

Malawi, as other countries in Africa, has her scientists who carry out research in areas relevant to the country and the region. As a nation, we also draw significant benefits from research findings within the region and the world over. The publication of resultant innovations and research findings in home-based journals offer greater access to information for policymakers, members of the community, practitioners and researchers. This is a result of relevant contextualization of research and innovations.

Let me take this opportunity as outgoing editor-in-chief to bid farewell and to extend gratitude to all authors, reviewers and our esteemed readers who earnestly supported us. We appeal for continued support to MJASI and the new editor-in-chief--Dr. Chikumbutso Chiziwa Kaonga. Dr. Kaonga is himself a renowned researcher and publisher who brings to MJASI novel energy to continue with our mission.

MJASI cherishes the ongoing partnership with you, the stakeholders, in 2018 and the years to come. Again, we sincerely thank all of you.

Bernard Thole, *PhD, MSc, B.Ed.(Sci.)*
Editor-in-Chief

Correspondence
Editor-in-Chief,
MJASI,
Polytechnic, University of Malawi
Private Bag 303,
Chichiri, Blantyre 3,
Malawi.

Email: mjasi@poly.ac.mw

Website: http://www.poly.ac.mw

Table of Contents

Provision of Affordable Housing in Blantyre: A Case of Non Governmental Organisations

Terence C.G. Namaona[a*], Mwiza L.V Msiska[b], Rodrick Chilipunde[c] and Doreen Kumbatira[d]

[a]Department of Architecture, The Malawi Polytechnic, 0888317777, tnamaona@poly.ac.mw

[b]Department of Quantity Surveying and Land Economy, 0884940530, msiskamwiza14@gmail.com

[c]Department of Quantity Surveying and Land Economy, 0999918734, rchilipunde@poly.ac.mw

[d]Department of Architecture, The Malawi Polytechnic, 0999851821, doreenkumbatira@gmail.com

Abstract

The provision of affordable housing to the poor remains a serious problem in Malawi. This has seen the rise of NGOs providing affordable housing to the low income groups. However, the rate and quality of affordable housing delivery still remains below satisfactory levels. The paper aimed at investigating the challenges faced by the NGOs in affordable housing provision. The objectives were to examine: the type, quantity and quality of houses provided by the NGOs; the public institutions support to NGOs; and the problems faced by the NGOs in affordable housing provision. In achieving these objectives, the methods used were interviews, questionnaires and observations. The questionnaires were administered to a purposive sample of officials at CCODE, HFH, local councils in Blantyre and a random sample of individuals from Malawi Homeless People Federation. Both qualitative and quantitative data analysis techniques were used. The study revealed that the NGOs are faced with numerous challenges such as: shortage of urban land, rising construction costs, poor coordination between public institutions and the NGOs, financial constraints, lengthy land acquisition process, disputes with local chiefs, and loan defaults by beneficiaries. The implications of the findings are that unless the challenges are resolved, NGOs will continue to deliver inadequate affordable housing. In addressing these challenges, the study recommended that all actors in the housing sector should improve their coordination efforts; the NGOs should enhance financial resources generation mechanisms; the NGOs and local councils should encourage blending of imported building materials with local materials and councils should allow for waiver of planning standards to allow beneficiaries to access secure tenure.

Keywords: Affordable Housing, Challenges, Non-Governmental Organisations, Quality, Quantity, Support

1.0 Introduction

The provision of affordable housing remains a critical problem in urban areas of Malawi (UN-Habitat, 2010). Both the State and the Market have failed to provide affordable housing facilities as they have failed to prioritize development needs of marginalised population. This has therefore seen the rise of NGOs providing housing needs to the marginalised population. However, the status of affordable housing delivery is still far below satisfactory levels. There are many constraints ranging from: lack of effective implementation strategies, poor promotion of security of tenure, inadequate supply of affordable land and infrastructure, inadequacy of housing finance systems and high cost of finance, high cost of building materials, poor utilisation of local building materials and technologies and lack of support to small-scale construction activities. (Thompson, 2009)

Housing affordability connotes the capacity of households to meet housing costs while maintaining the ability to meet other basic costs of living. (Onu, 2010). In agreement with Onu, (2010), Mitlin (2008) defines affordability as referring to people's ability to purchase essential (or basic) goods and services, such as adequate housing, healthy food, and medical care. It means that basic living expenses are less than a household's income. In addition, Centre (2008) argues that the idea of affordable housing recognizes the needs of households whose incomes are not sufficient to allow them to access appropriate housing in the market without assistance.

Many developing countries have failed to come to terms with their housing problems; especially for those people in the low-income groups since provision of shelter is one of the greatest problems in most of these countries. The scale of the housing problem in the third world as a whole remains enormous. Many people are homeless or live in substandard housing which is described as a menace to health and an affront to human dignity. Malawi faces different hazards that include floods, heavy storms, landslides, and earthquakes. Housing conditions have worsened under the pressure of growing populations, increased urbanisation and growing socio-economic problems. (Mwakalila, 2005) . Malawi as a country is not heavily urbanised at present, however, it is one of the highly urbanizing countries in the world at an annual rate of 6.3 per cent (UN-Habitat, 2010). In order to meet its housing demand Malawi needs to build 21000 annually (UNHabitat, 2010). Manda (2011) noted that due to the high rates of urbanisation, Malawi faces a considerable challenge of addressing its shelter needs.

Malawi Housing Corporation (MHC), Centre for Community Organisation and Development (CCODE) and Habitat for Humanity (HFH) are the major institutions involved in the provision of affordable housing in Malawi. Habitat for Humanity (HFH) is a Christian charity organisation that operates using a revolving budget of USD 1.7 million. It provides interest free building material loans and a measure of self-help "sweat equity", (UN-Habitat, 2010). It provides houses under the Mortgage and grants system which has recently been introduced. Since 1986, HFH has helped build nearly 6,500 houses in urban and rural areas of Malawi (Manda, 2011). CCODE was registered in 2003

and works in alliance with the Federation of the Rural and Urban Poor formerly known as Malawi Homeless People's Federation (MHPF) on issues of urban poverty in most urban Centre's of Malawi. CCODE offers support to the Malawi Homeless People's Federation (MHPF) to fulfill its objectives of providing houses, water, sanitation, employment opportunities and other initiatives (UN-Habitat, 2010). CCODE also works with Shack Dwellers International (SDI) and other shelter organisations to support community based federations involved in savings schemes to mobilize their funds to develop low cost community housing schemes. Since 2005, more than 600 houses have been built in Lilongwe, Blantyre and Mzuzu, and a further 600 houses are planned in Blantyre -500 houses and Kasungu -100 (Thompson, 2009).

Existing studies reveal that despite the presence of these institutions, less progress has been made in the provision of affordable housing as such challenges and constraints are still not fully understood. UN-Habitat (2010) reports that for Malawi to address the critical housing issues, it is important to understand how shelter is delivered and those issues that are hindering improved access to shelter.

While a few studies have highlighted challenges facing state led affordable housing delivery, the challenges facing NGOs have not been explored even though these NGOs continue to provide limited quantities and poor quality housing facilities hence failing to meet the housing demand. It is in the light of the above that this study investigated the challenges that NGOs face in the provision of affordable housing in Blantyre City in Malawi. Specifically, the objectives were:

1. To assess the quantity and type of houses provided by NGOs in Blantyre City;
2. To analyse the quality of the houses provided by the NGOs in Blantyre city;
3. To investigate the institutional support and institutional challenges NGOs face in the provision of affordable housing and
4. To examine problems faced by NGOs in the provision of affordable housing.

1 Materials and methods

The study employed both quantitative and qualitative methods in data collection and analysis. Quantitative approach was chosen because it helps to explains to what extent there is residential inadequacies or adequacies. Qualitative approach was chosen because it is appropriate for capturing reality as it is, as experienced by the respondents, sets out to interpret human actions and sets out to capture people's interpretations. The primary data was collected through interviews, questionnaires and direct observation. The people who were interviewed were: senior representatives of the following organisations: HFH, CCODE, Blantyre City Council (BCC) and Blantyre District Council (BDC). They were purposively sampled since they had to be familiar with the issues of particular interest

to the study. Forty randomly selected Malawi Homeless Peoples Federation (MHPF) members who were the beneficiaries of the CCODE housing units were also interviewed to support the information. Observation method was used to assess the quality of the houses provided by the NGOs and to relate responses given by respondents to the quality of the houses provided and their surroundings. A total of forty four questionnaires were administered. In addition to the above, a comprehensive literature review on affordable housing and challenges in housing provision was conducted.

A case study research design was adopted to operationalise the study. This was appropriate for this study as it offers prospects to generate adequately grounded insights that could potentially shed light on similar cases of challenges in housing provision. The approach enabled the study to concentrate on only two NGOs that are active in affordable housing provision and these are CCODE and HFH in Blantyre city in Malawi. The study was undertaken in Blantyre city because it is one of the major areas where these NGOs operate.

The qualitative data was analytically evaluated using combination of content and comparative analysis. Raw data was coded and grouped into different categories. The data collected, the opinions, observations and perceptions were classified into different forms to guide the data analysis. Analysis of data was done by noting key issues, themes, patterns in the responses, making contrasts and comparison, noting the relationship between different issues and building a logical chain of evidence. Coded data was organized according to common themes to identify patterns and highlight crucial ideas as expressed by the respondents. Graphs, charts, frequency tables representing numbers and percentages were used to explain the results of the study.

2 Results and discussion

2.1 Type and quantity of houses provided by the NGOs

2.1.1 Type of houses

From the analysis of responses made by the respondents interviewed, it was noted that the NGOs in Blantyre city are providing semi-permanent type of houses as indicated in table 1:

Table 1: Types of Houses

Type	Frequency	Percentage	Cumulative percentage
Permanent	6	14%	14%
Semi-permanent	38	86%	100%
Traditional	0	0%	

From table 1 above, it is clear that the NGOs provide semi- permanent type of houses as 86% of the respondents indicated that the NGOs provide semi-permanent type of houses.

The fact that the NGOs are providing semi-permanent type of houses implies that the durability, which is an aspect of affordable housing as expounded by Mitlin (2008) is not achieved. The semi-permanent type of houses is also a compromise on the quality of the houses and has an implication on maintenance requirements that are costly. Moreover, the semi-permanent type of housing is also vulnerable to natural disasters such as earth quakes, flash floods and wind storms as listed in (Malawi Government, 2014). Since these NGOs are delivering semi-permanent type of houses, it can be argued that they are challenged in a number of ways as they are not delivering the desired quality of houses.

Picture 1: Showing sample of a semi-permanent house by CCODE in Angelo Goveya, Blantyre city

2.1.2 Quantity of houses

Malawi needs to provide 21000 houses annually in order to meet its demand (UNHabitat, 2010).The study revealed that both NGOs have constructed less than 1000 housing units in Blantyre city .In particular, CCODE provided that they have constructed approximately 532 houses of which 465 are in Angelo Goveya and 67 houses in Machinjiri area 3. HFH indicated that they have constructed close to 350 houses in South Lunzu, Blantyre city under the mortgage system and 31 houses under the grants system making a total of 381 houses. Considering the fact that these NGOs have been in operation for more than 10 years each, CCODE was registered in 2003 and HFH in 1986, these numbers of houses constructed do not match the years they have been in operation and clearly show that these NGOs are challenged in a number of ways hence providing limited number of houses.

2.2 Quality of the houses provided by the NGOs

UN-Habitat (2005) and UN-Habitat (2000) provides that adequate housing must be habitable, in terms of providing the inhabitants with: protection against bad weather; adequate space, privacy and security; and physical security including good construction, ventilation, lighting and sanitation. Good-quality housing is an important element in ensuring a healthy community and country at large. Poor housing leads to many health problems. Everyone should therefore have access to quality housing and a nice home environment that makes them happy and satisfied. The quality of the housing provided by the NGOs in Blantyre City was assessed during the survey and was found generally to be of poor quality except for availability of services.

2.2.1 Legal security of tenure

It was found out that CCODE beneficiaries do not have access to legal security of tenure as they did not have access to the title deed at the time the study was undertaken. On the other hand, HFH beneficiaries have access to legal security of tenure as the Organisation provides the beneficiaries with a certificate of ownership. The beneficiaries later present this to the City Council for commencement of title deed processing. It can therefore be argued that the HFH beneficiaries have economic mobility as they can use their certificate of ownership or even their title deed to access mortgages. Also, HFH beneficiaries cannot be easily evicted as having the title deed is enough proof of ownership as such gives security to the property unlike the CCODE beneficiaries who are likely to face threats of evictions due to lack of proof of ownership. UN-Habitat (2005) and Bonnefey (2007) states that notwithstanding the type of tenure, all persons should possess a degree of security of tenure which guarantees legal protection against forced eviction, harassment and other threats.

2.2.2 Affordability

On the issue of affordability, it was found out that the houses are affordable to the beneficiaries as 77% of the total respondents indicated that the houses are affordable and only 23% were of the view that they are not affordable. This means that the beneficiaries are able to meet housing costs while maintaining the ability to meet other basic costs of living. Therefore, the beneficiaries have enough to spend on other necessities like food, clothes, healthcare and education. In line with this, Bonnefey (2007) pointed out that personal or household costs associated with housing should be at such a level that the attainment and satisfaction of other basic needs are not threatened or compromised.

2.2.3 Availability of services

An assessment was also made as to whether services were readily accessible to the housing that the NGOs provided. The services checked included: safe water, sanitation, electricity and all weather roads.

3.2.3.1 Accessibility to safe water

Human beings heavily depend on water and without water, there can be no life (Sunnarin, 2010) and it is for this reason that "access to water was considered a human right by the UN Economic and Social Council in 2002," (Dagdeviren, 2009). Safe water was considered to be accessible to the beneficiaries as 79% of the respondents provided that water was very accessible followed by 21% who rated it as accessible and none rated it as in accessible. However, from the observation, the water is at a communal source and only a few have it on their compounds. This means that time is wasted on movements between the house and water points as such missing other productive opportunities. Community members with physical and health challenges may find it difficult to draw water from those sources, ending up using poor quality water which is easily accessible to them hence compromising on their health. Use of poor quality water through cooking, drinking and bathing among others, exposes people to germs that cause diseases like cholera, chronic diarrhea and other water borne diseases. Accessibility to safe water therefore prevents deaths and improves people's quality of life. In addition, accessibility to safe water reduces sickness as many water borne diseases will be prevented. Nearness of water sources to houses saves time and as such allows for increased productivity. It also promotes inclusivity of children, women and people with physical and health challenges.

3.2.3.2 Accessibility to sanitary facilities

Improvement in sanitation can reduce the rate of diseases (Esrey, Potash, & Roberts, 1991). It was found out that sanitary facilities were available at most of the houses. 88% of the respondents rated it as very accessible followed by 12% who rated it as accessible and none rated it as inaccessible. Most of the houses had pit latrines on their compounds. Availability of the necessary sanitary facilities provides adequate sanitation which allows people to enjoy good health hence leading to improved productivity which leads to high standards of living. Improving access to sanitary facilities therefore prevents diseases like diarrhoea and also death in extreme cases, avoids expenses on medical care due to illness and saves time. Be that as it may, the location of sanitary facilities outside the units may pose security risk.

3.2.3.3 Electricity

Electricity was noted to be inaccessible to most of the beneficiaries, only a few had access to electricity since the houses were initially designed without electricity. The few who have electricity in their homes have managed to connect using their own finances. 71% of the respondents rated it as inaccessible and only 29% rated it as very accessible. Access to electricity allows for ability to work at night .It also saves time in doing most things because people are able to use equipment which uses electricity and also allows for easy communication. The lack of electricity is a compromise on the safety of the households as they use other unsafe sources of energy for cooking, heating and lighting leading to accidents such as injuries and burns. Also, the lack of electricity is a

compromise on security as this implies lack of security lights hence creating dark spots for thieves (Naceur, 2013).

3.2.3.4 Health care services

Access to health care services is a tool for improving the quality of a health life for everyone. Health care services were indicated to be very accessible to the beneficiaries. 63% of the respondents provided that they were very accessible and 37% rated it as in accessible. However, from the observation, it was noted that hospitals are not within the area as such residents have to travel long distance to the hospital. This therefore consumes time which would have been used for other productive activities. Also, the fact that the hospitals are not in close proximity to the residential areas may lead to deaths and delays in receiving appropriate care among others. UN-Habitat (2005), UN-Habitat (2007) and Bonnefey (2007) states that for housing to be adequate, it must be in a location which allows access to health care services, employment opportunities, schools, child care centers and other social facilities.

3.2.3.5 Accessibility to schools

Schools were noted to be readily available and in close proximity to the residing places of the beneficiaries. 88% of the respondents rated the schools as accessible and only 12 % were of the view that they were inaccessible. The availability of schools will allow more people to be educated leading to the development of the community and the nation at large.

3.2.3.6 All weather roads

Most roads in the area are dry weather. This was very clear for Angelo Goveya, an area where CCODE has constructed its houses. The roads there are in bad shape without any maintenance. This proves difficult during rainy season as accessibility to the area becomes a challenge and also easily cause road accidents. In addition, it is easy to imagine that during emergencies it may be hard to ensure that cars reach the hospital at the appropriate time a situation that consequently may lead to loss of lives.

Picture 2: Showing a sample of the road in Angelo Goveya in Blantyre City

2.2.4 Adequacy of space

The spaces inside the houses are inadequate, 75% of the respondents indicated so and only 25% indicated them as adequate. The inadequacy of space is a compromise on personal privacy and may end up causing stress at other times. It also creates overcrowding especially for large families. Overcrowding makes disease transmission faster so there is need for improvement in the area. In addition, it makes space use in effective.

2.2.5 Ventilation

Ventilation within the houses was inadequate as 58% of the respondents indicated that it was inadequate and 42% rated it as adequate. This was also confirmed during observation as the windows of the houses were noted to be small and rooms had no air vents as such not providing enough ventilation. This has implication on health and safety as it can lead to discomfort and spread of airborne diseases. The lack of ventilation puts the beneficiaries at risk of acquiring a number of airborne diseases such as tuberculosis. The poor ventilation affects the comfort of the residents especially when it is hot. Also, considering the fact that many of the residents use charcoal and fire wood for cooking and heating within the houses, which emit carbon dioxide, the implications on health and safety of the inhabitants are far reaching.

Picture 3: Showing outside view of the windows in one of the CCODE houses

2.3 Public institutional support to the NGOs and the institutional challenges

It was observed that the NGOs have a strong working relationship with public institutions. The table below shows the kind of support that the public institutions provide to the NGOs and a list of institutions that render this support:

2.3.1 Support provided by the public institutions to the NGOs

Table 2: Type of Support Provided by the Public Institutions to the NGOs

Support provided	Name of institution
• Provide land to the NGOs for construction of shelter and to use for other interventions	• Blantyre City Council • Ministry of Lands and Housing
• Provide technical support to the NGOs	• Blantyre City Council • Ministry of Lands and Housing
• Provision of land records	• Blantyre City Council • Ministry of Lands and Housing
• Supply clean and safe water to the beneficiaries	• Blantyre Water Board
• Supplies electricity to the beneficiaries	• Electricity Supply Commission of Malawi (ESCOM)

Table 2 above indicates some of the Public institutions that work hand in hand with the NGOs in affordable housing provision and these are: Blantyre City Council, Blantyre District Council, Blantyre Water Board, Ministry of lands and housing and ESCOM.

2.3.2 Institutional challenges

The following were indicated to be the challenges that the NGOs meet while working with the above listed public institutions:

1. Lack of capacity by the institutions to implement programmes which are helpful to affordable housing provision.
2. Loose agreements between and among key stakeholders which proves to be difficult to account for the respective roles and responsibilities.
3. Lack of adequate land to undertake the different interventions as land provided by these institutions is sometimes limited.
4. Poor coordination between government supporting institutions and the NGOs.
5. Delays in provision of water and electricity by BWB and ESCOM respectively.

These challenges are greatly hindering provision of shelter by the NGOs. For example delays in the provision of water and electricity by Blantyre Water Board and ESCOM deny people access to clean water and electricity respectively. As earlier indicated, the

lack of safe water affects the health of the beneficiaries and also has an opportunity cost implication in the sense that while people make effort to find clean water; they end up losing other productive activities.

The delays in land provision by Blantyre City Council and Ministry of lands affects the progress of different projects undertaken by the NGOs. This leads to delays in construction of houses as well as production of limited numbers of houses some cases.

2.4 Problems encountered by the NGOs in affordable housing provision

Although affordable housing delivery by the NGOs is good and admirable, the extent to which the efforts have benefited the low-income earners leaves much to be desired. It is unfortunate that effective, affordable and sustainable housing delivery processes continues to challenge the NGOs despite the efforts put in place. This has been attributed to a number of factors which includes: loan defaults by the beneficiaries, disputes with local chiefs and non-participating community members, high cost of construction, limited access to finance, lengthy land acquisition processes, shortage of urban land for housing and the legal constraints. Below is a detailed explanation of these challenges:

2.4.1 Loan defaults by the beneficiaries

Loan defaults was indicated to be a major challenge as 96% of the respondents cited it as a challenge hindering successful affordable housing provision. The result confirms findings by Manda (2007), Thompson (2009) and Manda (2011) who indicated that loan defaults are a great obstacle the NGOs are meeting in affordable housing provision. They pointed out that defaulting was experienced by HFH in their home improvement loan scheme introduced in 2002. The high loan default rates make it even more difficult for the NGOs to sustain their revolving funds. Failure of people to repay the loans means that the funds will get depleted and eventually they are not enough funds for loan provision hence few houses are provided.

2.4.2 Disputes with local chiefs and non-participating community members

Disputes with local chiefs and non-participating community members are also another problem hindering successful affordable housing provision by the NGOs. 92% of the respondents strongly agreed with the statement that disputes with the local chiefs and community members were a challenge followed by 8% of the respondents who agreed and none disagreed with the statement. Usually, there is duplication in land allocation by the chiefs and the government .At times the community members and the chiefs are not willing to give out land to the NGOs to use. This land may have been already allocated to the NGOs by the government as a result disputes arise. These disputes delay development and eventually halt projects and consequently affect the quantity of houses developed in a programme or even a year. The NGOs may face high construction costs since construction materials may have raised during the period that the project was delayed in order to sort out the disagreements. This therefore negatively affects delivery of affordable housing. The proposed Land Bill intends to abolish chieftaincy in urban areas, whether this will

be a success or not is yet to be seen as already, there is resistance from the chiefs on the proposal.

2.4.3 High construction costs

High construction costs are another challenge in affordable housing provision. 87% strongly agreed that it was a problem followed by 13% who agreed and none disagreed with the statement. In line with this, Thwala (2009) cited that construction costs in Malawi are high due to the fact that most of the building materials are imported. The failure of housing developers in most cases to use local appropriate building materials and technologies and the dependence on imported building materials contributes to the increasing cost of building materials hence the high construction costs. The housing standards and regulations prevents the use of readily available local building materials and also the use of some cost effective and environmentally friendly construction technologies, as such increasing the cost of construction is high. The high costs of construction implies that the NGOs will be producing limited quantity of houses as those few houses constructed will require more money hence failure to reach out to many households. Due to the high costs of construction, developers will be forced to use cheap labour and poor quality materials which seem affordable as such developing poor quality houses which are prone to natural disasters and affects the health of the inhabitants. Therefore there is need for the NGOs, other housing developers and the nation at large to explore the potential of local raw materials if we are to achieve sustainable housing development.

2.4.4 Financial constraints

Access to finance constitutes the most critical challenge confronting affordable housing delivery in Blantyre City. 83% of the respondents strongly agreed that it was one of the problems NGOs are encountering in affordable housing provision followed by 17% of the respondents who agreed and none disagreed with the statement. In line with this, Thompson (2009) argued that the high cost and difficulty in accessing finance is a great challenge hindering all housing developers including MHC and the NGOs who expressed concerns over access to finance and the cost of their operations even though they access donor grants and loans. Allen (2008) also noted that NGOs face the challenge of sustaining their revolving funds with relatively high default rates and below market interest rates. NGOs are thus experiencing difficulties in finding sufficient, appropriate and continuous funding for their work as such failing to meet the overwhelming demands across the country. The findings indicated that funding for the NGOs is mainly through donors which is usually not enough and at times not even available. Another leading cause of inadequate finance is the high interest rates on loans from banks which further compound this problem.

The failure by the NGOs to have access to adequate finance implies that they are not able to reach out to many households hence developing limited quantities of houses. Limited finance also affects the quality of the houses since the resources used may be limited and of less quality. The scarcity of housing finance also leads to the inability

of the NGOs to complete a number of ongoing housing projects on time and initiate new ones. The inadequate finance for operations denies the NGOs the chance of hiring and retaining more experienced professionals and skilled labour for efficient affordable housing provision. In other countries, micro finance institutions have aligned themselves with banks to deal with the funding challenges hence perhaps it is an opportunity to explore for the NGOs in Malawi offering loan products.

2.4.5 Lengthy land acquisition processes

Lengthy land acquisition processes is also another main challenge the NGOs are facing in affordable housing provision as 79% of the respondents strongly agreed that it was a challenge and 13% agreed with the statement. The lengthy and expensive land acquisition processes affects the quantity of houses developed. This may result in delays to complete the projects within the planned time as such losing out some projects as well. As a result of the lengthy land acquisition processes, the projects may at times prove to be expensive as they may meet up with the newly implemented laws or policies which may have some stipulations that end up making the projects expensive.

2.4.6 Shortage of urban land for housing

Land is an important factor in the property development process. Shortage of urban land for housing was indicated to be one of the problems the NGOs are meeting in affordable housing provision. 75% of the respondents strongly agreed with the statement followed by 25% of the respondents who agreed that land for housing were in short supply and none disagreed. Manda, (2007) also indicated that land allocated to the Malawi Homeless and peoples federation under CCODE is limited despite the fact that members are many and expanding hence failing to meet the housing demand. The fact that urban land for housing is very limited implies that the NGOs will only provide limited quantities of houses to the beneficiaries. The houses constructed may be of poor quality in terms of the sizes as most of the developers will have no choice but to develop small houses that fit on the site. This may lead to overcrowding in the units.

2.4.7 Legal constraints

Legal constraints was noted to be another challenge in affordable housing provision as 54% of the respondents strongly agreed that it was a challenge NGOs are facing followed by 46% who agreed and none disagreed with the statement. One of the challenges relating to legal constraints is the lack of up to date building regulations which is clearly stipulated in the draft Malawi National Housing Policy (2010). The current building by-laws and planning regulations tend to favour high-income earners by specifying very high standards. The outdated building code regulations and zoning laws make housing expensive and encourage non-adherence to regulations. The NGOs therefore end up using more resources yet developing few housing units because of the existing high building standards. This therefore acts as an obstacle to affordable housing provision.

3 Conclusion

This paper has examined issues relating to challenges against housing development and delivery by the NGOs in Blantyre City in Malawi. It aimed at assessing the quantity and type of houses provided by NGOs in Blantyre City ,analysing the quality of the houses provided by the NGOs in Blantyre city; investigating the institutional support and institutional challenges NGOs face in the provision of affordable housing and examining problems faced by NGOs in provision of affordable housing. It noted that the problem of providing adequate housing in Blantyre City has long been a concern, not only to government, the market but also to the NGOs. Findings show that since the 1990s, NGOs have demonstrated commitment to addressing the housing problem in several ways but due to: loan defaults by the beneficiaries, land disputes with local chiefs and non-participating community members, high construction costs, financial constraints, lengthy land acquisition processes, shortage of urban land for housing and legal constraints, the NGOs have so far provided insufficient number and poor quality of housing units in the country. Unless these problems are addressed, the problem of affordable housing provision will remain for some time.

As can be seen from the paper, most of these challenges are common to many developing countries and not only unique to Malawi. Other countries have developed viable solutions to similar challenges. Therefore, to broadly address these challenges, there is need to ensure that all actors in the housing sector, be it the government, private sector organizations, and the NGOs should improve their coordination efforts. To overcome the challenge of limited access to finance, the NGOs should enhance financial resource generation mechanisms in order to help in increasing financial availability as such help in providing sufficient and adequate houses to the lower income group .To reduce the high cost of construction, the combination of imported building materials and local materials should be encouraged. Blantyre City Council should create a waiver of planning standards to allow beneficiaries of NGOs intervention to access secure tenure. It is therefore expected that the findings and recommendations emanating from the study should advance our understanding of the challenges and help find solutions to sustainable affordable housing provision in Malawi.

4 References

Allen, C. (2008). Access to housing finance in Africa.

Bonnefey, X. (2007). Inadequate housing and health: an overview.

Centre, U. (2008). Housing Affordability Literature review and affordable housing Programme. Urban Research Centre.

Dagdeviren, H. a. (2009). Access to Water in the Slums of the Developing World. Working Paper, 57. Brasilla, Brazil: International Policy Centre for Inclusive Growth.

Esrey, S., Potash, J., & Roberts, L. &. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworminfection, schistosomiasis, and trachoma. WHO Bulletin OMS, 69. WHO. Retrieved June 21, 2016, from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2393264/pdf/bullwho00050-0101.pdf

Malawi Government. (2014). Safer House Construction Guidelines. Lilongwe: Malawi Government.

Manda. (2011). Understanding Pro Poor Housing Finance in Malawi. International Institute for Environment and Development(IIED).

Manda, M. (2007). Mchenga Urban poor Housing Fund in Malawi. Sage.

Manda, M. A. (2007). Grassroots-led Urban Development. Network Association of European researchers and urbanisation in the south.

Mitlin, D. (2008). Finance for low-income housing. International institute for environment and development.

Mwakalila. (2005). Evaluation Of Habitat For Humanity Tanzania on the welfare of Marginalised groups in Dodoma.

Naceur, F. (2013, December). Impact of urban upgrading on perceptions of safety in informal settlements: Case study of Bouakal, Batna. Frontiers of Architectural Research, 2(4), 400-408. Retrieved June 21, 2016, from http://www.sciencedirect.com/science/article/pii/S2095263513000332

National housing policy. (2010). Malawi government.

Onu, V. (2010). Urban residential housing and low income earners. European scientific journal, 16.

Sunnarin. (2010, April 7). How Water Quality Affect Human Health. Retrieved June 21, 2016, from Young Journalist's Blog: http://sunnarin.wordpress.com/2010/04/07/how-does-water-quality-affect-human-health/

Thompson. (2009). Access to Housing finance in Africa. Finmark Trust.

Thwala. (2009). Problems facing the implementation of Low cost housing schemes Nigeria.

UN-Habitat. (2000). The Right to Adquate Housing. Office of the United Nations High Commissionerfor Human Rights.

UNHabitat. (2010). Malawi urban housing sector profile.

The Role of Incentives in Promoting Improved Cookstoves: A Case Study of Balaka, Dedza and Ntcheu Districts

Akimu Ndhlovu[a]

[a]Concern Universal, Malawi. akimundhlovu@gmail.com

Abstract

A study was undertaken in three Districts of Malawi to determine the impact that free seed distribution with improved cook stoves had on community members' decisions to adopt those stoves. The research employed methods that included face to face and focus group interviews using a question guide, observations and review of previous research work. The research found that the seed distribution only acted as an incentive for a very small proportion of respondents, and for most it was just a reward as the inherent benefits of the stoves themselves, such as using less wood fuel, were the main motivators. However, the proportion of respondents who knew about the seed packages before buying a stove was low. A number of other barriers were identified as hindering higher stove sales, and they appeared to be more significant influencers on buying decisions than the seed distribution itself. These were, in particular, affordability and accessibility. Group Village Heads could also have a positive influence on their community members' decision to buy an improved stove.

Key words: impact, improved cook-stoves, adopt, incentive, benefits, reward, barriers, sales, fuel.

1.0 Introduction

In many countries including Malawi, the rate of solid fuel usage especially in rural areas is 80% to 90%, and the number of people who use these fuels for cooking is expected to rise as population growth outpaces economic development. According to Malawi Demographic and Health Survey 2010 (MDHS, 2010), 98% use solid fuel for cooking in Malawi with wood being the most common in rural areas (94 percent) than in urban areas (37 percent). Twelve (12%) percent use charcoal for cooking, including 53 percent in urban areas and 4 percent in rural areas. Wood is the fuel most commonly used for cooking (85%). The International Energy Agency (IEA) estimates that by year 2030, 100 million more people will use traditional biomass fuels than do so today. Even where there is access to electricity or Liquid Petroleum Gas (LPG), primarily in urban areas, the use of solid fuels for cooking persists due to cost and cultural factors (IEA 2004).

However, the rate of adoption of improved cooking technology is very low in most areas including Malawi. For example, a study conducted in Pakistan in 2011 found that only 20% of the sample households in the study area used improved cookstoves. As with many developing countries, this reflects to a low rate of adoption (Inayatullah 2011). Ruiz-Mercado (2011) performed sensor-based measurements of stove use in the Guatemala stove study, providing experimental evidence of the levels of sustained use and new insights into the daily dynamics of stove use whereby using small temperature data loggers as stove use monitors (SUMs), to record continuous stove temperature signals and identified cooking events for 80 homes over a period of 2.6 years, measuring continuously stove surface temperature in alternate months. From the analysis of the temperature signals binary indicators of daily use were derived and counted the number of meals per day. The author quantified the percent stove-days, which represent the fraction of stove use from the total of stoves and days available. Using this metric,it was found that the set of specific stoves not used was different every day. It was found that some 10% of this population cooked elsewhere, did not cook at all, or used the open fire. At a household level this means that long-term users might not cook with the improved stove or with any stove at all in some days or seasons. It also implies that some households, despite their sustained usage, cook only one or two (out of three main meals observed in this population) with the improved stove.

In another study done by Concern Universal in Malawi in 2012, it was found that households often continue to use the three-stone fire even when they were aware of its inefficiencies. It further reported that users feel the three-stone fires were inefficient citing reasons that they need to have two cooking places so that the stove is seen as complementing and not replacing the three-stone fire; to speed up cooking as the improved cook stoves (ICS) are largely perceived as slow; and to cook certain foods that do not cook well on stoves because of power levels. An assessment done by ProBEC (2004) found that households in Mulanje district in Malawi used and experienced the energy saving stove either the portable "Chitetezo Mbaula" or the fixed mud stove. Nonetheless several households used a stove for a certain time only and did not replace it after the end of its lifespan as approximately 29% of the households were using stoves, the *Mbaula* being twice as common as the fixed stove. Another 29% used the stoves in the past, but did not replace worn out or broken stoves and about 42% of the families never used a stove. Others were never motivated to use an improved cooking stove. One reason for this high variation was frequent breaking of stoves.

Incentives have been used from time immemorial as they have a psychological background which can be linked to motivation and usage behaviour. There are a number of motivational theories one of which relates to incentives, for example the "Incentive Theory of Motivation". This theory suggests that people are motivated to do things because of external rewards. The difference between an incentive and reward is that while incentives aim to motivate and encourage certain future behaviour, reward is

the appreciation for the accomplished behaviour and is a potential reinforcer as it can influence certain positive behaviours (Yavuz, 2004).

In relation to stoves, there have been a number of incentives used in different countries. CU, in its Msamala Sustainable Energy Project, distributed pigeon peas to people who had bought stoves. The primary objective of giving these seeds to stove owners was to provide an alternative source of fuel. After harvesting pigeon peas, the large stems of the plant provide a convenient fuel for cooking stoves. By using this fuel, they would minimise the frequency of collecting fuel from the forests and thereby helping to conserve them in the process. This built on a study commissioned by CU to evaluate the performance of integrated food-energy systems over a three-year period (2008-2010). It was found that such systems had beneficial impacts on fuelwood consumption, household nutrition, and soil fertility.

In the case of Msamala project, it was also observed that upon issuing the pigeon peas, stove uptake started picking up steadily and it was therefore considered that the pigeon pea seeds might have offered a short-term incentive to buy a stove as well as/instead of the incentive of a future fuel source. The same approach was taken in Ntcheu and Dedza districts, using groundnut seeds as well as pigeon pea seeds. In this case it did not lead to an increase in stove sales. However, in most instances in Ntcheu and Balaka, stove owners were not foretold that they would receive seeds upon purchasing of a stove and therefore they operated as a *reward* rather than *incentive*. This study was therefore commissioned due to this observed difference in impact of the distribution of pigeon peas in these two projects. The key objective was to find out whether incentives and/or rewards, such as free seeds, played any role in influencing people's decisions to buy an improved stove or not.

A related piece of research on roles of local leaders on usage found that local leaders sometimes have an influence on the level of take up of new technologies. Research conducted in Zambia showed that the recruitment of village headmen as lead farmers and incorporating chiefs in the promotion of conservation agriculture (CA) increased implementation of CA (Nyanga, 2012). Some farmers began practicing CA because they saw a chief or village headman, who commands great authority, or a lead farmer implementing it successfully. This study considered whether this same impact could be achieved in relation to cook stove uptake.

Considering that very little research has been done to date on the role of rewards and incentives in relation to improved stoves sales and usage, the study used an interactive approach with owners and non-owners of stoves to find out what role the pigeon pea and ground nut seeds issued by CU played in influencing their stove acquisition decisions.

2.0 Study objectives

The overall object of this study was to determine the role that incentives play in stove uptake. This study concentrated on comparing stove technology uptake with incentives to uptake without incentives.

The specific objectives of the study were:

1. To generate evidence on the role of crop seed incentives and rewards used in improved stove dissemination.

2. To find out if village heads play a role in influencing community members to acquire stoves.

3.0 Methodology

The study was conducted in Balaka, Ntcheu and Dedza, where CU had been promoting improved stoves through its projects and at times gave out crop seed in the course of cook stove dissemination.

This study was conducted in a target population of about **28,000** and the sample size for the study was 377 which was generated using the following sample formula:

Where;

s = required sample size.

= the table value of chi-square for 1 degree of freedom at the desired confidence level (3.814)

N= the population size

P = the population proportion (assumed to be 0.50 since this would provide the maximum sample size)

d= the degree of accuracy expressed as a proportion (0.05)

A purposive stratified random sampling was employed, whereby districts and Traditional Authorities (TA) from stoves adopters' database, were purposely selected. Random sampling was used to select group villages (GVH) that comprised of a number of villages using a statistically generated random number table. Respondents to be interviewed were also sampled randomly from the villages falling under the sampled GVH. Questionnaires were administered to the selected households and focus group discussions were conducted in five selected villages to validate the findings from the administered questionnaires.

4.0 Results

The survey questionnaire was administered to 377 people; 79% of these were female while 21% were male. The study focused on women more than men as they are the

ones who do the cooking and influence their husbands to buy stoves for them. However, some men who were willing to respond on behalf of their spouses were also interviewed. A total of 191 respondents were interviewed in Balaka, 80 from Dedza and 106 from Ntcheu districts. The mean household size of respondents was 6 with most households having three to seven members.

The survey found that 62% of respondents had bought an ICS, while 38% had never owned one. However, only 80% of those who had at one stage bought a stove still had it. Of those that no longer had a stove, 92% said theirs had broken, 4% said they had given it away and the remaining 4% said it had been stolen.

4.1 Awareness of seed scheme and influence on decision to buy

The results showed that 81.5% of the interviewed households, who owned stoves, had received seeds (mainly pigeon peas in Balaka), while 18.5% had not received anything. It was found that only 23% (26 out of 113 respondents) of the respondents, who bought a stove, were aware in advance that if they bought a stove they would receive free seeds. The remaining 77% indicated that they bought stoves because of the inherent benefits of the stoves themselves and were only aware of the pigeon pea opportunity after they had already made a decision to buy. As a result, the seeds acted as a *reward* rather than an *incentive.*

The study found that 29 out of 191 stove buyers knew in advance of buying a stove that they would receive seeds. Yet, of those, only 13.3% bought a stove directly because of the seeds. The remaining 86.7% bought stoves for different reasons even though they knew they would receive free seeds.

The focus group discussions validated this finding. In one focus group session, in Balaka (Mchenga village), two of the thirteen people said they bought a stove because they learnt from others that there were also seeds given away. No other focus group in Balaka identified the same occurrence. All focus groups echoed this by highlighting that people who had bought stoves did so because they developed an interest in stoves after demonstrations; stoves were of good quality; used less firewood; were available when needed. The role that ICSs can play in reducing deforestation was also clearly recognised.

Some people thus just used the inputs as food and not seed to benefit them in the future. This applied mainly to early adopters.

Table 1 *Knowledge of seed scheme among those who bought stoves*

Those who bought stoves by district and role of incentives/ rewards	When did you know about incentives?			If before, did this influence your buying decision?		
	Before	After	Total	Yes	No	Total
	26	87	113	3	23	26
	26	87	113	3	23	26

4.1.1 Test for significance

Research Question: Do crop incentives influence peoples' decision to buy stoves?

Null Hypothesis: Crop incentives influence the decision to buy stoves

Alternative Hypothesis: Crop incentives do not influence the decision to buy stoves

Table 2: Correlations between knowledge of incentive scheme and willingness to buy stoves

		When did you know about incentive	If before, was it a motivation to buy a stove?
When did you know about incentive	Pearson Correlation	1	0.115
	Sig. (2-tailed)		0.551
	N	113	29
If before, was it a motivation to buy a stove?	Pearson Correlation	0.115	1
	Sig. (2-tailed)	0.551	
N		29	29

From Table 2 above, there is a weak positive correlation between knowledge of incentives and decision to buy (0.115). This implies that much as people were willing to buy stoves after they knew of the potential incentive, the incentive played a very small role in influencing their decision to buy the stoves but other factors did.

Table 3 *One-Sample Test*

	Test Value = 0					
					95% Confidence Interval of the Difference	
	T	Df	Sig. (2-tailed)	Mean Difference	Lower	Upper
When did you know about incentive	44.503	112	0.000	1.770	1.69	1.85
If before, was it a motivation to buy a stove?	32.953	28	0.000	1.897	1.78	2.01

From the results above, the probability value, p=.000 which is less than the significance level of 0.05, the null hypothesis was rejected. It was thus concluded that crop incentives did not influence peoples' decision to buy improved cook stoves.

4.2 Potential influence of seed distribution on those who had not bought a stove

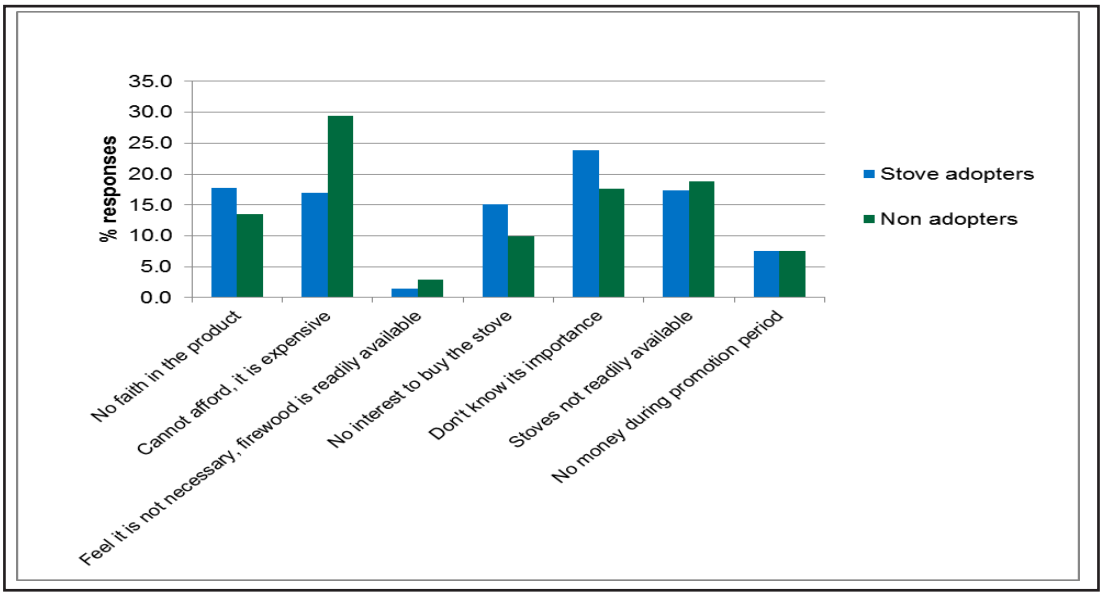


Figure 1. Reasons for some peoples failure to buy Chitetezo stove

For those that had not yet bought the improved stoves, 42.4% were aware that there was a free seed distribution scheme for those who buy a stove, and the remaining 57.6% were unaware. The results also show that out of the number that knew of the seed scheme but still did not buy one:

- 63% could not afford one;

- 11% were not aware of the stoves' benefits over other cooking technologies;
- 21% were willing to buy a stove but they were not readily available; and
- 4% had no interest to own them at all.

Perceptions on reasons for the low stove-technology uptake were similar among those who adopted the technology and those who did not when asked why stove usage was not higher. There was a general feeling that there was a low level of confidence in the product (e.g. they break easily). Others felt that the stoves were too expensive (price of MK300-MK350). In addition, where stoves were subsidised, respondents indicated that the people who were willing to buy them had no money during the promotional period.

However, many stove buyers also said they thought that non-buyers had either no interest in owning the stoves or were unaware of the stove's benefits.

These questionnaire results were consistent with findings from the focus group discussions, where people without stoves indicated that they were not aware of the stoves' benefits, lacked money, commitment and interest, chiefs did not take a leading role, stoves were of poor quality and/or they were not readily available. This explains the need for adequate awareness and good stove distribution mechanisms to spur uptake.

4.3 Suggestions for increased stove uptake

Respondents were further asked to give their opinions as to what they felt could be done to increase stove sales. Suggestions by adopters and non-adopters were compared and Figure 2 below presents the results. Both adopters and non-adopters commonly suggested: bringing the stoves closer to the prospective buyers; subsidising the price of the stove; and intensifying the raising of awareness and promotion of the stoves.

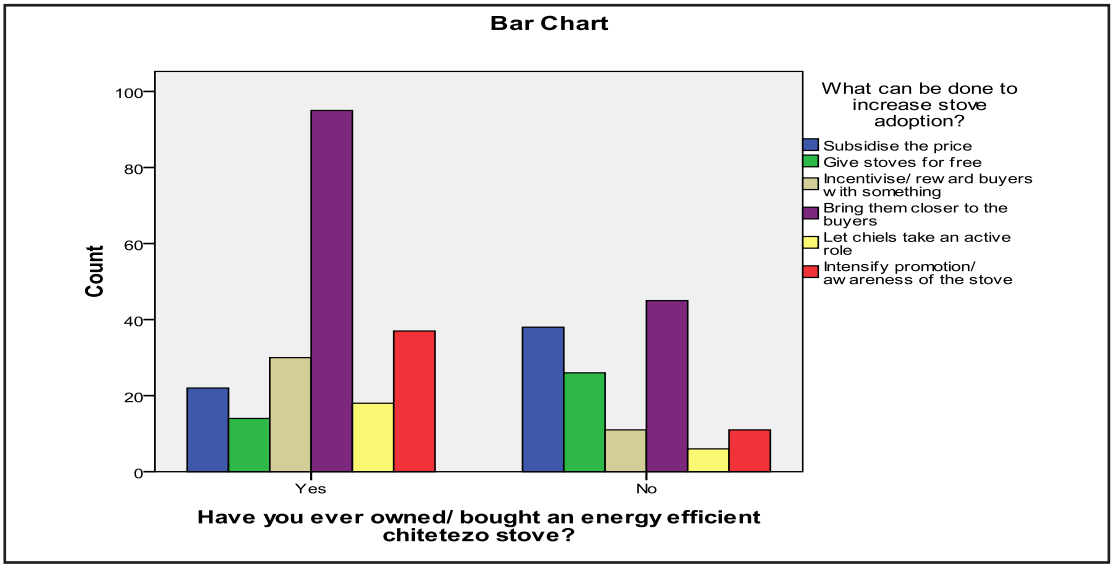


Figure 2: Suggestions for increased stove uptake by stove

However, as can be seen from Table 2, more non-adopters suggested that stoves be offered at a subsidy to promote adoption than adopters which suggests that there was no willingness to pay for the stoves. Similarly most of the non-adopters wanted the stoves to be given for free. This was different with adopters, more of whom wanted stoves to be brought closer to the potential buyers and suggested intensification of campaigns to bring about awareness in order to increase stove uptake.

4.4 Role of Carbon finance in stove sales and usage

During the focus groups discussion, there was a general recommendation that carbon financing should be encouraged as it could go a long way in helping stove sales. Carbon finance has the potential to incentivise stove sales as both adopters and non-adopters indicated that they would be encouraged to use the *Chitetezo Mbaula* if doing so brought further development benefits to the communities through reinvestment of carbon finance.

If carbon finance was to be used, it was critical that institutions promoting such initiatives were transparent so that community members are kept informed and able to participate in such initiatives.

4.5 The role that Village Heads play in influencing subjects to acquire stoves

In areas where local leaders spread messages of ICS, adoption was high whereas areas where local leaders did not speak of ICS adoption was low. This could inform that activities of village heads influenced people's decision to buy one.

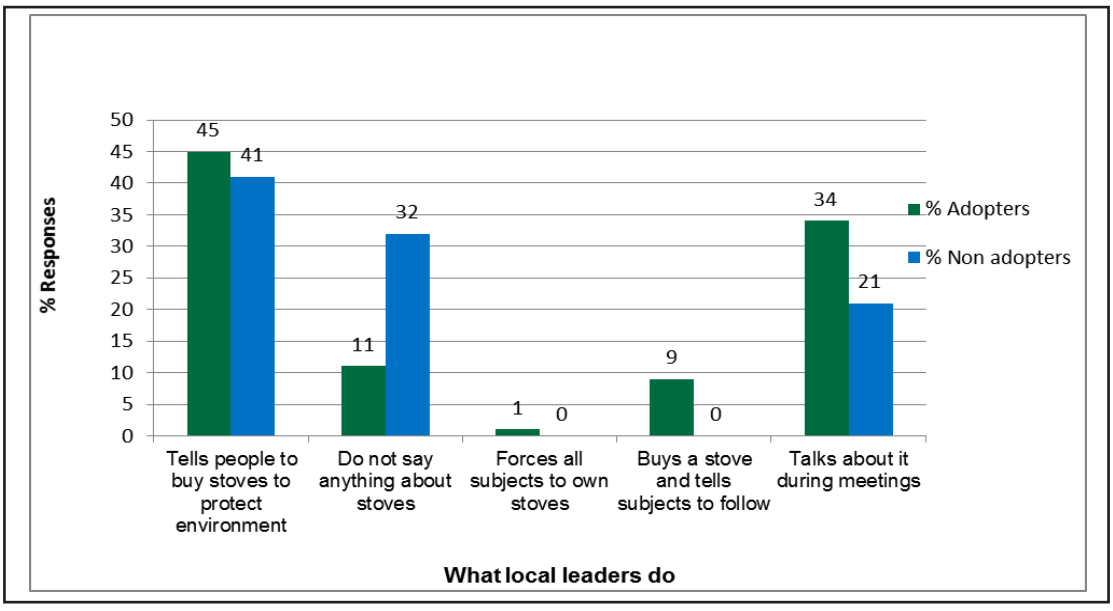


Figure 3: Role of Local leaders in stove uptake

The survey found that 45% of responses from ICS users indicated that local leaders had told their community members to buy stoves to protect the environment, compared to 41% among non-users who said the same. Further, 34% of responses from users and 27% of non-users indicated that local leaders talk about stoves during the meetings. It was noted that some 11% of users and 32% non-users indicated that local leaders had not said anything about stoves and only 1% indicated that local leaders forced subjects to purchase a stove.

It was not possible to draw cause-effect relationships from this research only. However, inferences may be made of potential positive influence of village heads' participation in technology uptake.

5.0 Discussion

The results of the study show that there is no evidence that free seeds provided a significant incentive to buying *Chetetezo* stoves. The seeds proved to be an incentive for buying an ICS in only a small number of cases. The most common motivation for stove buyers was simply the benefits the stoves brought themselves, particularly reduced fuel wood demand. This is consistent with what Muneer and Mohamed (2003) found that education of women in particular as well as improved awareness regarding the relative advantages of improved cookstoves has been significant factors for improved cookstoves adoption in Sudan.

However, it was also found that awareness of the seed scheme before buying a stove was low. It could be possible that with a higher level of promotion activity for the seed scheme there might be an increase in the proportion of people incentivised to buy a stove.

In order to increase stove uptake, it would be important to overcome the other challenges hindering stove sales as identified in this study which include: bringing the stoves closer to the prospective buyers; reducing the price of the stove; and raising awareness of the stoves' benefits to prospective buyers. Affordability was by far the most significant reason given for not buying a stove among the survey participants who were not using one. As rightly documented in literature, studies reveal that middle income households in parts of Africa have adopted improved stoves far more quickly than low income households due to higher financial costs (Jones (1989)). The findings from the study also suggest that timeliness of promotion appeared significant too, and has to coincide with the time of year when the households had money such as during harvest.

Stove durability was another factor to consider, as stove breakage was by far the most common reason for those who had once purchased a stove to no longer be using one just like Levin and Cotterman (2012) suggested that durability concerns are critical barriers to improved stove uptake. This could have negative effects to the reputation of ICSs amongst potential adopters and potentially hamper new sales as well, and the focus group sessions suggested this was so.

Respondents who had purchased an ICS were more likely to have observed their Village Heads talking about and promoting the stoves. Respondents who had not bought a stove were also more likely to report that their Village Heads had not ever talked about the ICS. This indicated a strong potential role for Village Heads in promoting the stoves.

Use of carbon credits from stoves to deliver carbon finance reinvestment could possibly be an alternative incentive for ICS sales and use. If it was pursued, a transparent mechanism for distributing such finance was called for.

6.0 Recommendations

The following recommendations were made from the findings of this study:

1. If future attempts were made to use (or further test) seed distribution as an incentive for stove sales, the scheme would need to be actively promoted to prospective buyers in advance of sales. However, the initial evidence suggests that seeds might not provide a significant incentive even if awareness is raised.
2. If incentives are to be used for the promotion of a new technology, it has to go together with adequate awareness raising of the benefits of that technology as this remained the strongest motivator for buyers, and thereby the incentive could reinforce decisions to buy a stove.
3. Reducing the cost of the stoves would remove the most common barrier remaining for non-stove adopters. There is also need to promote stoves during the time that most people have the ability to buy – i.e. when household finances are less stretched in meeting short-term necessities.
4. Chiefs and local leaders should be used to help promote stove usage by leading by example and talking about the stoves publically.
5. There is need to maintain accessible supply and high quality of stoves to counter the negative impact stove breakages were having on stove user numbers

7.0 References

Concern Universal (2012) Socio-cultural acceptability of improved cook stoves (ICS) in rural Malawi.

Global Alliance for Clean Cookstoves. 2011. *Igniting Change: A Strategy for Universal Adoption of Clean Cookstoves and Fuels*. 180 Massachusetts Avenue NW, Suite 400, Washington, DC 20036. www.cleancookstoves.org.

IEA [International Energy Agency] (2004) *Energy and development*, *World Energy Outlook 2004*. Paris: IEA

Inayatullah, J. (2011) *What makes people adopt improved cookstoves? Empirical evidence from rural northwest Pakistan*. The Governance of Clean Development Working Paper 012 – January 2011 International Development UEA, University of East Anglia, Norwich NR4 7TJ

Jones, M.H. (1989) *Energy Efficient Stoves in East Africa: An Assessment of the Kenya Ceramic Jiko (Stove) Program*. Report to USAID, No. 89-01, Washington, D.C.

Levin, D.I & Cotterman, C., (2012) What Impedes Efficient Product Adoption? Evidence from Randomized Variation in Sales Offers for Improved Cookstoves in Uganda.

Malawi Governemnt, 2010 Malawi demographic and health survey 2010. National Statistics Office. Zomba, Malawi

Muneer, S.T. & Mohamed, W.M. (2003) Adoption of biomass improved cookstoves in a patriarchal society: an example from Sudan. *The Science of the Total Environment* 307(1-3): 259-266,

Nyanga, P.H. (2012), "Factors Influencing Adoption and Area under Conservation Agriculture: A Mixed Methods Approach" *Sustainable Agriculture Research;* Vol. 1, No. 2; 2012. Department of International Environment and Development Studies (Noragric), Norwegian University of Life Sciences, Norway.

Programme for Biomass Energy Conservation –ProBEC (2004) Impact Assessment at Local Level. Experiences from Malawi- Mulanje District

Ruiz-Mercado, I (2011), Adoption and sustained use of improved cookstoves. Energy Policy, doi:10.1016/j.enpol.2011.03.028

Yavuz, N. (2004). *The use of non-monetary incentives as a motivational tool: a survey study in a public organization in turkey*, (MSc in Political Science and Public Administration Thesis. The Graduate School of Social Sciences of Middle East Technical University)

Why Long-Lasting Insecticide Nets Fail to Attain Required Impact on Malaria Reduction: Case of Kasinje Area in Ntcheu District

J. Chandhla[a], K. Kalulu[a*],

S. Kumwenda[a], L. Kalumbi[a] and K. Chidziwisano[a]

[*]Corresponding author email: kkalulu@poly.ac.mw

Abstract

The study explored factors leading to failure to attain a planned 10% reduction in malaria morbidity through free mass long-lasting insecticidal nets (LLINs) distribution programme in Ntcheu District from October 2011 to February 2012. Data on knowledge and practice on malaria control and prevention, LLINs ownership and use were collected through face-to-face interviews with 150 respondents using a structured questionnaire. Chi square tests were performed at 95% to test for factors associated with LLIN practices. The community was found to be knowledgeable on what causes malaria with 75% positing mosquito bites as the cause. Although 54% of the respondents sought prompt medical attention whenever they noticed malaria symptoms, a combined 46% sought medical attention at least within one week after onset of signs and symptoms thereby maintaining transmission cycle. There was low LLIN utilisation with 31% of the respondents indicating not having slept under LLINs a day prior the study interviews despite receiving at least and LLIN during the mass distribution. Proper hanging of LLINs was done by only 15% of the households. About 48% of the respondents reported washing LLINs at least once a month which is likely to cause loss of incorporated insecticide from frequent washing. Mass distribution of LLINs alone may not be effective in reducing malaria prevalence. Prior to distribution, there is need for adequate and intensive sensitization of communities on causes of malaria, importance and proper use of LLINs.

Keywords: Free distribution, Long Lasting Insecticidal Nets, Malawi, malaria control and prevention, mosquito nets, utilisation.

1.0 Introduction

Despite being a preventable and treatable disease, malaria remains a major public health challenge taking thousands of lives every day in the tropical areas of Asia, Africa, Central and South America (Monclair, 2008; National Institute of Allergy and Infectious Diseases, 2007). Malaria is a disease of major public health concern in the African Region, with about 550 million people at risk. Ninety percent of malaria cases are from

Africa, where 75% of malaria cases are due to plasmodium falciparum (World Health Organization, 2008). It is associated with factors like poverty, poor health, reduced immunity and untreated illnesses. Poor people often do not have access to health services for Intermittent Preventive Treatment (IPT), early diagnosis and treatment of malaria. Mostly, they lack access to personal protection from an insecticide treated net. Combined with poor housing facilities, poor hygiene and limited education, the poorest and most vulnerable will have a double burden and be at higher risk than those living in the urban areas and better living conditions (Monclair, 2008).

Malaria treatment and prevention is based on three primary interventions that are recommended by the WHO Global Malaria Programme (WHO/GMP) thus diagnosis of cases and treatment with effective medicines; distribution of insecticide-treated nets (ITNs), more specifically long-lasting insecticidal nets (LLINs), to achieve full coverage of populations at risk; and indoor residual spraying (IRS) to reduce and eliminate transmission. The use of LLINs is considered to be a highly cost-effective strategy for malaria prevention and has been contributing to significant reductions in malaria morbidity and mortality. Over the years there has been a strategic shift from ITN as primarily for the protection of individuals (high risk groups), to LLIN as a tool for vector control for which universal access to the entire population in the target area is essential (Kilian, Wijayanandana & Ssekitoleeko, 2010). In Africa the coverage of insecticide treated nets (ITNs) has not been achieved as the majority of mosquito nets are accessed by those who can afford them, leading to an increasing equity gap between the rich and the poor in accessing lifesaving commodities (Monclair, 2008). In order to address this gap, free distribution of LLINs to reach universal coverage is considered a key intervention for the prevention of malaria (Zegers de Beyl, 2012). The World Health Organization recommends that LLIN should be distributed for free to achieve universal coverage (one net for every 1.8 people in the target population). The LLINs work by protecting the person sleeping under the net (individual level) and by extending the effect to an entire area (community level). Personal protection operates by preventing contact between the mosquito and the person under the net. The wider effect occurs when the insecticide in the net actually kills the mosquitoes that touch it, therefore affecting the vector population (Newman, 2012).

1.1 Malaria management in Malawi

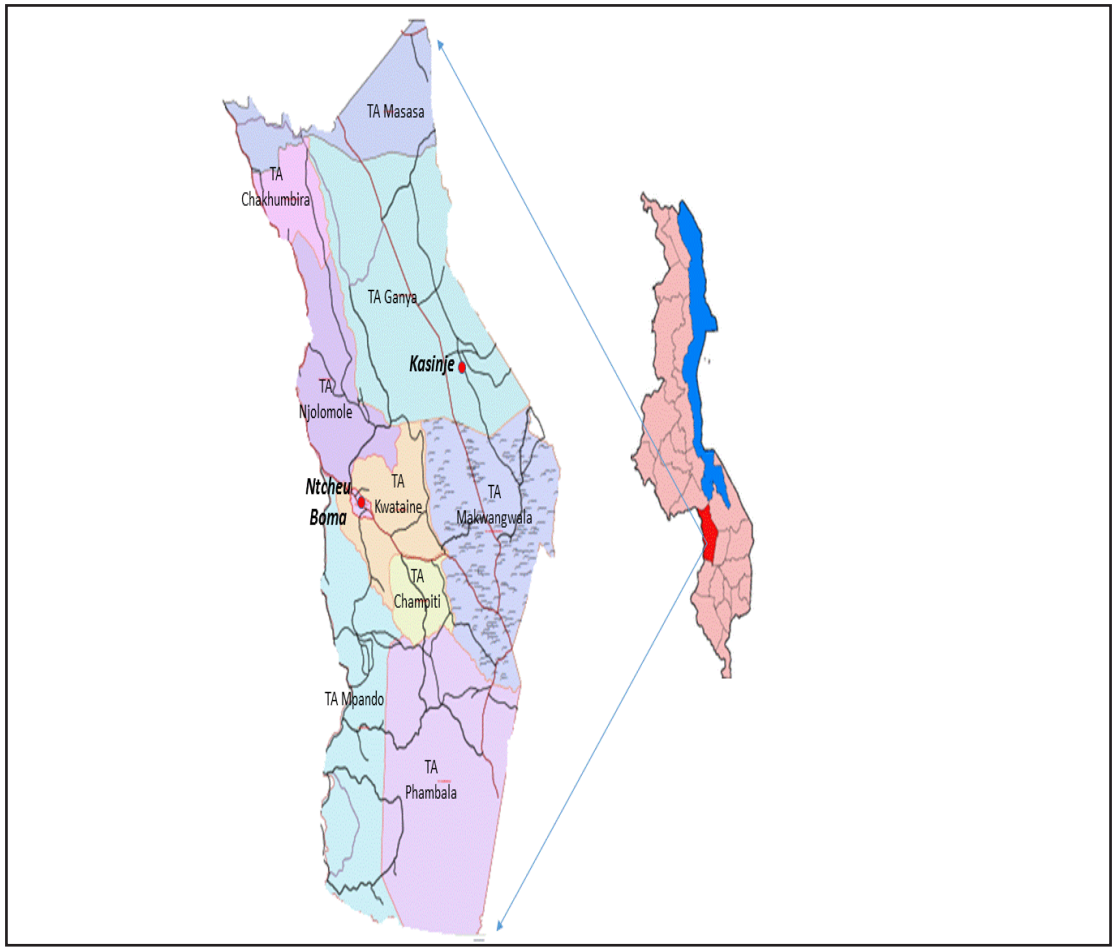
Malawi is one of the hardest hit of the countries in malaria-endemic countries of sub-Saharan Africa, where the disease accounts for 34% of all outpatients visit and is estimated to be responsible for about 40% of all under-five and 40% of all hospital deaths but its severity and complicated effects are most common among infants and pregnant women. Malaria is endemic throughout Malawi and continues to be a major public health problem, with an estimated six million cases occurring annually (National Malaria Control Programme (NMCP) [Malawi] and ICF International, 2012). According to Mathanga et al., (2013) every Malawian resident lives in a region of high malaria transmission, defined as greater

than one case per 1,000 residents. It is the leading cause of morbidity and mortality in children under five years of age and pregnant women. As in most of sub-Saharan Africa (SSA), children under the age of five years bear the highest burden of malaria (Mathanga , et al., 2012). As one way of responding to the situation in 2008 the Malawi Government started implementing an LLIN policy to include free distribution of LLINs to children born in health facilities, children attending their first visit under the Expanded Program on Immunization (EPI) and pregnant women at their first visit to an antenatal care clinic (ANC). Under this policy, national distribution campaigns are to take place every two to three years and targeting pregnant women and children under five as they are taken to be the most vulnerable populations in Malawi (Mathanga , et al., 2012).

LLINs procurement and distribution is currently being scaled up, targeting one net for every two people in a household. Furthermore, there is an increase in awareness on appropriate use of nets, as well as in developing and distributing information and educational campaign materials (National Malaria Control Programme (NMCP) [Malawi] and ICF International, 2012). The ownership and use of treated mosquito nets such as the LLINs is the primary prevention strategy for reducing malaria transmission in Malawi.
From October 2011 to February 2012, Concern Universal and Ntcheu District Council conducted a free mass distribution of LLINs across Ntcheu district aimed at reducing malaria-related morbidity and mortality at household level. A total of 22,932 were added to the existing 681 usable nets in the community in order to adequately serve a population of 10,790 households. The targeted prevalence rate reduction was 10%. An impact evaluation study by Concern Universal and Ntcheu District Hospital in March 2013 established a malaria prevalence rate reduction of 6.34%, a figure below the 10% target. This study therefore explored factors leading to the lower reduction in the prevalence of malaria in Kasinje Health Centre catchment area by specifically focusing on the community's knowledge and practice on malaria control and prevention, LLIN ownership and use. The study was conducted from May 2013 to March 2014.

2.0 Methods

The study took place in Kasinje Health Centre catchment area *(Figure 1)*. The health centre is at a distance of 83 km from Ntcheu District Headquarters.



The total population for the health centre's catchment area at the time of the study was estimated to be 52,310 coming from 38 villages. All the villages were under Traditional Authority (T/A) Ganya and clustered into 15 Group Village Heads (GVHs). A total of 150 households (based on population of 649 households from 6 randomly selected villages, confidence level of 95%, 5% error and a 15% malaria prevalence rate) were involved in the study. The respondents were identified through a multistage random sampling from group village head, village up to individual households. The participants were randomly selected from the participating villages. Data was collected through household questionnaires and documentation review. Household interviews targeted household heads in whose absence an adult member at the household was interviewed as this group was deemed knowledgeable with issues explored in the study. Consent was obtained from the study participants and the district health office as this was part of the routine monitoring activities of the programme. Data analysis was done using SPSS. Sample characteristics were described as proportions and presented with 95% confidence intervals (CI). Statistical analysis was performed to test for factors that are associated with LLIN practices using Chi square tests.

3.0 Results and discussion

3.1 Demographic characteristics of respondents

The study involved a total of 150 respondents out of which 32% (48) were males and 68% (102) were females. The age category of above 40 years constituted the highest (50%) of the respondents. About 52% and 7.3% of the respondents reported to have attained primary and secondary education respectively while none attained tertiary education. Faming was the main occupation among the study community as reported by 94.7% (142) of the respondents. Table 1 shows the demographic characteristics of the household respondents.

Table 1: Demographic characteristics of the household respondents

Attribute	Respondent category	Frequency
Gender	Male	48 (32.0%)
	Female	102 (68.0%)
Age group (years)	15 to 20	2 (1.3%)
	21 to 25	5 (3.3%)
	26 to 30	27 (18%)
	31 to 40	41 (27.3%)
	Above 40	75 (50%)
Marital status	Married	65 (43.3%)
	Single	68 (45.3%)
	Other	17 (11.3%)
Education level	Primary	78(52.0%)
	Junior Certificate of Education (JCE)	61(40.7%
	Malawi School Certificate of Education (MSCE)	11 (7.3%)
	Tertiary	0 (0%)
Occupation	Builder	1 (0.7%)
	Farmer	142 (94.7%)
	Housewife	7 (4.6%)

3.2 Knowledge and practice on malaria control and prevention

3.2.1 Knowledge on what causes malaria

Table 2 shows the responses obtained from the respondents when asked on what they knew to cause malaria.

Table 2: Causes of malaria

Malaria cause	Frequency
Bite from parasite-infected mosquito	25 (16.7%)
Any mosquito bite	87 (58.0%)
Inhalation of malaria causing organisms	5 (3.3%)
Direct contact with malaria patient excreta	4 (2.7%)
Poor household and personal hygiene	6 (4.0%)
Exposure to extreme weather conditions	10 (6.7%)
No knowledge	13 (8.7%)

A combined 112 (47.7%, CI: 66.9 – 81.4) mentioned a mosquito bite (i.e. whether parasite-infected or not) as a cause of malaria compared to 38 (21.3%, CI: 15.1 – 28.8) who mentioned other unorthodox causes of malaria. This indicates that respondents were significantly likely to mention mosquito bite as a cause of malaria. The awareness of the respondents that malaria is caused and transmitted by a bite of mosquito is common knowledge in malaria endemic countries such as India, Turkey, Nepal, Haiti, Latin America, Sudan and Ghana (Curtis et al., 2006). However, a smaller proportion (16.7%) of the respondents accurately stated the correct transmission route (by bite of a mosquito which has *Plasmodium falciparum*). Sexton (2011) emphasises the need to have mosquitoes recognized as the sole cause of malaria if the belief that LLINs are a complete defence against transmission and disease is to be inculcated in the community.

3.2.2 Knowledge on the signs and symptoms of malaria

Table 3 shows the respondents' knowledge on the signs and symptoms of malaria.

Table 3: Signs and symptoms of malaria

Sign/symptom	Frequency
High fever, flu-like illness and shaking chills	79 (52.7%)
Headache, muscle aches and tiredness	48 (32.0%)
Nausea, vomiting and diarrhoea	23 (15.3%)

The community was conversant with signs and symptoms of malaria with high fever, flu-like illness and shaking chills as well as headache as common signs and symptoms. This is in agreement with the National Institute of Allergy and Infectious Diseases (2007) which attributes malaria to causing a string of recurrent attacks, or paroxysms, each of which has three stages namely chills, followed by fever and sweating. Along

with chills, the person is likely to have headache, malaise, fatigue, and muscular pains, and occasionally nausea, vomiting, and diarrhoea. In terms of time taken to seek medical attention once malaria signs and symptoms are noted the study established that 13.3% (20) took a day, 19.3% (29) took 3 days, 13.3% (20) took more than 1 week and 54.0% (81) sought attention whenever they noted the signs and symptoms.

3.2.3 Ownership of LLIN

The mass distribution campaign was effective at achieving high levels of net distribution as 88% (132) of households indicated having received the LLINs through external interventions such as those implemented by Concern Universal and Ntcheu District Health Office. Of those that had received LLINs, 70.5% (93) of the households reported to be adequately provided with the nets while 29.5% (39) received fewer nets than the recommended universal coverage requirement of one net for every two people or per sleeping space. Respondents were further asked to ascertain if all the nets they received were available and 70.7% (106) reported that all the nets were available. The coverage (88%) of at least one LLIN per household and availability (70.7%) established in this study were higher than 41% reported in the 2010 Malawi Demographic and Health Survey whereby a household owned at least one long-lasting insecticidal net. A sustained high coverage of LLINs results in reduction of mosquito density and thus reduction of overall malaria transmission. To achieve the required impact on vector mosquitoes, high coverage within a target community is essential (World Health Organization, 2011). Curtis (2006) postulated that high coverage of bed nets, particularly those treated with an insecticide (ITNs and LLINs), results in a decrease in malaria mortality and morbidity and reduces transmission. Clearly, there is still a proportion of household members who are still exposed to mosquito bites within the households that received the LLINs. According to World Health Organization (2011), in addition to providing personal protection to members of the population covered in 100% coverage or universal coverage, LLINs lead to a decline in malaria transmission rates. Community wide protection through LLINs coverage will only be reached when a significantly high portion of the community is covered (Sexton, 2011).

3.2.4 LLIN use

When the respondents were asked if they had slept under a mosquito net (LLIN) the night before the interview it was reported that 46 (30.7%, CI: 23.4 - 38.7) had done so in comparison to 104 (69.3%, CI: 61.3 - 76.6) who had not. This indicates that participants were significantly likely to report not sleeping under the LLIN. The reasons given by respondents on why they did not use LLINs included low mosquito density (51.3%), extreme fatigue (20.7%), laziness and forgetting to fix the net (12.7%), dirty nets (6.7%), heat discomfort (6.0%) and working on night shift (2.7%). Other reasons included LLINs being torn or damaged i.e. having holes (39%), donation to relatives (22%) and being used for unintended purposes such as screening windows, vegetable garden fences (31.7%); and selling (7.3%).

Low utilisation of nets in this study could also be attributed to the knowledge of the benefits that respondents attached to sleeping under a net as argued by Koenker et al. (2012). Table 4 shows the responses obtained when the study tried to establish the knowledge of the respondents on the benefits of sleeping under a net. Interestingly of those who reported to be inadequately provided with LLINs, 59% (23/39) reported protection from any mosquito bite as a benefit.

Table 4: Benefits of sleeping under LLINs

Benefit of sleeping under LLINs	**Frequency**
Protection from malaria-causing mosquito bites	42 (28.0%)
Protection from any mosquito bites	68 (45.3%)
Protection from small insect bites	18 (12.0%)
Combat mosquito nuisance	17 (11.3%)
Didn't know	5 (3.3%)

Only 28% of the respondents correctly pointed preventing bites from malaria causing mosquito as one of the benefits of LLINs. This possibly makes it difficult to introduce LLINs as a strategic measure for preventing malaria transmission and it could potentially result in misuse of the received LLINs.

The study also established that apart from the use of the LLINs, there existed other mosquito bite preventive methods within the community. About 19.3% (23) of the respondents indicated using traditional mosquito repellents such as a local herb called *mpungabwi,* 17.3% (26) used artificial repellents and 3.3% (5) reported wearing clothes providing maximum possible covering such as long pants and long sleeve shirts.

The study further assessed if respondents had slept under the nets received during mass distribution the night before the interview. It was found that 39.8% of those who had been adequately provided with nets slept under a net compared to 23.1% among those who were not adequately provided with LLINs. However, the difference between these two groups was not significant ($p = 0.059$). These findings underscore Pulford et al. (2011) who argue that mosquito net ownership in itself is not synonymous with utilisation. Findings are also in agreement with a study done in Niger, West Africa, which showed that as few as 33% of available mosquito nets in mosquito owning households were used the night prior to the study (Thwing, et al., 2008). World Health Organization (2011) highlight the need for households to use and not merely own LLINs if intended benefits are to be acquired. Pulford (2011) posited that ownership is not the only obstacle to achieving reductions in malaria morbidity and mortality associated with LLINs use;

rather, individuals who own (or who have available) mosquito nets must use them in order for the potential health impact to be fully realized. Graves (2011) found that net ownership is a necessary prerequisite for net use but whether or not a net owner will use a net every night, some nights, or not at all depends on complex multilevel interactions between individual characteristics, household characteristics, social and cultural factors, community-level factors, aspects of the physical environment and characteristics of the net itself.

LLINs coverage does not necessarily reflect the number of nets being hung or properly used (World Health Organization, 2011). LLINs need to be hung in a way that it will not come into contact with the person sleeping under it so as to reduce the possibility of being bitten by any mosquito that might come in contact with the net. When the study explored the hanging practice of the LLIN it was established that only 15.3% (23) of the beneficiaries hung the nets properly by using six nails on the wall with ropes secured to the nails. On the extreme part of the poor LLINs hanging practice, 9.3% (14) of the beneficiaries did not even hang the LLINs nets but used them to cover themselves just like a blanket. These findings are in agreement with Gerstl et al. (2010) also found a low proportion of proper net hanging. The study sought to find out the time the nets are fixed. The study found that 6.8% (10) fixed their nets around 6pm, 69.3% (104) hung their nets around 7pm, 7.3% (11) hung their nets around 8pm, 14.7% (22) around 9pm, 2.0% (3) did not know. Consequently, a greater proportion of the households sleeping under the LLINs were not completely protected from the anopheles mosquito bites. This could explain why some people who sleep under LLINs still get malaria.

In terms of washing of the nets 1.3% (2) indicated washing once every week, 47.7% (73) once every month, 30.7% (46) once a year, 8.0% (12) once in two years and 8.7% (13) had never washed their nets. The results showed that almost half wash their LLINs at short intervals. Too frequently washing of LLINs results in loss of effectiveness. Repeated washing of LLINs at short time intervals using local washing methods may render the nets ineffective within a short time in preventing local vectors (Atieli et al., 2010). Washing gradually removes insecticides on LLINs leading to progressively loss of power against mosquitoes (World Health Organization, 2011). Of those who had washed their nets the study found that 36.5% (50) of the respondents washed their LLINs with soap, 8.8% (12) with insecticide while 54.7% (75) washed using water only. LLINs need to be washed with soap at first before washing it with mosquito insecticide. This is done to effectively remove the dirt that has accumulated during the period it was hung and used so as to expose the incorporated insecticide. LLINs are designed to resist repeated washing, however excessive washing and the use of harsh detergents (such as some traditional soap) rapidly reduces their useful life. The rate of insecticide loss and subsequent reduction in efficacy is dependent on the washing method and frequency used in the field or community (Atieli et al., 2010). A study in Tanzania showed that this loss on LLIN efficacy becomes significant after 18 washes (Msangi et al., 2008).

4.0 Conclusion

Almost one in every two (47.7%) of the community members were knowledgeable that malaria is caused by mosquito bites. The community was also knowledgeable on the signs and symptoms of malaria. Nevertheless, only 13.3% community members at day-one of symptom recognition sought medical attention, this implied weak health seeking behaviour of the respondents which presents a danger of developing severe malaria which could result in disability or death. Late health seeking behaviour tends to maintain malaria transmission cycle in a community thereby leading to high malaria cases.

The free mass distribution of LLINs did not reach universal coverage because some households did not receive any and some households received less LLINs than the required number. This means that not every household sleeping space was covered and some household members were not sleeping under the LLINs leading to exposure to mosquito bites including the anopheles mosquitoes having malaria causing parasite. This at the end results in high malaria transmission rate despite the coming in of the intervention of free mass distribution LLINs in the area.

The free mass LLIN distribution campaign improved ownership and access (88%) rather than use (30.7%) in Kasinje Health Centre catchment area. Low LLINs utilisation; poor hanging and washing practices of the LLINs imply that a large proportion of the respondents tend to be exposed to mosquito bites thereby increasing the malaria transmission route regardless of the fact that they have the LLINs. Nevertheless, the respondents fixed the LLINs for use in good time.

The community was not well knowledgeable of the benefit of sleeping under LLINs and this makes it difficult in introducing the nets as a strategic measure for preventing malaria transmission as it results in their low utilisation as well as misuse.

References

Atieli, F.K., Munga, S.O., Ofulla, A.V. and Vulule, J.M., 2010. The effect of repeated washing of long-lasting insecticide-treated nets (LLINs) on the feeding success and survival rates of Anopheles gambiae. *Malaria journal*, *9*(1), p.1.

Baird, J.K., 2005. Effectiveness of antimalarial drugs. *New England Journal of Medicine*, *352*(15), pp.1565-1577.

Uzochukwu, B.S. and Onwujekwe, O.E., 2004. Socio-economic differences and health seeking behaviour for the diagnosis and treatment of malaria: a case study of four local government areas operating the Bamako initiative programme in south-east Nigeria. *International Journal for Equity in Health*, *3*(1), p.1.

Curtis, C.F., Maxwell, C.A., Magesa, S.M., Rwegoshora, R.T. and Wilkes, T.J., 2006. Insecticide-treated bed-nets for malaria mosquito control. *Journal of the American Mosquito Control Association*, *22*(3), pp.501-506.

Gerstl, S., Dunkley, S., Mukhtar, A., Maes, P., De Smet, M., Baker, S. and Maikere, J., 2010. Long-lasting insecticide–treated net usage in eastern Sierra Leone–the success of free distribution. *Tropical Medicine & International Health*, *15*(4), pp.480-488.

Kilian, A., Wijayanandana, N. and Ssekitoleeko, J., 2010. Review of delivery strategies for insecticide treated mosquito nets: are we ready for the next phase of malaria control efforts?. *TropIKA. net*, *1*(1), pp.0-0.

Koenker, H., Munoz, B., Boulay, M., Mkocha, H., Levens, J., West, S.K. and Lynch, M., 2012. Trends in weekly reported net use by children during and after rainy season in central Tanzania. *Malaria journal*, *11*(1), p.1.

Mathanga, D.P., Walker, E.D., Wilson, M.L., Ali, D., Taylor, T.E. and Laufer, M.K., 2012. Malaria control in Malawi: current status and directions for the future. *Acta tropica*, *121*(3), pp.212-217.

Monclair, M., 2008. Scaling up malaria interventions: Integrating free distribution of long lasting insecticide treated mosquito nets during vaccination campaigns. A new strategy to meet the millennium development goal.

Msangi, S., Lyatuu, E., Masenga, C. and Kihumo, E., 2008. The effects of washing and duration of use of long-lasting insecticidal nets (PermaNets) on insecticidal effectiveness. *Acta tropica*, *107*(1), pp.43-47.

National Institute of Allergy and Infectious Diseases. 2007. *Understanding Malaria.* Bethesda, MD 20892-6612 301-496-5717 www.niaid.nih.gov: National Institute of Allergy and Infectious Diseases.

National Malaria Control Programme (NMCP) [Malawi] and ICF International. 2012. *Malawi Malaria Indicator Survey 2012*. Lilongwe Malawi, and Calverton, Maryland, USA: NMCP and ICF.

Newman, R. 2012. *World Malaria Report 2011.* Retrieved from http://cdrwww.who.int/entity/malaria/mpac/feb2012/gmpdir_global_report.pdf

Obidiya, O.S., Chima, I.E., Ekadi, T.S. and Ilodigwe, E.E., 2012. Health seeking behaviour among adult residents of Yenagoa city, Nigeria. *CJPSci. 5*(2).

Pulford, J., Hetzel, M.W., Bryant, M., Siba, P.M. and Mueller, I., 2011. Reported reasons for not using a mosquito net when one is available: a review of the published literature. *Malaria journal*, *10*(1), p.1.

Sexton, A.R., 2011. Best practices for an insecticide-treated bed net distribution programme in sub-Saharan eastern Africa. *Malaria journal*, *10*(1), p.1.

Thwing, J., Hochberg, N., Eng, J.V., Issifi, S., James Eliades, M., Minkoulou, E., Wolkon, A., Gado, H., Ibrahim, O., Newman, R.D. and Lama, M., 2008. Insecticide-treated net ownership and usage in Niger after a nationwide integrated campaign. *Tropical Medicine & International Health*, *13*(6), pp.827-834.

World Health Organization, 2011. Insecticide-treated mosquito nets: a WHO position statement. Global malaria programme.

World Health Organization, 2008. *World malaria report 2008*. World Health Organization

Zegers de Beyl, C. 2012. *Post-Campain Survey/Baseline Survey for continuous distribution of LLINs in Eastern Region, Ghana.*

Heat Recovery from a Medical Waste Incinerator at Zomba Central Hospital, Malawi

Tawina Kapusa Mlowa[a]

[a]Department of Physics and Biochemical Sciences, University of Malawi-The Polytechnic, Private Bag 303, Blantyre 3, Malawi. Emails: tmlowa@poly.ac.mw, tawinamlowa@gmail.com

Abstract

Energy can be recovered from medical waste incinerators and utilized for other purposes as a means of energy conservation. The aim of this study was to recover heat from a medical waste incinerator at Zomba Central Hospital in Zomba, southern region of Malawi, for possible reuse. This was achieved by measuring temperature distribution in the incinerator to determine the optimum position for a heat exchanger, designing an optimum heat exchanger based on the temperature distribution and assessing the performance of the whole heat recovery system. Highest and consistently higher temperatures (up to 500^0C) were observed at the back of the incinerator compared to the front which reached 148^0C. This was due to the insulation of the incinerator's back surface. Hence the heat exchanger optimum position was found to be the back of the incinerator. Optimum flow rate of water through the heat exchanger was $3.75 \times 10^{-5} m^3/s$. At this flow rate heat gained was 10.87 J/s or 39.132 kWh. This translated into a saving of MK 1589.6 on the hospital's electricity bill if the heat recovery system was used at the hospital to heat 810L of water per day and MK47670 (USD 87.5) per month or MK1.96 per 1L of water.

Keywords: Energy conservation, Heat exchanger, Temperature, Waste incineration, Water.

1.0 Introduction

Amedical waste incinerator is a furnace for thermal treatment of wastes (Warhurst & Watson 2006). Medical waste incineration is part of the waste treatment process whose objective is to treat the waste so as to reduce its volume and hazard, whilst capturing or destroying potentially harmful substances, European Commission (2006). The medical waste incinerator at Zomba central hospital is a single 1.76 m by 0.71 m by 0.8 m chamber, batch-operated, diesel-fed and its temperatures can reach up to about 500^0C.

Malawi energy supply is insufficient for a population of 14 million. According to the Malawi household census report (NSO, 2008) 97 % of energy supply for heating is from biomass (firewood, charcoal, agricultural and industrial wastes). Hydropower generates 95 % of electricity but only 8% of the population has got access to this electricity. Thermal energy generation only accounts for the remaining 6%, Government of Malawi (2006).

This leaves a need for the provision of alternative energy sources which are affordable and environmentally sustainable.
Kelly (2010) gave an emphasis on the need to make the built environment more energy sustainable. His results showed that a lot of money can be saved when buildings are built in such a way that energy consumption is reduced. One of the ways of doing this is by having systems that recycle the energy being used. As such scavenging heat from an incinerator would also be a good example of making an infrastructure environmentally friendly. A further advantage is in investment; Münster & Meibom (2010) analyzed several waste-to-energy technologies and showed that production of energy from waste incineration is one of the best investments. The focus of their analysis was on different uses of waste for energy production. The waste-to-energy technologies analyzed included co-combustion of coal and waste, anaerobic digestion and thermal gasification. Using a mathematical model Münster & Meibom(2010) showed that a combination of these waste-to-energy technologies would be more effective and that effectiveness would depend much on the type of waste, storage of heat and geological scope.

Furthermore, in Japan, waste-to-energy municipal solid waste (MSW) incinerators were analysed to find if they are really green house gas (GHG) reducers. Net GHG emission is affected by the type of wastes and amount of energy being produced, Tabata (2013) . The analysis by Tabata showed that 16.2% of Japan's electricity household demand and up to 25% of hot water demand could be met by the waste-to-energy incineration plants . Similary, Fruergaad et al. (2010) showed that in Denmark, MSW incineration contributes 20% of the heat supplied to the more than 400 district heating networks. Results from the investigation on MSW incineration in Denmark showed that waste incineration in one network caused a CO_2 saving of 48 kg CO_2/GJ energy input while in the other network a load of 43 kg CO_2/GJ. This was caused mainly by differences in operation mode and fuel types of the other heat producing plants attached to the networks.

In Malawi, apart from the use of electricity, many studies on methods of heating water using renewable energy have focused on the use of solar energy. Nkhonjera (2011) studied the effects of installing thermo siphon solar water heating system (TSWHS) on total energy bill at Mzuzu University in northern Malawi. The study showed that using the TSWHS could bring a saving on utility energy of 107 MWh annually with a 10% rate of return on investment for 9 years. It was therefore concluded that installation of a TSWHS at MZUNI is both economically viable and saves utility energy. The findings by Nkhonjera were very helpful in this study as they provided an idea that recovering heat from a medical incinerator could help to reduce the hospital's monthly expenditure on utility bills and also provide the much needed hot water for the patients.

There have been some efforts on increasing energy efficiency for example the provision of energy efficient bulbs by the Electricity Supply Commission of Malawi (ESCOM) and other alternative sources of energy. Zomba Hospital is one of the public districts hospitals in Malawi. It has about 600 in-patients who need hot water for bath. Thus there is a need

to investigate the possibility of recovering the waste heat from the incinerators as this would provide the much need energy for heating water at the hospital. The medical waste incinerator at the hospital is similar to other incinerators in the other district hospitals; therefore the results of this study could also be applicable to them.

This paper evaluates the potential of recovering heat from the medical waste incinerator using a heat exchanger. This was achieved by measuring temperature distribution in the incinerator so as to determine the optimum position to place a heat exchanger; designing an optimum heat exchanger based on the temperature distribution in the incinerator and finally determining the optimum operating flow rate of the heat exchanger.

2.0 Materials and method

2.1 Measuring temperature inside the incinerator

The internal wall of the incinerator is made up of mud bricks for insulation but the outside wall is made up with metal. The dimensions of the incinerator's furnace are 1.76 m by 0.71 m and about 0.8 m high. Temperature inside the incinerator was measured using K-type thermocouples which had been insulated and calibrated. A solar powered data logger was used to record temperature data collected from the incinerator. Solar energy was used for this part to utilize renewable and environmentally sustainable energy. The thermocouples were installed in the incinerator at various points as shown Fig. 1. Thermocouples for measuring temperature $T_{3\text{-front}}$ and $T_{2\text{-front}}$ were positioned near the opening/door of the burning chamber. $T_{2\text{-front}}$ and $T_{3\text{-front}}$ were 0.6 m apart. The thermocouples for measuring temperature $T_{4\text{-back}}$ and $T_{6\text{-back}}$ were positioned at the back of the chamber, 1.70m away from the opening/door of the chamber. $T_{4\text{-back}}$ and $T_{6\text{-back}}$ were installed about 0.6m apart. The ventilation opening at the back of the incinerator was used as passage for the thermocouples $T_{4\text{-back}}$ and $T_{6\text{-back}}$ installed at the back.

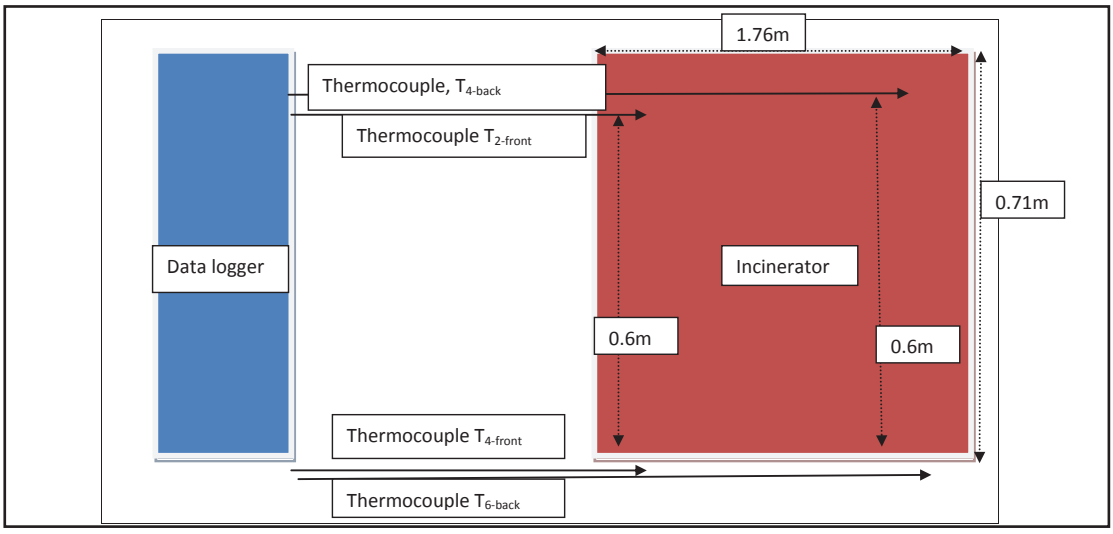


Figure.1: Schematic drawing of thermocouple positions inside the incinerator

2.2 The heat exchanger

The heat exchanger was designed using the distribution of temperature inside the incinerator. The temperature distribution data was used to find the optimum position to install the heat exchanger and the suitable material for the construction of the heat exchanger. The heat exchanger element was made of galvanized steel pipe of ¾ inch diameter.

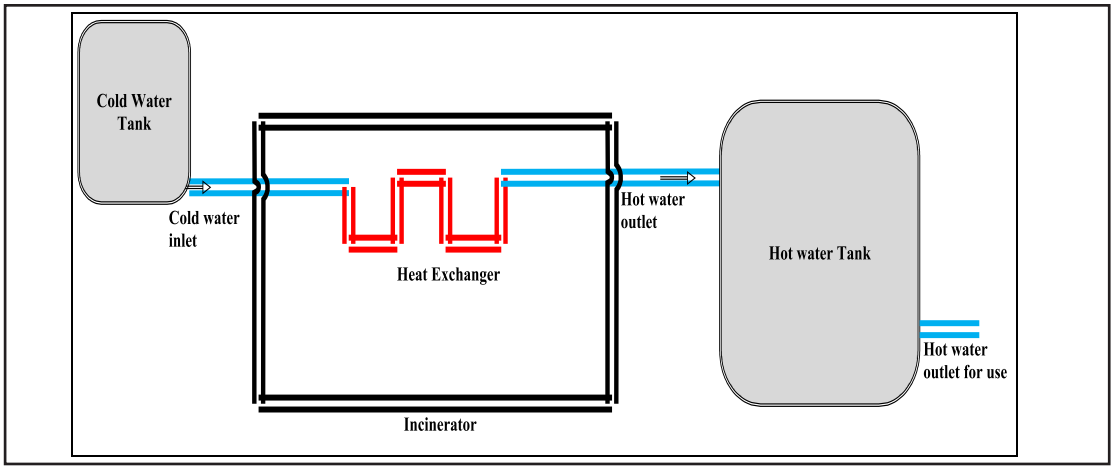


Figure. 2: The installation of the heat exchange

Figure 2 shows how the heat exchange system worked. Water that was at low temperature was stored in the tank labeled cold 'water tank' which was elevated at a height of 1.8 m from the ground. The tank was positioned at this height in order for the water to flow by gravity force. A gate valve was connected to the tank that acted as outlet control for the cold water that flew through heat exchanger that was into the incinerator. Galvanized steel pipes were used to construct a heat exchanger since the steel was able to withstand high temperatures in the incinerator. Being galvanized, the steel does not come into contact with the water, hence corrosion is prevented. However, continuous contact between the galvanized steel and hot water could still result in rusting, therefore the recommended type of pipe would be copper. This pipe was coiled and the coiled part was installed at the back of the incinerator. The pipe as the heat exchanger was coiled so that the water inside it would stay longer in the incinerator to achieve desirable temperatures. The temperature of the water from the heat exchanger (outlet temperature) was also measured. From the incinerator, the heated water was stored in the tank labeled 'hot water tank'. Since the water at the outlet was below 100^0C, a Polyvinylchloride (PVC) pipe was connected to the hot water tank as an outlet channel to users. Temperature for the water was measured at two points; in the cold water tank and in the pipe just before it enters the hot water tank. Temperature here was also measured using thermocouples and recorded by the data logger.

The hot water tank was placed on a stand built using bricks of about 0.4m for the water to flow out using gravity.

2.3 Measuring water flow rate

Water rise in the hot water storage tank was recorded every 5 minutes by a measuring tape. The rise in water was measured in centimeters and then this rise was calculated into liters. Total volume of the tank was 200L with a height of 0.9m; therefore every cm represented a volume of 2.2L. Volume flow rate (V_f) was then calculated by dividing volume flow by time taken.

3.0 Results and discussions

3.1 Temperature distribution in the incinerator

Figure. 4 shows temperature distribution in the incinerator measured at 4 points. Both plots (a) and (b) of Fig.4 show that temperature values at the back, measured by $T_{6\text{-back}}$ and $T_{4\text{-back}}$, of the incinerator were always higher than those measured at the front, measured by $T_{2\text{-front}}$ and $T_{3\text{-front}}$. The highest temperature value recorded at the back of the incinerator was 500^0C and at the front was 148^0C. This difference is due to heat loses at the front because the incinerator does not have a door and there is a lot of convection losses to the external surrounding since the incinerator is left open during burning. Further to that, the incinerator design is such that the back is well insulated such that temperatures remained high for a longer time than at the front.

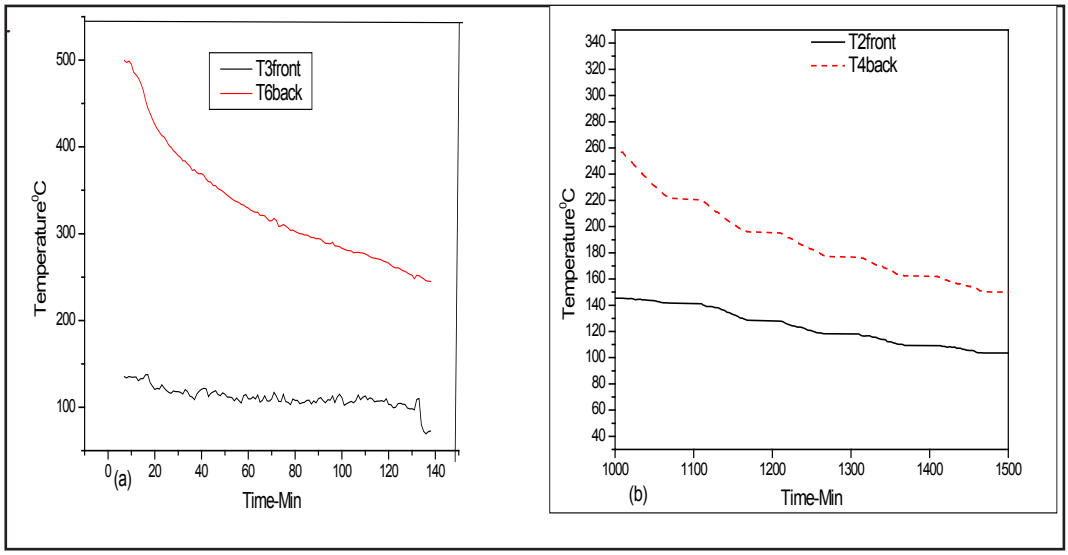


Figure. 4: Temperature distribution in the incinerator

There are points of temperature drop and increase because the burning of wastes is done as a batch process; therefore temperature drops as another batch of wastes is just being

brought into the incinerator and then the temperature increases as the wastes start to burn. Temperature variation is also caused by the type of wastes being burnt. Hard wastes like sharp objects and bottles or wet wastes such as wastes stained with blood are burnt using additional fuel (diesel) and they are the ones usually put at the back of the incinerator, hence the higher temperature recordings. Taking from these results, the heat exchanger was then installed at the back of the incinerator.

3.2 Rate of water flow

Having installed the heat exchange system into the incinerator, water was made to flow through the system and optimum flow rate of was calculated based on the required temperature. The optimum flow rate was the flow rate which resulted in outlet water with temperature of around 90-95^{0}C.

Table 1 shows the volume flow rate of water through the heat exchanger. The average flow rate was 3.75 x 10^{-5} m^3/s. Increasing the flow rate above 3.75 x 10^{-5} m^3/s resulted in temperature drop for the water that came out of the incinerator since the water was required to stay in the heat exchanger for some time to be heated. Reducing the flow rate below this rate caused the water temperature to rise above its boiling point hence only steam came out of the outlet pipe.

Table 1: Flow rate of water through the heat exchanger

Volume (L)	Time (min)	Flow rate L/min
40.0	0	
49.3	5	1.86
63.0	10	2.74
75.5	15	2.50
85.5	20	2.00
94.0	25	1.70
103.3	30	1.86
114.0	35	2.14
124.0	40	2.00
136	45	2.40
149.2	50	2.64
162	55	2.56
175	60	2.60
Average flow rate		**2.25L/min (3.75 x $10^{-5}$$m^3$/s)**

Fig. 5 shows temperature of water as it flowed through the heat exchanger at the average flow rate of 3.75 x $10^{-5}$$m^3$/s. T_{input} is the temperature of the water as it came from the storage tank before entering the heat exchanger in the incinerator and as shown in the

temperature was almost constant at room temperature of 23^0C. $T_{output,}$ Temperature of the water coming out of the heat exchanger was at most times constant between 94^0C and 96^0C. There are some major fluctuations in water temperature such as at time 10 minutes, 45 minutes and 115 minutes due to temperature changes in the incinerator. As already indicated, temperature changes in the incinerator were due to mode of burning the wastes at that time such as whether extra fuel (diesel) was added or not.

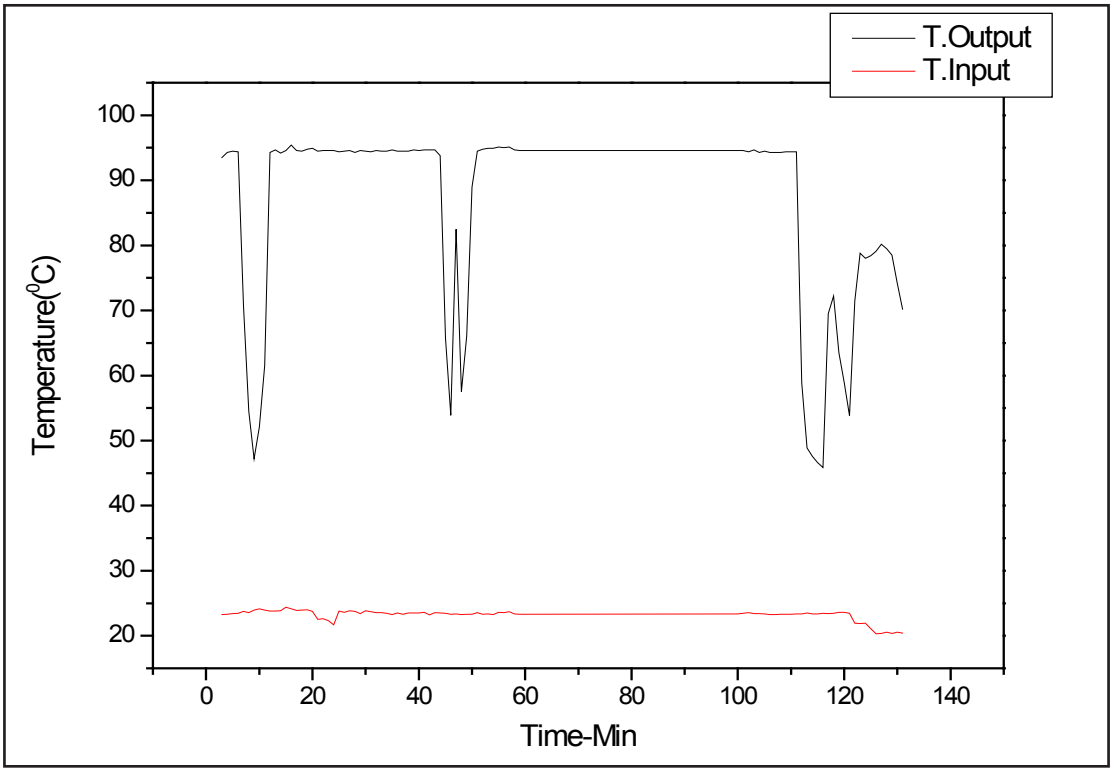


Fig. 5 Variation of water temperature

At the flow rate of 3.75 x 10^{-5} m^3/s, 10.870J of heat energy per second was transferred to the water as it flowed through the heat exchanger. Therefore within the 3 hours that temperatures in the incinerator are above 150 ^{0}C, a minimum amount of 0.405 m^3 (405L) of water can be heated. Since the burning of wastes is done twice a day, then 0.810 m^3(810L) of hot water would be produced per day. Hence this is the amount that can be used by patients and other users within the hospital. Energy required to heat 810L of water to 90^0C is 61.4KWh; if electricity provided by ESCOM is used, at the current tariff of MK25.89/KWh, a cost of MK1589.6 would be incurred. The cost of installing the whole heat recovery system is about MK60000.Therefore if the heat recovery system was used at the hospital, MK1.96 would be saved per every 1L of water and Mk1589.6 for every 810L of water heated water per day and MK47670 (USD 87.5) per month. Therefore the investment amount of Mk60000 would soon be paid off.

4.0 Conclusion

Having an optimum position to install a heat exchanger and data for the temperature distribution inside the incinerator, a heat exchanger was designed. The heat exchanger was made of galvanized steel pipes which were passed through the incinerator. For optimum outlet temperature (of 95°C) of the water from the incinerator, the optimum flow rate of the water was determined to be 3.75×10^{-5} m^3/s and this gives a heat energy gained of 10.870J/s. At this energy flow rate, 810L of water can be heated to 90-95^{0}C in 6 hours. The use of the heat-recovery system would save the hospital about MK1590 worth of electricity bill per every 810L of water heated.

Hence it is concluded that recovering heat from the waste incinerator can be one of the ways of providing hot water in the hospital. This system, once installed, would only use up the already available heat energy in the incinerator hence a good way of conserving energy and reducing electricity bills.

Therefore, based on these findings, there is a need to upscale this project to provide hot water for all the wards in the hospital. In that up scaled design, copper pipes should be used to prevent rusting/corrosion since the water, when heated us easily corrodes. Since the outlet temperature of the water flowing from the heat exchanger can reach boiling point at lower flow rates, it therefore implies that it is possible to use the steam generated for other purposes.

5.0 References

European Commission (2006). Integrated Pollution Prevention and Control:Waste Incineration.
United Kingdom: European Commission.

Fruergaad T., Christensen T.H., Astrup T. (2010). Energy recovery from waste incineration: Assessing the importance of district heating networks. Waste Management New York , Journal of waste management.7: 64-72.

Government of Malawi, Malawi Growth and Development Strategy, 2006.

Kelly M. J. (2010). Energy Efficiency, Resilience to Future Climates and Long-Term Sustainability. Philosophical Transactions of the Royal Society: 1083-1089.

Kodres C.A. (2009). Theoretical Thermal Evaluation of Energy Recovery Incinerators-Modelling. Journal of Energy Resources Technology.109 (2): 79-83.

Münster M., Meibom P. (2010). Long-term affected energy production of waste to energy technologies identified by use of energy system analysis. Journal of Waste Management.12 (30):10-19.

National Statistical Office (NSO) (2008). Housing and population census. Zomba: Government of Malawi

Nkhonjera L. (2011). Effects of Installing Thermosiphon Solar Water Heating System on Total Energy Bill at Mzuzu University. In Dhungel SK., Krishnakumar G (Ed.), Energy Audit for Professionals (p. 4). Mumbai India: NAM S&T Centre.

Tabata T. (2013). Waste-to-energy Incineration Plants as GreenHouse Gas Reducers:Case Study of seven Japanese Metropolises. Waste Management and Research: 1110- 1117.

Warhurst M, Watson A (2006). Dirty truths: Incineration and Climate Change. Retrieved May 14, 2013, from Friends of the Earth: http://www.foe.co.uk

Application of GIS in Health Human Resource Deployment to Health Facilities: A Case of Blantyre Health District in Malawi

Eddons C. S. Munthali[a], Patrick A. Chikumba[b*] and Ken C Gondwe[c]

a,b,c University of Malawi, The Polytechnic, Department of Computing and Information Technology

emunthali@poly.ac.mw, pchikumba@poly.ac.mw, kcgondwe@poly.ac.mw

Abstract

Availability of healthcare professionals and accessibility to healthcare facilities are important aspects of health system and has direct impact on the population's health. Applying Geographic Information Systems (GIS) techniques, this study analysed the geographical allocation of health professionals per categories of nurses, clinicians and Health Surveillance Assistants (HSAs) and how GIS could help in distribution of professionals to health facilities. Using Blantyre District Health Office in Southern Malawi as a case study, data on people accessing each health facility and number of health professionals at a facility was collected and analysed. The study found out that applying GIS can help enrich the information required for equitably distributing health human resource. Some health facilities seen to have more personnel were discovered that they still need deployment of additional staff to those health facilities seem to have inadequate number of personnel. Using provider-to-population ratios the research was able to isolate Health Professional Shortage Areas (HPSAs) and Medically Underserved Areas using a threshold based criteria of 1,000:2 as per WHO requirement. The research also adopted gravity model of migration to predict the degree of interaction between two places. Employing gravity model and taking into account population size of two facilities and their distance, the research was able to determine relative strength of the bond between two health facilities and predict where more professionals could be deployed.

Keywords : Geographic Information Systems, Health Facility, Health Professionals, Health Human Resource.

1.0 Introduction

The healthcare plays a very important role for the well-being of the community; it is defined as the prevention, treatment, and management of illness and the preservation of mental and physical well-being through the services offered by the medical, nursing, and allied health professions (KPMG, 2009). The primary healthcare is a crucial element

of national healthcare delivery, especially in developing countries like Malawi where majority of the population living in rural areas. Rural environments present unique challenges for healthcare access such as shortages of medical personnel. Availability of healthcare experts at a health facility is also an important factor for a health system and has a direct impact on the population's health.

Accessibility to the healthcare is concerned with the ability of a population to obtain a specified set of healthcare services. Many factors affect a population's ability to access appropriate levels of the healthcare (Michael et. al., 2004) which are grouped into three categories; availability, accessibility and affordability. Geographic accessibility (often referred to as spatial or physical accessibility) is concerned with the complex relationship between the spatial separation of the population and the supply of healthcare facilities and thus has a strong underlying geographic component (Michael et. al., 2004). It is also intuitive that the level of public health of a population may be affected negatively by the distance to healthcare services (Guagliardo, 2004).

The public sector is the major employer of professional health workers. Hornby and Ozcan (2003) reported that 69 % and 31 % of health workers, in Malawi, were in the public sector and private sector respectively. Malawi has low health worker ratio (Gordon, 2008). There are not enough health personnel in some of the health facilities despite having many graduating each and every year from Health Training institutions and universities. Malawi, like many African countries, is lacking health human resources, preventing it from delivering acceptable quality healthcare services to its population.

The reasons underlying the shortage of health professionals are multiple and include limited output from training institutions, high attrition rates resulting from migration and disease, and increased workloads because of HIV and AIDS (Muula et. al., 2005). It is therefore imperative to look into the equitable allocation of health experts and services into various health facilities and find out if the allocation takes care of the spatial separation of population and number and type of cases referred to a health facility.

Health managers rely on forms and sometimes spreadsheets coming in form of reports from different health facilities to, among others, help them determine personnel deficiency and come up with decisions of allocating health personnel in certain parts of the country. Msiska (2009) argued that spatial dimension offered by GIS is crucial in accessing and allocating health facilities and services. There is also inadequate reporting system which may slow down resource distribution (Oppong, 2011).

The problem of lack of access to health professionals in health facilities could be as a result of uneven distribution of health workers. This can, among other reasons, be attributed to poor reporting formats to help managers make better decisions coupled with unavailability of an enabling tool for spatial analysis of health facilities and services. The

complexity of development tasks such as determining health facility location and health human resource distribution requires the acquisition of up-to-date information to remove uncertainty in decision making. To achieve equitable distribution of health personnel officers and health facilities among population requires the use of perfect knowledge which can only exist where there is accurate and relevant information. Proper knowledge reduces uncertainty in decision making and planning for these important resources in health management systems.

The paper discusses the use of GIS in analysing the geographical distribution of health professionals in the health facilities in Malawi and to determine population's accessibility to healthcare which would help decision makers in distributing health personnel experts. GIS is well suited to measuring spatial accessibility to healthcare as they contain the core components needed for such analysis through data capture, storage, management and manipulation tools for both spatial and attribute data (Michael et. al, 2004). According to Longley et al., (2005, p. 4) "Almost everything that happens, happens somewhere. Knowing where something happens can be critically important."

2.0 Literature review

Despite having limited resources, GIS has proved to be very important in developing countries particularly in Africa. It has found its useful application in traffic and transport, agriculture, allocation decisions, spatial planning (land use), service planning (Education, health and social) and environmental and natural resources (Saugene, 2005). Geospatial applications do not just produce maps, but do carry out a geospatial data analysis as well. Some typical types of analysis include computing of: distances between geographic locations, the amount of area within a certain geographic region, what geographic features overlap other features, the amount of overlap between features, the number of locations within a certain distance of another and many more (Mitchell, 2005). The results of analysis may be shown on a map, but are often tabulated into a report to support management decisions.

The recent phenomena of location-based services promises to introduce all sorts of other features, but many could be based on a combination of maps and analysis. For example, you have a cell phone that tracks your geographic location. If you have the right software, your phone can tell you what kinds of facilities are within walking distance. While this is a novel application of geospatial technology, it is essentially doing geospatial data analysis and listing the results for you (Mitchell 2005).

The tremendous potential of GIS to benefit the healthcare industry is just now beginning to be realized. Both public and private sectors are developing innovative ways to harness the data integration and spatial visualization power of GIS. Parker and Campbell (1998) explain that early applications of GIS in the healthcare research mainly focused on

distribution of health and disease but more lately GIS has been applied to the planning and management of healthcare services. GIS plays a critical role in determining where and when to intervene, improving the quality of care, increasing accessibility of service, finding more cost-effective delivery modes, and preserving patient confidentiality while satisfying the needs of the research community for data accessibility (ESRI, 2009).

Several studies have been undertaken in the use of GIS as a tool in resource allocation. In California, Goulias (2007) argued that assessments of transportation investment from a "social efficiency" viewpoint were absent from transportation policy analysis and marketing practice mainly due to the lack of tools capable to assess the role of transportation infrastructure investment on the provision of activity opportunities to residents of each locality. It was therefore suggested a GIS-based tool as an optimal resource allocation tool for forecasting the travel demands of demographic groups within California.

The tool identified specific locations in an entire state where resource allocation had succeeded in maximizing benefits to the public. In addition, the tool and the GIS maps derived from this tool showed which locations in California failed to be optimal and require their residents to travel excessively to pursue the same amount of activities when compared to other optimal locations around the state where travelling enables better time allocation. The tool showed which demographic segments suffer the most from sub-optimal time allocation and what type of investment is needed to alleviate this suffering. It also showed the distribution of benefits of the transportation system and identified differences in benefits across regions.

In China a GIS-based method was used to determine whether land should be reallocated a new use (Liu et. al., 2006). It was used to assess land suitability in the Qinling Mountains, Shaanxi Province of China through consideration of physical features and current land use. Through interpretation of Landsat TM images and extensive field visits the area was modeled into land types in five altitudinal zones (valleys and gullies, hillsides and terraces, foothills, mid-mountain, and subalpine mountain). Then, a suitability score was assigned to five physical factors: climate, hydrology, topography, soil, and vegetation. Next, their integrated overall suitability value scores were compared with the observed land cover to determine whether it should be reallocated a new use. Implementation of the recommended land reallocations helped to achieve suitable use of land resources and prevent land degradation.

A similar study was also done in China by Wang et al (2005) on optimal water resource allocation in Arid and Semi-Arid areas of Heihe river basin in northwest China. The study developed a dynamic model for equitable distribution of water in water-shortage areas which aimed at optimally satisfying the requirements of each locality, given limited supplies, and to maximise the total economic benefit of the entire area.

In terms of human resource allocation, Massey (2011) explored the use of GIS to examine the regional distribution of human resources for health and related maternal health indicators in Senegal. Results showed that a regional imbalance in the distribution of health personnel and health indicators existed in Senegal. The disparity contributed to the disproportionate burden of disease experienced in the eastern part of the country. Based on a spatial analysis, a priority index was used to identify regions to target for the recruitment and training of midwives.

3.0 Methodology

This research adopted both qualitative and quantitative methods. Qualitative research method was chosen because of the exploratory nature of the research's aims and objectives. Quantitatively, the research was able to calculate the ratios of health human professionals to catchment population. Using GIS prototype tool, the research measured the spatial distance between each health facility and analysed spatial disparities of health facilities and health professionals. The case of Blantyre DHO was used with health surveillance assistants (HSAs), nurses and clinicians as health personnel; and malaria and diarrhea as disease cases.

Data was collected through document analysis and semi-structured interviews. The research demands the knowledge of populations served by the health facilities. Different documents were used to capture information about the catchment area for each health centre. The researchers also used semi-structured interviews to collect information from district health officer and HMIS officers. In addition to these, prototyping was also used to collect data of practical relevance and to gain a practical understanding of using GIS. To facilitate the data collection process an approval was sought from the National Health Sciences Research Committee in Ministry of Health.

The research adopted gravity model of migration which is a model in urban geography derived from Newton's law of gravity, and used to predict the degree of interaction between two places (Rodrigue et. al., 2009). When used geographically in this research, the words 'bodies' and 'masses' are replaced by 'locations' and 'importance' respectively, where importance can be measured in terms of population numbers or other appropriate variables. The gravity model of migration is therefore based upon the idea that as the importance of one or both of the location increases, there will also be an increase in movement between them and farther apart the two locations are, however, the movement between them will be less, a phenomenon known as distance decay (Rodrigue et. al., 2009).

Of particular importance to this research are two points in determining patient migration between two health facilities as well as the number of people in the community likely to use one health facility. The gravity model can also be used to determine the sphere of influence of each central place like a facility by estimating where the breaking point

between the two settlements will be. An example of this is the point at which community or patients find it preferable, because of distance, time and expense considerations, to travel to one facility rather than the other.

A Two-Step Floating Catchment Area (2SFCA) as defined by Luo and Qi (2009) was also used which is a special case of a gravity model of spatial interaction that was developed to measure spatial accessibility to primary care physician. It can also be used to measure other accessibility such as accessibility to healthcare facilities, jobs and others. It was inspired by the spatial decomposition idea first proposed by Radke and Mu (2000). The 2SFCA method is for combining a number of related types of information into a single and immediately meaningful index that allows comparisons to be made across different locations. Its importance lies in the improvement over considering the individual sources of information separately, where none on its own provides an adequate summary.

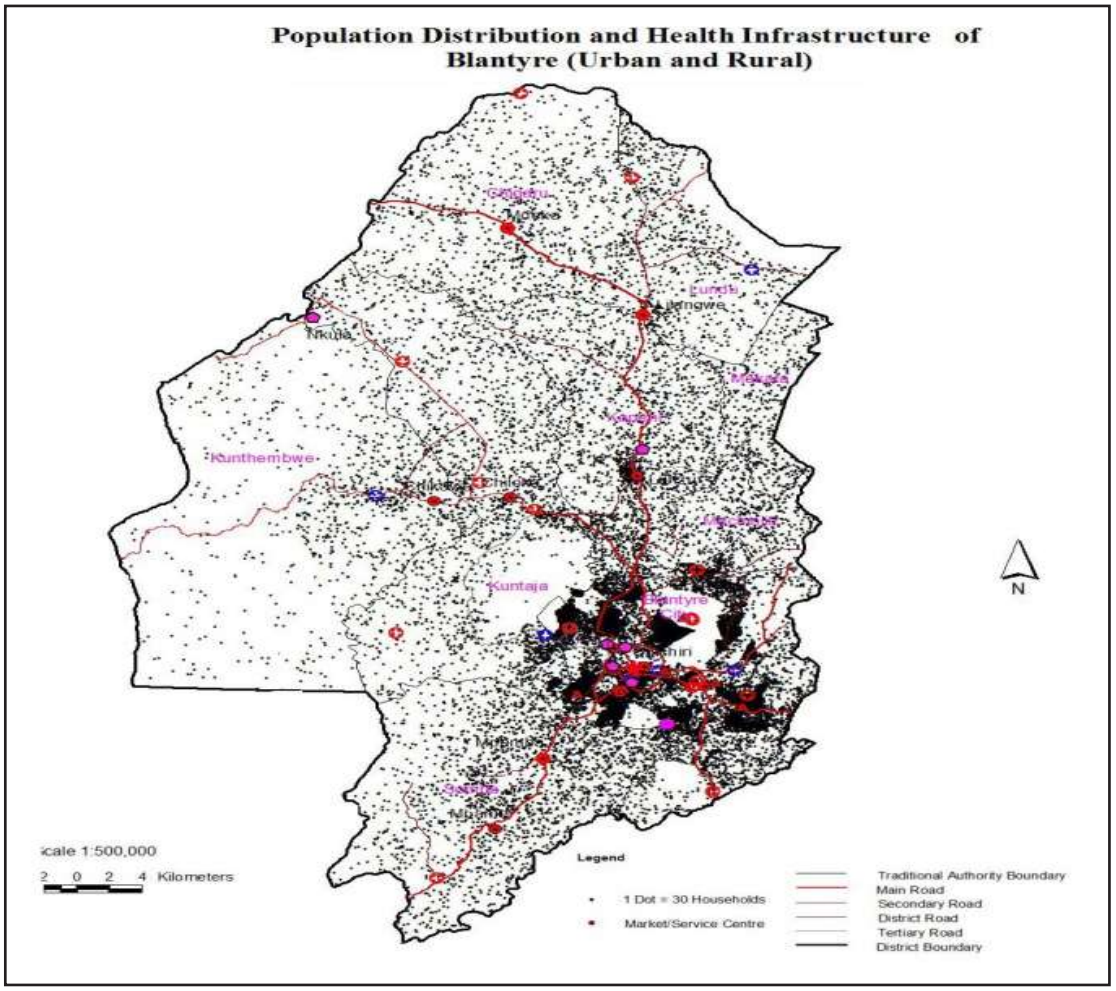


Figure 1: Population Distribution and Health Infrastructure of Blantyre

4.0 Mapping with GIS

4.1 Catchment Area and Provider-to-Population Ratio

In order to plan and monitor the use of services, there is need to know the geographical area and population that a facility is supposed to serve. In this research, GIS prototype was used to map total population per facility (see Figure 1). According to government policy, a health facility is supposed to serve population within 5 km radius. The research regards population within this radius as target population.

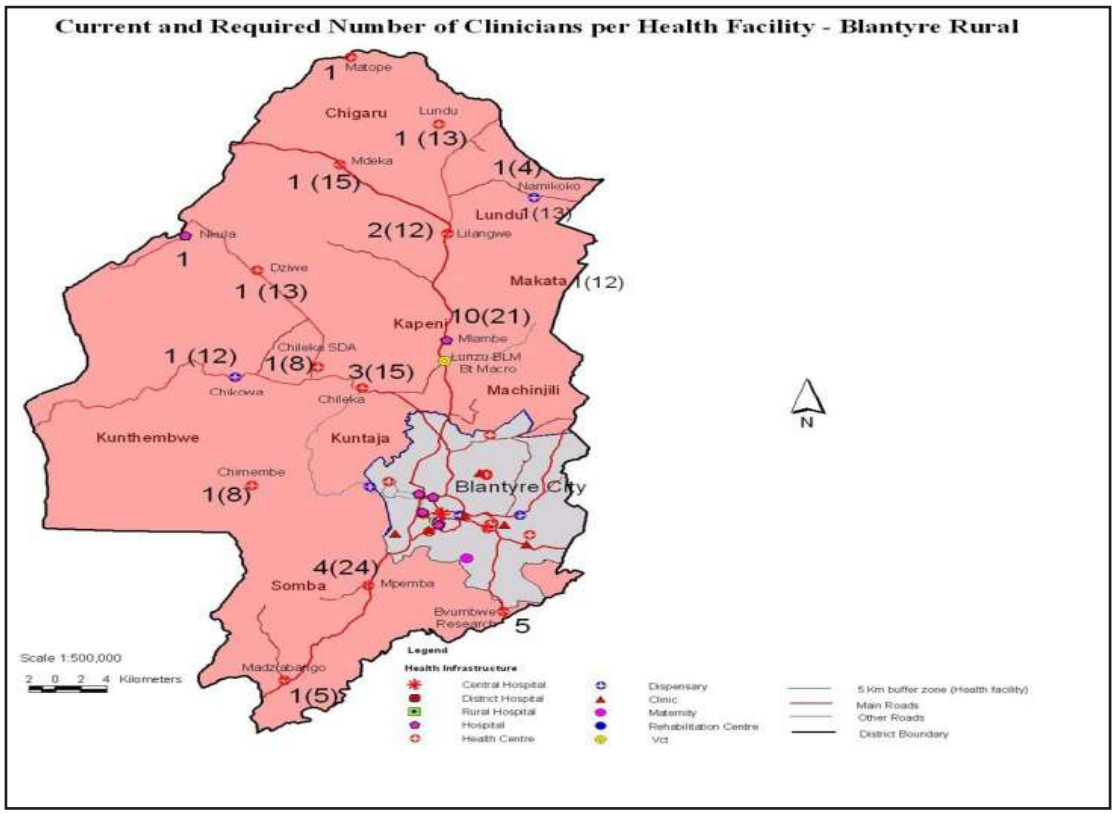


Figure 2: Clinicians per health facility

The provider-to-population ratio was used in this research because of its ease of computation and because it requires minimal data requirements. As such, it can be nicely used as a crude approximation of spatial accessibility. The provider-to-population ratio is also particularly useful to track changes over time as geo-references in historical data are sparse.

The provider-to-population ratio was so important in isolating Health Professional Shortage Areas (HPSAs) and Medically Underserved Areas (MUA). The research adopted the idea from the United State's Department of Health and Human Services (DHHS) where HPSAs were defined using an elaborate system of threshold based criteria. For

geographical area, this research considered areas that exceed a threshold of 1,000:2, as per WHO requirement since WHO determined that countries below a threshold of two (2) to three (3) doctors, nurses and midwives for every 1,000 people are very unlikely to achieve the MGDs (WHO, 2006).

The GIS prototype was used to locate the numbers of the professionals per facility as the actual situation on the ground, as an example shown in Figure 2. The provider-to-population ratio was used to determine the need of professionals per facility. Numbers presented in brackets shows the calculated required number of clinicians per facility using the provider-to-population ratio taking into account the government policy of 2 clinicians and a nurse for every 1000 population.

4.2 Gravity model of migration

The gravity model, as social scientists refer to the modified law of gravitation, takes into account the population size of two places and their distance. Since larger places attract people, ideas, and commodities more than smaller places and places closer together have a greater attraction, the gravity model incorporates these two features. The relative strength of a bond between two places is determined by multiplying the population of city A by the population of city B and then dividing the product by the square of the distance between the two cities as illustrated below:

$$\frac{\text{population}_1 \text{ x population}_2}{\text{distance}^2}$$

Generated from the GIS prototype, Figure 3 shows distances between different facilities within Blantyre. Applying the "how far is it?" feature from GIS software and facility population data to determine the gravitational attraction between two facilities in Blantyre and of course in Malawi, decision makers can determine where to place health professionals to supplement nearby health facilities. After calculating distance between facilities with GIS and using 2011 catchment population data the researchers were able to determine gravitational attraction between facilities. Opponents of the gravity model explain that it cannot be confirmed scientifically, that it is only based on observation. They also state that the gravity model is an unfair method of predicting movement because it is biased toward historic ties and toward the largest population centers.

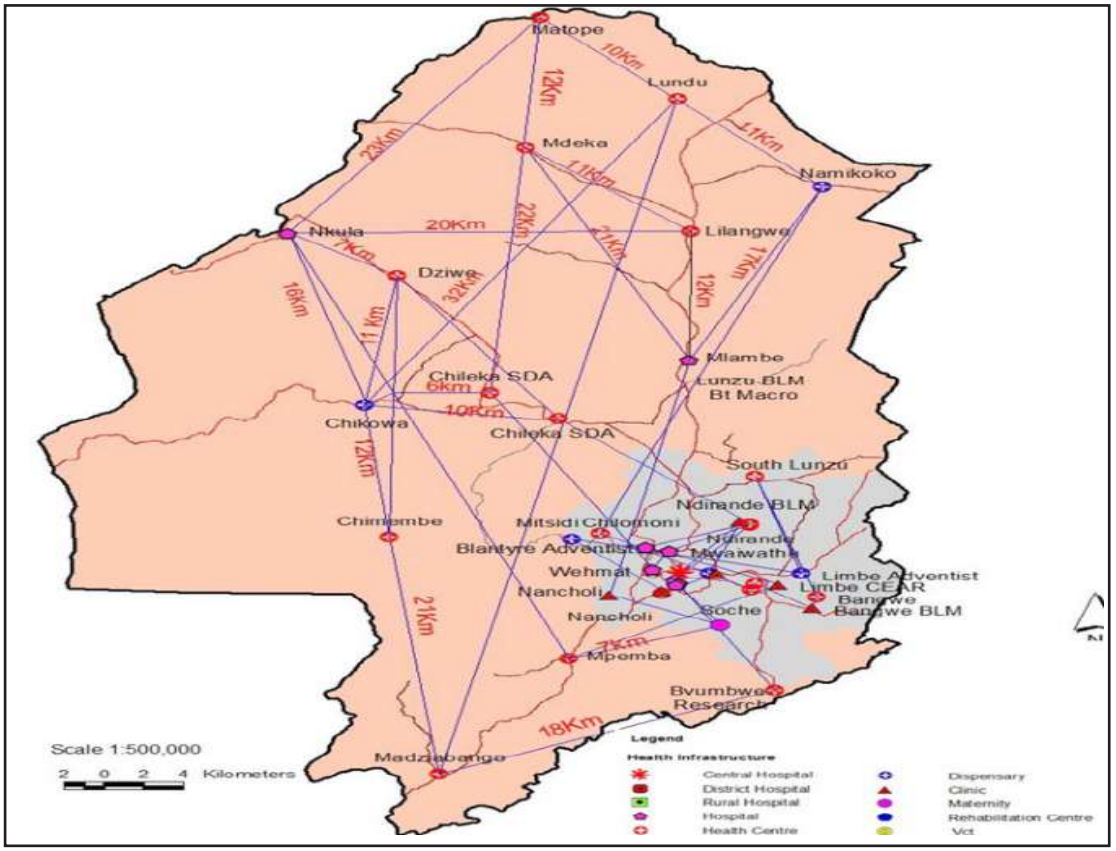


Figure 3: Distance between health facilities

5.0 Application of GIS

Using GIS software in the mapping as explained above, research brought to light geographic distribution of population and the distribution of health facilities in Blantyre health district. After analysing population distribution from the map, it was found out that people are more concentrated in urban than in rural areas. Mapping health facilities and employing the 5 km radius for each health facility that it is supposed to serve, research discovered that Blantyre urban is well covered up with healthcare than Blantyre rural (see Figure 4).

The research recognised that services offered by medical, nursing, and allied health professions play a very important role for the well-being of the community especially in developing countries like Malawi. It also recognised that the availability and ability of a population to obtain a specified set of healthcare services is an important factor for a health system and has a direct impact on the population's health.

The research looked at spatial or physical accessibility, concentrating on the complex relationship between the spatial separation of the population and the supply of healthcare

facilities which has a strong underlying geographic component – geographic accessibility. GIS was applied to analyse geographic distribution of health facilities, services and allocation of health professionals to see spatial separation of population and supply of healthcare facilities. The research findings show that there is low ratio of health professionals to population contrary to WHO requirement of 2:1000.

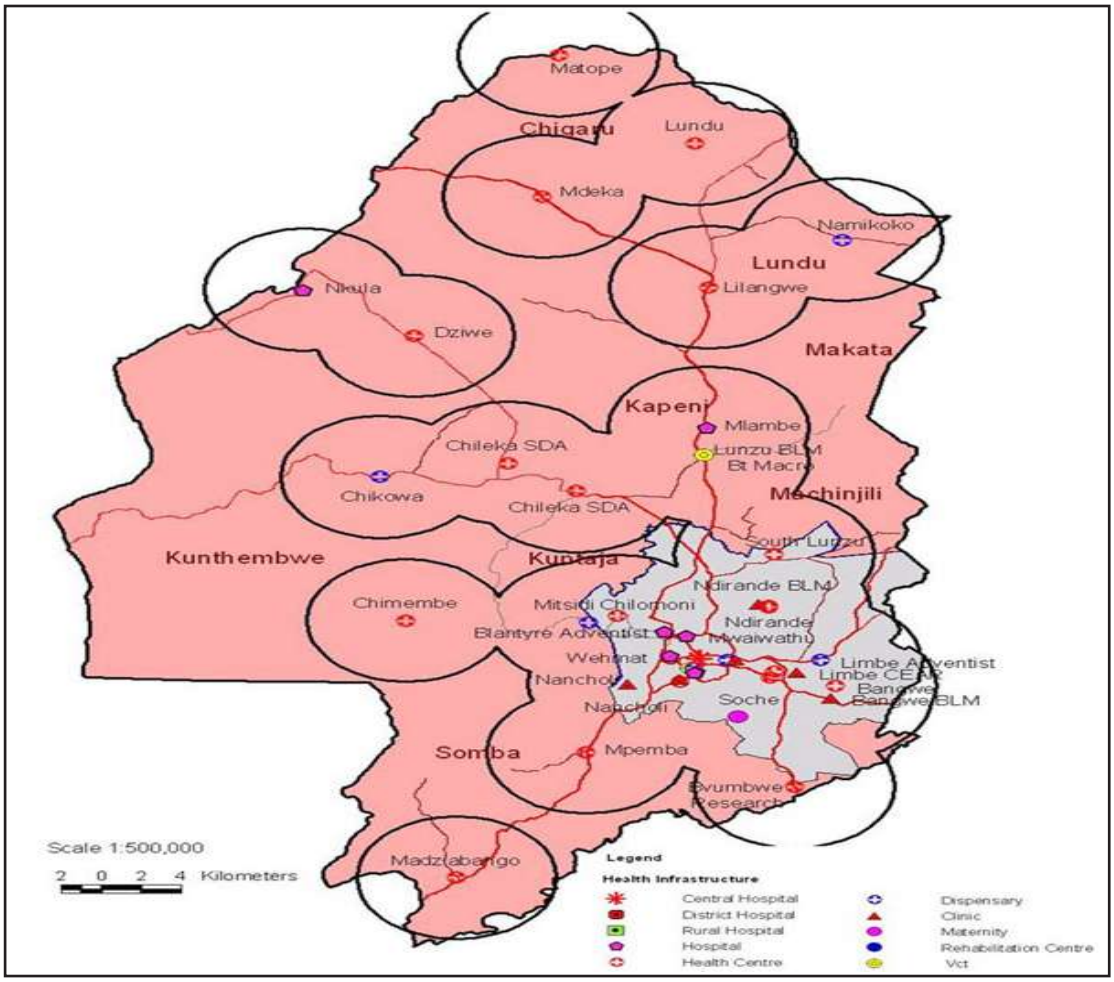


Figure 4a: 5km Radius of Health Facilities in Blantyre Rural

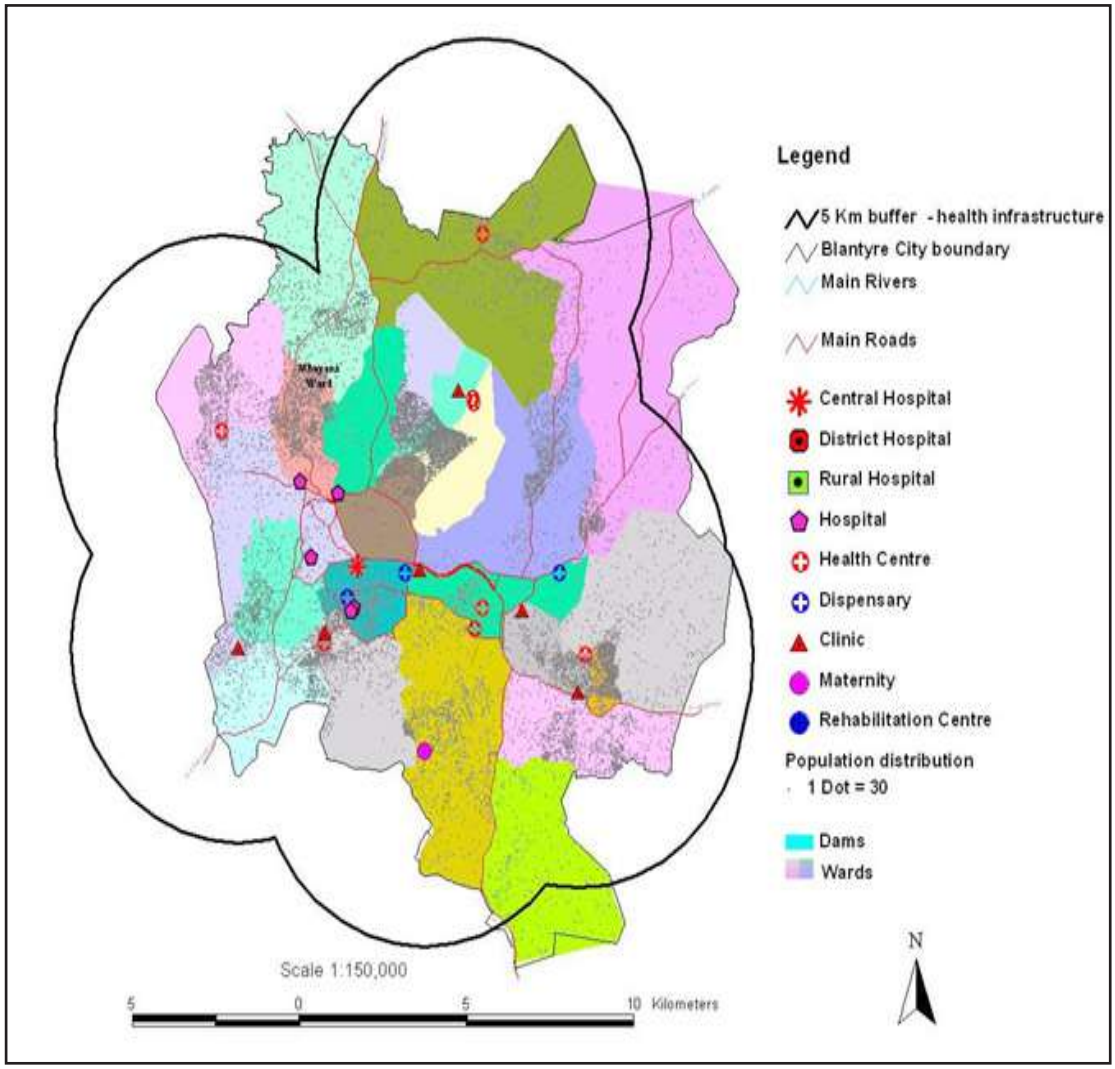


Figure 4b: 5km Radius of Health Facilities in Blantyre

Research findings show that there is the shortage of human resource for health in Blantyre. It was therefore imperative to look into the equitable allocation of health professionals and services into various health facilities and find out if the allocation does take care of the spatial separation of population and number and type of cases referred at the health facility.

The research has explored the application of GIS in analysing the geographical allocation of health professionals and looked at how best GIS as a tool can help health management when making decisions of equitably distributing scarce health professionals into various health facilities in Malawi. Preliminary investigations also indicated that there is inadequate reporting system which slows down health human resource distribution. Concerning this, one of the officers at Blantyre DHO had this to say; "When it comes

to displaying data, we normally use MS Excel. We have GIS software installed in our computers but we don't know how to use it. …you can teach us. …we should easily map health areas, compare the performance of each, and determine if any geographic patterns exist, which is very difficult and time consuming in Excel."

This implies that GIS is well suited to measuring spatial accessibility and can help enrich information which could be used to know how resources, like health personnel, are distributed for maximum utilization. Viewing data in Excel require a health program manager to spend significant amount of time and energy to understand the health service coverage and geographic distribution of services. It has been found that with GIS, managers can easily evaluate both the performance and distribution services through a map. The use of spreadsheet programs for viewing extensive tabular data can make it difficult both to analyse data and to draw valid conclusions.

GIS has got mapping and visualisation tools to communicate the results of analysis. Using GIS, therefore, it was very easy to know where an event had happened because of the geographic coordinates that it uses in relation to spatial and non-spatial data. It can be used to get ground measurement of the geo-referenced objects like health centres, analyse geographical location of the health facilities and enrich the information by displaying it in the form of maps, graphs, charts, and tables for important decision making. It was demonstrated that GIS can easily show how a health service facility relates to the population.

Using GIS therefore helped the researchers to explore, analyse and report the geographical allocation and distribution of health professionals in the health facilities and determine population's accessibility to healthcare which could help decision makers when making decisions of equitably distributing health professionals.

With the capabilities of GIS as explained above, the researchers believe that the results from the research would help the government of Malawi in general and Ministry of Health in particular to make better decisions when it comes to planning the deployment of professionals in to health facilities in a district. The researchers recognised that measuring access to healthcare facilities is very important as it widens understanding of health system's performance and facilitates the development of evidence-based health policies. It is very important that health programs are tailored to the specific needs and unique characteristics of a community or a facility. For example: What is the distribution of those living in the community? What percentage of the population is underserved? GIS allows you to organize and analyze such data geographically. GIS is therefore a very powerful tool when designing health programs and assessing health needs.

6.0 Conclusion

GIS can be an essential tool to understand what is going on. Health managers can use GIS information products which provide a visual framework for conceptualizing, understanding, and prescribing action. GIS is increasingly being implemented as enterprise information systems which go far beyond simply spatially enabling business tables in a database management system. Geography is emerging as a new way to organize and manage organizations. GIS is transforming the way that organizations manage their assets, serve their customers/citizens, make decisions and communicate. In government and many large corporations, GIS can provide a broader context for assets and resource management.

In line with national strategies regarding the development of using Information Technology (IT) in the country, there is a good view for using GIS. Now, most health departments and health organisations have established their ICT departments and are trying to acquire new technology in information infrastructure. It is recommended that this development needs to consider the introduction and application of GIS in these organizations.

It is also recommended that activities have to be done to familiarize managers and decision makers with GIS benefits and improve the level of using it in different aspects of management. With these actions, most organizations, especially organizations related to resource allocation planning and management will identify the vital role of GIS in resource distribution. Much attention should also be paid in the use of GIS in different activities. One of the important actions in this program should be preparing strategies that must dictate the next action of the country for developing spatial data usage.

References

ESRI. (2009). Geographic Information System and Pandemic Influenza Planning and Response. ESRI.

Goulias, Konstadinos G. (2007). An Optimal Resource Allocation Tool for Urban Development Using GIS-based Accessibility Measures and Stochastic Frontier Analysis. California Path Program Institute of Transportation Studies. University of California.

Gordon, M. (2008). Evaluation of Malawi's Emergency Human Resources Program.

Green, C. (2012). Purple Paper Geographic Information Systems and Public Health: Benefits and Challenges. Purple Paper • Issue No. 37 • March 2012.

Guagliardo, M. F. (2004). Spatial accessibility of primary care: concepts, methods and challenges. International Journal of Health Geographics, 3(1), 3. doi:10.1186/1476-072X-3-3.

Hornby, P., & Ozcan, S. (2003). Malawi human resources for health strategic plan. Lilongwe, Malawi: Ministry of Health.

KPMG. (2009). Improving Health Outcomes in Rodrigues. Rodrigues: KPMG Advisory Services Ltd.

Longley, P. A., Goodchild, M., Maguire, D. J., and Rhind, D. W. (2010). Geographic Information Systems and Science (3 Edition). Hoboken, NJ: Wiley.

Liu Y. S., Wang J. Y. and Guo, L. Y. (2006). GIS-Based Assessment of Land Suitability for Optimal Allocation in the Qinling Mountains, China. Pedosphere 16(5): 579-586, 2006. Soil Science Society of China. Elsevier Limited and Science Press.

Luo, W., & Qi, Y. (2009). An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians. Health & Place, 15(4), 1100–1107. doi:10.1016/j.healthplace.2009.06.002.

Massey P1. (2011) Reducing maternal mortality in Senegal: using GIS to identify priority regions for the expansion of human resources for health. World Health Population. 2011;13(2):13-22.

Michael, B. (2004). Using GIS to Measure Physical Accessibility to Health Care. RMIT University.

Mitchell, T. (2005). Web Mapping Illustrated. O'Reilly Publishers.

Msiska, B. (2009). Application of GIS in the Monitoring and Management of HIV/AIDS: A Case from Malawi. Oslo.

Muula, A. S., &Maseko, F. C. (2005). Survival and retention strategies for Malawian health professionals. Retrieved from http://41.87.6.35:8080/xmlui/handle/ 123456789/317

Oppong, J. Y. (2011). Wildlife conservation and livelihood options: A case study of Kakum conservation area. Retrieved from http://ir.ucc.edu.gh/dspace/handle/ 123456789/883

Parker, E., & Campbell, J. (1998). Measuring access to primary medical care; some examples of use of Geographical Information Systems. Health and Place.

Radke, J., & Mu, L. (2000). Spatial decomposition, modeling and mapping service regions to predict access to social programs. Geographic Information Sciences, 6(2), 105 – 112.

Rodrigue, J. P., Comtois, C., &Slack, B. (2009). The Geography of Transport Systems (2 Edition). London ; New York: Routledge.

Saugene, Z. B. (2005). Challenges, opportunities and strategies for using geographic

information systems for public health management : an action research study from Mozambique. Retrieved from https://www.duo.uio.no//handle/10852/9382

Wang, F., & Luo, W. (2005). Assessing spatial and non-spatial factors for healthcare access: towards an integrated approach to defining health professional shortage areas. Health & Place, 11(2), 131–146. doi:10.1016/j.healthplace.2004.02.003

WHO. (2006). The World Health Report 2006 – working together for health. Retrieved 3 October 2014, from http://www.who.int/whr/2006/en

Viability of Community Led Total Sanitation in Rural Malawi: A Case of Ntcheu, Balaka and Phalombe Districts

S. Kumwenda[a], K. Kalulu[a],

K. Chidziwisano[a], L. Kalumbi[a],

V. Doyle[b] and B. Ngwira[a]

[a]University of Malawi, The Polytechnic, Department of Environmental Health, P/Bag 303, Chichiri, Blantyre 3, Malawi

[b]Concern Universal Malawi, 21 Link Road, P.O. Box 1535, Namiwawa, Blantyre, Malawi

Abstract

Starting from 2008, the Malawi Government adopted Community Led Total Sanitation (CLTS) as a recommended approach for reducing open defaecation. Its aim was to declare the country open defaecation free by 2015. However, it is not known whether the approach produced consistent results in districts where it was tried. Therefore, this study assessed its viability using a convergent parallel design. A total of 634 household representatives aged 18 and above were interviewed using a structured questionnaire on viability of CLTS, latrine and hand washing coverages. Qualitative data on viability were collected from 36 focus group discussions, 17 key informants and 6 transect walks. Latrine coverage ranged from 61.1% to 97.6% with villages not following CLTS principles having the lowest coverage. Perceived hand washing by study participants was at 96.1%. CLTS was not in conflict with social, religious and cultural values of communities. There were variations in the way process of triggering was done. Necessary follow-ups were not being consistently done by natural leaders, extension staff and District Coordinating Teams. From a gender perspective, women and children participated more than men in in the CLTS programme. Perceived impacts by communities included increased latrine coverage, increased handwashing practice and reduction in diarrheal diseases. It was found that the approach was acceptable despite it being implemented differently in various communities. The variations in CLTS implementation were not aimed at adapting to local situation but rather cutting costs and solving the problem of lack of resources. This led to non-viability of the CLTS approach.

Keywords: Follow-up, Malawi, sustainability, sanitation and triggering.

1.0 Introduction

Open defaecation (OD) is practiced by 1.1 billion people (mostly from low and middle income settings) in the world (UNICEF, 2009) and it remains one of the areas of public health concern globally. Open defecation is prevalent in sub-Saharan Africa and South Asia where improved sanitation coverage is lowest globally especially among the poor in rural areas (Selendy, 2011; WHO/UNICEF, 2014). Malawi Millennium Development Goals' report indicated coverage of 40% for improved latrines (National Statistical Office, 2014). The estimated proportion of Malawians practicing OD was at 11% in 2010 (Malawi Government, 2011) and it reduced to 8% in 2014 (WHO/UNICEF, 2014). The Malawi Government adopted Community Led Total Sanitation (CLTS) approach as the prescribed strategy for the promotion of sanitation and reduction of OD in the country in 2008 (Malawi Government, 2011; Ministry of Irrigation and Water Development, 2008).

CLTS represents an alternative to achievement of sustainable development goals to the conventional top-down approaches characterised by communities being told on what action they should take to achieve intended sanitation outcomes (Kar, Chambers, & Plan UK, 2008). It is an approach, pioneered by Kamal Kar in Bangladesh in 1999, and has since spread to other countries in Asia and Africa (Kar & Bongartz, 2006; Kar & Pasteur, 2005). The main aim of CLTS is to reduce OD through collective action after analysis of the community's sanitation profile, practices of defaecation and the consequences (Kar et al., 2008). The CLTS approach is based on six principles of community sensitization, no blueprint design, external facilitation, post-triggering follow-ups, zero subsidy and use of natural leaders. Community sensitization provides an avenue for facilitators to learn about existing sanitation and hygiene practices within the community and establish rapport with communities. The no blueprint design principle realises that communities are capable of analysing faecal-oral routes of disease spread, and conceiving ways to deal with them without outsiders offering prescribed solutions. External facilitation demands that facilitators should not teaching or lecture on the action the community have to take to attain OD and the facilitators be external to the community as they are new to community. Post-triggering follow-ups are to ensure that CLTS is sustained and improvements in latrines and practices are made over the long term. It involves checking if the plans made during triggering (See Figure 1) are being implemented, reminding communities about the plan and encouraging them to adhere to their plan. The follow-ups need to go beyond ODF achievement to sustain the status. No subsidy principle prohibits hardware subsidy, but make use of facilitation by local 'non-expert' community members, supported by low-cost training, none of which require much budget (Kar et al., 2008). The principle encourages use of local materials as such there is need for proper management of community resources such as forests (Kar & Bongartz, 2006; Kar et al., 2008). The last principle requires that during triggering, those people who show leadership skills (natural leaders) be chosen by the community to champion the process. Natural leaders are better placed

to facilitate change as they are aware of the local conditions (Mehta & Movik, 2010). After the triggering session the natural leaders are oriented on CLTS implementation. Figure 1 shows the steps followed when implementing CLTS.

Studies have shown that some of the successfully triggered villages fail to attain open defaecation free (ODF) status (Mara, Lane, Scott, & Trouba, 2010; Phiri, Kalulu, Kumwenda, Chidziwisano, & Kalumbi, 2014). Furthermore, in most cases communities that have attained ODF slide back to OD (Tyndale-Biscoe, Bond, & Kidd, 2013). Some of the reasons for low attainment and sustenance of ODF include financial constraints, lack of support, facilitation skills, availability of construction materials and local ground and soil conditions (Phiri et al., 2014; Tsinda et al., 2013; Tyndale-Biscoe et al., 2013; Water and Sanitation Program, 2011).

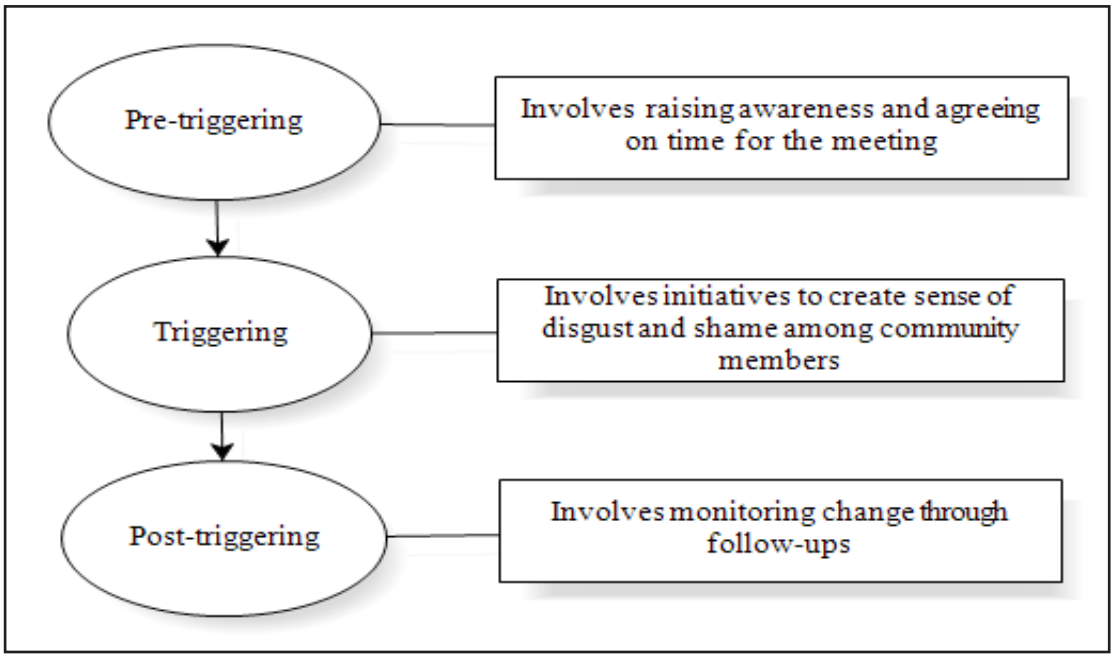


Figure 1: Steps in implementing CLTS

This study therefore sought to explore the key success factors and threats to the viability (defined as capable of working successfully) of the CLTS approach which has been adopted by Malawi Government in implementation of sanitation programmes in the country so as to inform policy and practice. The dimensions of viability explored in the study included acceptability of the CLTS approach, quality of facilitation, post-triggering follow-ups, gender and social inclusion, construction support mechanisms and perceived impacts.

2.0 Methods

The study employed a convergence parallel design where both qualitative and quantitative data were collected at the same time (Figure 2) (Creswell & Plano Clark, 2011).

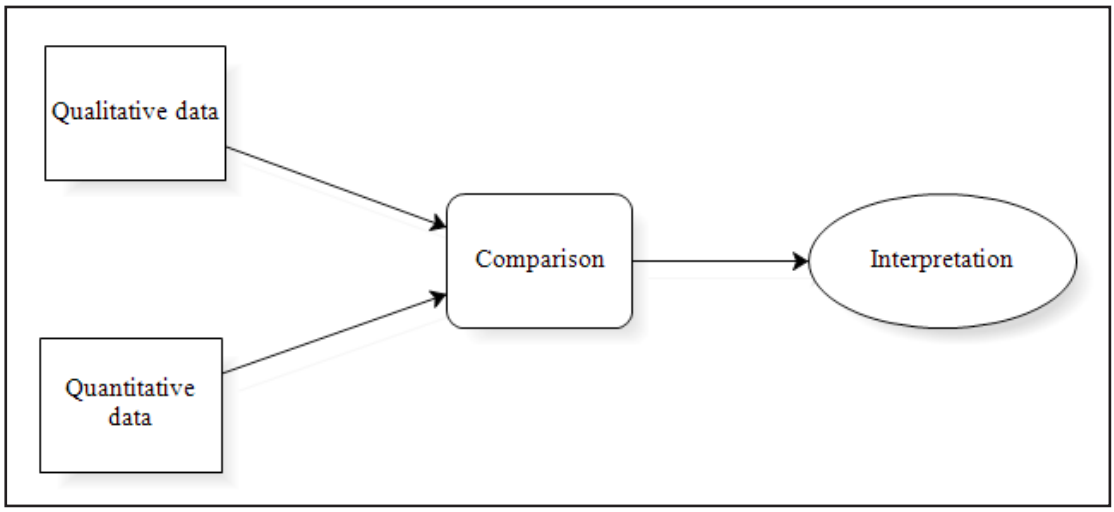


Figure 2: Convergent parallel design (Creswell & Plano Clark, 2011)

Both qualitative and quantitative data were collected for purposes of triangulation. Data collected were analyzed and compared to identify any agreements and disagreements and then interpreted (Creswell & Plano Clark, 2011). The study was conducted in July, 2014, six months after the CLTS implementation was concluded and two years after the start of CLTS implementation. The study sites included communities/villages of Traditional Authority (TA) Kalembo in Balaka District, TA Makwangwala in Ntcheu District and TAs Kaduya and Nazombe in Phalombe District (Figure 3) where Concern Universal and partners had been implementing CLTS. For quantitative part, the number of villages per district was selected based on TA population size.

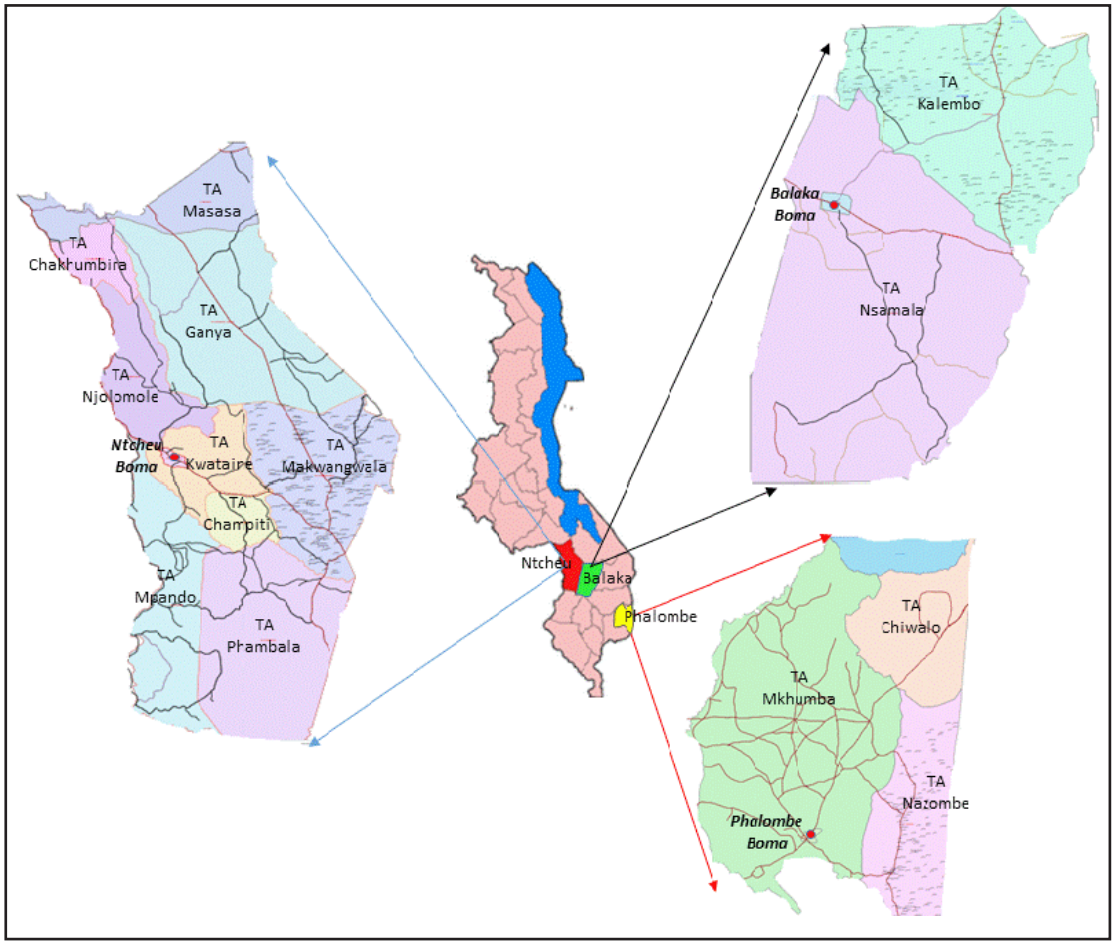


Figure 3: Map of Malawi showing the study area

List of villages were obtained from the District Commissioner's office and for each village the households were chosen from village head's list using random numbers. Every respondent was eligible because it is expected by the CLTS approach that all community members participate fully. For quantitative study, 634 household representatives aged 18 and above were interviewed using a pre-tested Chichewa translated structured questionnaire. This sample size was calculated at 95% confidence level, error of 5%, 10% non-response rate and a conservative estimate of 50% of communities sliding back to OD and failing to attain ODF as the most conservative estimate where the proportion is not known.

For qualitative data, a total of 8 to 10 people participated in each of the 36 Focus Group Discussions (FGDs) and 17 participated in Key Informant Interviews (KII), (Table 1). Those who took part in FGDs included men, women, male youth, female youth, elderly and vulnerable and natural leaders. District Officials, local leaders and Non-Governmental Organizations (NGOs) were involved in KII. Participants for FGDs and

KIIs were conveniently and purposively sampled respectively. For KII, key members in the implementation of CLTS programme in the three districts were targeted. Two transect walks were conducted per district. The villages for transect walk were randomly selected from the list of villages chosen for household survey. Written permission was obtained from the District Authorities after reviewing the study proposal, tools and consent forms. Verbal consent was sought from those involved in household interviews and FGDs while written consent was obtained for those where pictures were taken.

Table 1: Category of participants for FGDs and KIIs

Interview type	**Category**	**Number of FGDs**		
		Balaka	**Ntcheu**	**Phalombe**
FGDs	Men	2	2	2
	Women	2	2	3
	Male youth	2	2	2
	Female youth	2	2	2
	Elderly and Physically challenged	2	2	1
	VHC/Natural leaders	2	2	2
KII	District Environmental Health Officer (DEHO)	1	1	1
	WASH Coordinator/ Facilitator	1	2	1
	Water Officer	1	1	0
	HSAs	2	0	2
	Local leaders	1	1	2
Questionnaires	Traditional Authorities	206	218	210

Qualitative data were recorded in Chichewa language, transcribed verbatim into English and analysed manually using thematic analysis. After the third reading of the transcripts, quotes were pulled out and summarized in a table according to themes. Representative quotes that were common were picked and included in the study results. Quantitative data were entered onto an SPSS version 16 database. Quantitative data were analysed using descriptive statistics and were summarized in tables and graphs using.

3.0 Results

The demographic characteristics of the study participants for quantitative part were summarized in table 2.

3.1 Demographics

Table 2: Demographic characteristics of household respondents

	Characteristic	Balaka	Ntcheu	Phalombe	Total
Sex	Male	61	67	55	183 (28.9%)
	Female	145	151	155	451 (71.1%)
Marital status	Married	167	142	144	453 (71.5%)
	Divorced	16	22	28	66 (10.4%)
	Single	2	20	5	27 (4.3%)
	Other	21	34	34	89 (14.0%)
Highest education level	Never been to school	71	25	35	131 (20.7%)
	Junior Primary	60	78	68	206 (32.5%)
	Senior Primary	46	69	72	187 (29.5%)
	Secondary education	19	37	28	84 (13.2%)
	Tertiary education	0	0	1	1 (0.2%)
	Other	10	9	6	25 (3.9%)
Head of house	Male	162	166	147	475 (74.9%)
	Female	32	42	55	129 (20.3%)
	Other	12	10	8	30 (4.7%)
Religion	Christian	77	206	186	469 (74.0%)
	Islam	128	9	23	160 (25.2%)
	Other	1	3	1	5 (0.8%)

Table 2 shows that the majority of respondents were female (71.1%) and 20.3% of the households were female headed. It is also shown from same Table 2 that 62%, 4%, 11% from Balaka, Ntcheu and Phalombe respectively were Muslims.

The study results were presented according to the following themes: acceptability, quality of facilitation, post triggering follow-up, perceived impacts, construction support mechanisms, gender and social inclusion.

3.2 Acceptability of CLTS

On the perception of respondents on how CLTS was implemented, the results show that FGD participants seem to have liked the CLTS process. During FGD one respondent said:

"Everybody welcomed the programme since it was introduced by the health personnel in the village...therefore we started constructing toilets on our own".

There were however, others who indicated not to have liked the process with the bringing of feaces to the community and embarrassing people being given as the reasons.

In the studied districts, respondents acknowledged that the CLTS programme which

they locally called 'kudyerana manyi' (eating each other's feaces) was generally compatible with their social, religious and cultural values. One Female FGD participant commented:

"Both our culture and religion do not have a negative attitude on CLTS programme due to the fact that they do not allow open defaecation hence encourage people to have latrines and wash hands when doing anal cleansing after visiting latrines".

Furthermore, CLTS was blending in well with culture as crude language e.g. *"manyi"* for feaces and *"kunya"* for defecating was acceptable within the communities.
However, in predominantly Islamic communities there was confusion regarding having a hand washing facility positioned outside the latrine. In such communities they practice anal cleansing which also involve handwashing but without soap. One FGD participant commented:

"...the problem is that Islam as religion has its own rituals which encourage its members to have a clay pot within the latrine which is used for anal cleansing. For this reason people had a different view since we were told to use the hand washing facility which should be placed outside the bathroom"

It took time for them to appreciate the distinction between hand washing outside the latrine and during anal cleansing as they felt it was double handwashing.

On transition from subsidy led to CLTS approach; it was observed that in Ntcheu, the process was done without proper awareness to communities. Communities in this district were reluctant to adopt CLTS as it did not encourage subsidies.

3.3 Quality of CLTS facilitation

CLTS facilitation in the three districts was done by implementing NGO, Village Health Committee (VHC), Government Extension Staff, Health Surveillance Assistants (HSAs) and chiefs. The study found that out of 634 respondents who took part in a household survey, 444 (70.0%) participated in triggering session and out of these 115 (25.9%) were able to explain the triggering process. During FGDs, some participants were able to explain the key techniques that made them change their behaviour. The techniques explained included mapping, indirect eating of feaces and walk of shame. One respondent said:

"Walk of shame was the most effective; more especially when children brought in feaces from the bush. The parents in the village were disgusted and ashamed…triggering process brought in great disgust when the facilitator asked one community member to eat roasted fish that had been smeared with feaces brought in by the children."
It was also noted that there were variations in the way the process of triggering was

done as external facilitators were not always used. In other areas of Balaka district, more than one village were being triggered in one session for a shorter duration than the 4 to 5 days recommended by Kar et al. (2008).. This process was locally termed *"emergency triggering"* by Health Surveillance Assistants (HSAs) where *"emergency"* to them meant doing things in a rush with minimal resources. This involved a facilitator triggering VHC members (often from more than one village) who were in turn given the responsibility to trigger their respective villages. This was done not according to plan but due to lack of resources. One female participant commented:
"When the VHC's came they only told us to stop eating our friends' feaces by not defecating in the bush because it is not healthy since through open defaecation we may contract cholera and diarrhoea."

The FGD participants welcomed the idea of using external facilitators during triggering. However, there were a few that felt the use of external facilitators was not good as it seemed as if they were being mocked by people from other areas. In Ntcheu district, external facilitators were not involved in most cases, and there was no proper transition plan. As regards to community participation, respondents felt that this was an acceptable principle as it was them who would be using latrines and enjoy associated benefits. Thus they accepted the responsibility for latrine construction and proper use. Our study also found that communities need to be followed up even after attainment of ODF status in order to maintain it. One female FGD respondent said:

"You (referring to the interviewer) need to be constantly reminding us especially of drop-hole covers and hand washing because we forget".

The study also found variations in the facilitation process within and across the study district. For example in Phalombe district there was a variation in triggering time as well as steps followed between CU (an NGO) and District Health Office (DHO). CU was taking 3-4 hours while DHO team took 2 hours maximum. This was attributed to leaving out some steps due to resource constraints. In Balaka district, instead of involving the whole village in triggering, in other situations, only village chief and VHC members were triggered and given the responsibility to trigger the rest of the communities. In Balaka, it was indicated that triggering was just a demonstration of what is supposed to happen during triggering.

3.4 Post triggering follow-ups

In all the districts, household respondents were also asked during questionnaire administration on how the natural leaders were chosen during triggering session (Table 3). Natural leaders were chosen to lead on implementation of the plans and monitoring of the activities after triggering.

Table 3: How natural leaders were chosen

District	Chosen by chief	Chosen by facilitator	Chosen by community	Did not know
Balaka	14.6% (30)	1.5%(3)	68.5% (141)	15.5% (32)
Ntcheu	5% (11)	1.8% (4)	77.9% (170)	15.1% (33)
Phalombe	1.9% (4)	0% (0)	97.2% (204)	1% (2)

The study found that there were different arrangements in terms of structures responsible for overseeing the implementation of CLTS. Despite most of the communities indicating choosing natural leaders during triggering session (Table 3), in most cases the natural leaders were either members of the village health committee or were working with the village health committee. The study also established that the necessary follow-up visits were not being consistently done by the natural leaders and District Coordinating Team (DCT)[1].

One village chief said:
"After triggering, no extension worker (means HSAs and Officers from NGOs) has come into this village to make a follow-up on the work they started. This tendency is not good as it jeopardises the chances of my village achieving the desired long-term change in behaviour; some of the households that have stopped OD may revert back to OD practices due to lack of follow-up".

Despite being oriented by the DCT, the existing local structures (including natural leaders) had minimal support from DCT to undertake follow-ups. The challenges reported by the DCT included lack of resources for follow-up visits, lack of coordination and prioritization of commitments in their specific departments. All this was a major threat to the sustainability of CLTS. For instance, one of the NGO Water, Sanitation and Hygiene (WASH) facilitators commented that:

"CU always takes a leading role in planning for follow-ups. The Government departments (i.e. through DCT) which are supposed to be leading do not show much commitment. For example, DCT does not allocate resources for follow-ups. In most cases extension workers (i.e. HSAs[2]) rely on CU to provide follow-up resources. In some other cases we conduct the follow-ups without Government staff."

[1] District Coordinating Team (DCT) is a committee formed by District Executive Committee to oversee implementation of CLTS in the district. It is comprised of members from Ministry of Agriculture, Irrigation and Water Development, Ministry of Health and other Ministries present at the district. Their role is to monitor and receive reports on CLTS in the district. They sometimes participate in implementation of CLTS as guests. They are also involved in follow-ups

[2] The actual implementation of CLTS in Malawi is done by officials from NGOs and HSAs

Furthermore, one Government staff said that there were limited resources such as transport to support the follow ups as in the quote:
"Limited resources and no proper planning on how follow-ups should be done are hindering the district from registering tangible success in CLTS. For instance, the district does not have follow-up transport and tools like forms and checklist for extension workers to use during follow-up exercise."

3.5 Perceived results of CLTS by study participants
During FGDs, participants felt that intervention activities that triggered behaviour change included faecal oral route transmission (bottle of water exercise) demonstration, medical expenses calculation, mapping and walk of shame. In all the three districts, faecal oral route transmission (bottle of water exercise), medical expenses calculation, mapping and walk of shame were the major drivers for behaviour change. In addition children and the youth were critical change agents in the triggering sessions in Ntcheu and Phalombe respectively. Children were involved in singing songs that brought shame while the youth were actively involved in identification of OD sites.
The study found that CLTS process allows discussion and choice of appropriate technologies. For instance, an FGD with men from Phalombe District revealed that the design of foot operated hand washing facility that was recommended by community members during triggering session motivated children to adopt the hand washing facility and the practice. The children loved using this type of facility which resembled foot break of a motorcar. In this village they locally called it 'kuponda giya' (copying a motorcar gear). The only challenge was that sometimes children used such facilities for playing.

From the household survey 96.1% of the respondents perceived that people washed hands after visiting the toilet in their community. When asked why they washed hands respondents said that they washed hands using soap and sometimes ash (due to shortage of money for buying soap) in order to remove germs, to keep hands clean and to remove foul smell.

From the FGDs and KII, it was also noted that CLTS had also resulted in an increase in the availability of hand washing facilities and the practice of washing hands after using the toilet. This was evident in the FGDs as one of the participants said,

"In our village, triggering took place in 2012 and has led to increase in latrine coverage. Triggering has also led to increase in hygiene behaviour like hand washing" Woman in Balaka.

The other perceived result identified by the participants was that the CLTS programme had led to increased latrine ownership. It was found from household survey that 91.5%

of households owned latrines implying that 8.5% were OD households. The latrine coverage was lower in some Traditional Authorities (T.A.s) implementing "emergency CLTS" and those using VHCs and chiefs for triggering though not consistent in all cases. The latrine coverage was relatively lower in Balaka where 62% of respondents were Muslims (Table 4).

Table 4: Latrine coverage per Group Village Headman (GVH) and responsibility for triggerin

District	GVH	Households with latrines	Responsibility for triggering
Ntcheu	Gwaza	49 (96.1%)	NGO staff and HSAs
	Gumbi	68 (98.6%)	HSAs, VHCs and chiefs
	Makwangwala	49 (89.1%)	NGO staff and HSAs
	Msiyaludzu	31 (91.2%)	NGO staff and HSAs
	Tcheza	9 (100%)	NGO staff and HSAs
Balaka	Kalembo	35 (87.5%)	NGO staff and HSAs
	Kuntiyani	11 (61.1%)	NGO staff and HSAs
	Makwinja	17 (85.0%)	HSAs using *"emergency triggering"*
	Nandumbo	41 (97.6%)	VHCs and chiefs
	Nkanda	54 (90.0%)	NGO staff and HSAs
	Nkweta	18 (69.2%)	HSAs using *"emergency triggering"*
Phalombe	Phodogoma	28 (93.3%)	NGO staff and HSAs
	Kaduya	23 (88.5%)	VHCs and HSAs
	Namalima	33 (94.3%)	VHCs and HSAs
	Nazombe	26 (92.9%)	VHCs and chiefs
	Makhonja	88 (96.7%)	NGO staff and HSAs
Total		580 (91.5%)	NGO staff and HSAs

Respondents reported that after CLTS, there was an increase in latrine ownership, number of hand washing facilities and as a result decrease in OD. In addition the community members were proud of the improved hygiene status of their villages. One participant from Phalombe commented:

"We felt good that during the walk of shame, no faecal matter was discovered and it was something that showed improvement on the issue regarding CLTS in our community"

.

Despite CLTS, the study noted that others continued to defeacate in the bush. This observation was corroborated from a transect walk in one of the villages where fresh and old human feaces were found.

CLTS had motivated many people to construct latrines on their own without any external influence as they were able to link between hand-washing, use of latrine and disease prevention.The FGD participants posited that the CLTS programme had led to a decrease in the number of cases of diseases related to OD such as diarrhoea in under-five children as well as adults though not confirmed from health facility data. During KII a Government staff said:

"At Kalembo along Shire River there is a reduction in cholera cases for four years now we have not heard of any cholera case".

3.6 Gender and social inclusion in CLTS

It was found that gender considerations had been accidental rather than intentional. There was limited evidence of specific efforts to ensure both women and men had equal access to the CLTS programme and benefits. It was noted that women dominated in all the VHCs that participated in FGDs. It was also reported that fewer men participated in the triggering process. On the roles of women on CLTS, it was observed that women were mostly involved in cleaning the surrounding, sweeping inside the latrine, making sure that water is available for hand washing and general cleaning of the surrounding. This was expressed in the quote by a woman from Phalombe:

".....for us women, we rely on our husbands to construct latrines, but our job is to make sure the latrine is clean and also water is available in the hand washing facility."

The study found that there were no formal mechanisms to support the elderly and the physically challenged people who did not have latrines; and could not afford to source the required materials to build latrines on their own.

"I wish I had a latrine of my own. Unfortunately I don't have children or relatives who can construct the latrine for me. Young men in our village don't show an interest to us. It's really a shame to always use other people's latrine." FGD with elderly.

However, the CLTS approach did not exclude the vulnerable groups during triggering process. An interaction with a household with three physically challenged children, found that they had a latrine in place which was constructed by themselves as a result of CLTS. In addition they had a hand washing facility installed and drop-hole cover.

3.7 Construction support mechanisms

The study observed that there was no deliberate or systematic resource management initiatives (e.g. forest management) associated with the CLTS programme. This is likely to affect availability of locally available materials for construction of latrines. Participants complained of lacking strong tree logs for reinforcing the latrine floor, bricks and cement for latrine pit lining. This may lead to collapsing of pit latrines especially during the rainy season.

"With current economic status of most community members, the construction of latrines is considered to be expensive. The villagers mostly say they cannot accept sleeping in thatched-roof huts and on the other hand build latrines with cement and reinforcing steel just to defecate. As a result, they prioritize other household issues other than investing much in latrines" .
WASH facilitator, Ntcheu District.

Communities understood the issue of no subsidy since they were told by NGO and Government extension workers to be fully responsible for their latrine construction. Thus they constructed latrines on their own. However, in one of the FGDs in Ntcheu district, participants were indecisive on the no subsidy issue as they could not agree on whether it was good or not. A local Government staff from Ntcheu district stated that subsidy approach programmes should be completely stopped and villagers properly sensitized before introduction of a non-subsidy approach programme such as CLTS. The participants reported that the no-subsidy principle was emphasized during the triggering sessions by the facilitators. About 5.4% of the household respondents felt that there was still need for external support because the community members lack money for buying strong logs of trees and slabs for durable toilet floor.

4.0 Discussion

4.1 Acceptability of CLTS

Relating to the extent to which CLTS principles were compatible with people's social, cultural, and religious values the study showed that CLTS approach in the three districts was blending well with social and cultural beliefs despite 'shit'[3] being a taboo in most cultures (Bevan, 2011; Budge, 2012). However, the essence of hand washing after anal cleansing was not appreciated by the Moslem communities. Anal cleansing was considered to be a sufficient hand washing practice and caused confusion. The confusion was mainly between hand washing during anal cleansing and hand washing outside the latrine. This confusion makes the success of CLTS difficult. Similar results were observed in a prior study done in Malawi by Engineers without boarders (Hockin, 2011).

[3]'Shit' refers to feaces during triggering sessions.

We found that, the Transition from subsidy-led to CLTS approach was not well conducted as the communities were not properly sensitized. It is important that the transition between these two approaches is carefully managed to avoid confusing the communities which would negatively impact the success of the programme (ref). The implementers of CLTS in Ntcheu district did not consider the subsidy history of the area. According to the CLTS principles, this may be a contributing factor for CLTS failure (Kar et al., 2008). In a prior study, it was reported that CLTS is very effective in communities where there has not been any other sanitation promotion approach used previously (WaterAid, 2007).

4.2 Quality of facilitation

We found that triggering was not in line with CLTS principles as facilitation needs to be done by competent external facilitator who is well trained. Using VHC members, village head and HSAs being local to the area would not qualify as external facilitation.

The variations in triggering imply that CLTS is being implemented differently compromising the underlying principles of CLTS and above all not following what was planned. This could contribute in failing to attain ODF status by villages. CLTS is a participatory approach; hence limited participation has a detrimental effect to the achievement of ODF. For CLTS to be effective, it requires that an external facilitator should help the community to analyse the situation, identify areas of improvement, plan how to improve and implement these plans (WaterAid, 2007). In addition, the facilitation is supposed to be done in one village at a time because of the assumed high social capital or cohesion that is likely to exist for a smaller community (Kar et al., 2008). Such challenges in CLTS implementation were also found to be common in India and East Java (Hueso & Bell, 2013; Mukherjee, Robiarto, Effentrif, & Wartono, 2012).

4.3 Post triggering follow-ups

It was observed that follow-ups were not consistently done in all the three districts. This was in line with notes compiled in Kenya which stated that follow-ups are critical in the success of CLTS because it makes the communities not to slacken (Tiwari, 2011). Kar and Chambers (2008) further said that through follow-up visits communities tend to improve their latrines and hygiene practices. This has an advantage in the achievement of ODF because communities tend to interact with technical personnel thereby acquiring skills and knowledge for construction of improved sanitary facilities.

Follow-up visits are equally important for those villages that have attained ODF status. It is recommended that normal follow-ups to the triggered village should be conducted by the extension workers 1 to 2 times per week until ODF status is attained (Kar et al., 2008). Water Institute (2012) studies in Uganda showed that ODF villages which were not followed up for up to two years had lost their ODF status. This shows the

importance of continuing follow-ups even after the village has attained the ODF status. In this study, it was noted that follow-ups were not done due to lack of support mainly transport for the extension workers.

Lack of follow-ups such as review meetings as well as household visits to monitor latrine construction negatively impacts on the success of CLTS and in the long run its sustainability. Study notes compiled in Kenya noted that a common mistake is to focus on triggering without follow-ups (Tiwari, 2011). The ratio of triggered communities certified as ODF worldwide is low often in the range of 25-40% which reflects low quality triggering and perhaps most significant is failure to follow up appropriately after triggering (Tiwari, 2011).

4.4 Perceived results of CLTS

The study found that in all the three districts, participants felt that the CLTS implementation had reduced OD as a result of intervention related activities such as faecal oral transmission, medical expense calculation, mapping and walk of shame. Though our study noticed differences in latrine coverage between T.As with some which were implementing "emergency CLTS" having lower coverage but this could not be entirely attributed to the way triggering was done as there was no baseline. It was also observed that the proportion of community members practicing OD in the 3 studied districts (8.5%) was lower than the 11% reported by the Malawi ODF strategy (2010) and was similar to the MDG End line Report of 2014 (National Statistical Office, 2014).The major drivers for behavior change identified in this study ought to be emphasized during triggering sessions as they have been seen to increase ODF status and other related outcomes in other countries (Nepal, 2014). Children and the youths also played a major role. For any CLTS to be successful children and the youth need to be part of the process as they have shown to be an open source of information and powerful change agents in bringing about disgust and shame among the elders. In case of CLTS failing to gather information about where the community defeacate may lead to failure in attaining ODF status and associated health benefits (Fernandez, 2008). The CLTS approach was also perceived to have increased latrine coverage as reported in the results. This was similar in Zimbabwe where CLTS approach also increased latrine coverage (Whaley & Webster, 2011).

4.5 Gender and social inclusion in CLTS

Triggering sessions were mainly attended by women. Despite men taking a leading role in latrine construction, women and children were also involved. Mostly women were responsible for the cleaning of the household surroundings including latrines and are mostly found at home. The participation of more women during CLTS process was due to their role at a household. Most men are not found at home and this makes them

to miss out on village activities. On inclusion of the physically challenged, there was no formal mechanism for their inclusion. There is need to put in place deliberate efforts to include and assist the physically challenged in having latrines that are appropriate to them. It was also noted that social issues such as poverty and lack of community cohesion were noted to be affecting CLTS implementation. In other areas, it has been noted that people with disabilities tend not to be present at triggering, lack voice in the community and sometimes are hidden by families (Wilbur & Jones, 2014).

4.6 Construction support mechanisms

It was found that latrines collapse as a result of poor quality construction materials especially during the rainy season. This was in line with a study done in Rwanda which also found that most latrines collapse due to rains (Tsinda et al., 2013). As observed in this study, lack of locally available materials such as tree logs could derail the minimal successes registered. This problem is expected to increase due to increase in deforestation (Kumwenda et al., 2014). The study further observed that there was no deliberate or systematic resource management initiatives (e.g. forest management) associated with the CLTS programme. This is likely to affect availability of local materials for construction of latrines. Since CLTS encourages use of local materials, programmes such as community forests should be encouraged in villages where CLTS is being implemented. However, great care should be taken by the local leaders on the purpose of the forest because it may also provide an environment for OD to community members if not properly sensitized (Kar & Bongartz, 2006; Kar et al., 2008). Availability of local resources makes the no subsidy principle feasible. It has been found in a study done in Zimbabwe that ability to own a latrine depends much on affordability which is one of the contributing factors for one to own a better latrine and move up on the sanitation ladder (Grimason, Davison, Tembo, Jabu, & Jackson, 2000; Whaley & Webster, 2011)(Whaley & Webster, 2011). However, CLTS requires that the communities should use their local solutions to have latrines with an aim of making them stop practicing open defeacation (Cole, Pinfold, Ho, & Anda, 2014; Keraita, Jensen, Konradsen, Akple, & Rheinländer, 2013). Though "one size does not fill all" as different households are at different economic status, there is need to consider many things when implementing sanitation interventions to avoid violating human rights (Bartram, Charles, Evans, O'Hanlon, & Pedley, 2012; Tilley et al., 2014).

5.0 Conclusions

CLTS was an acceptable approach to improving sanitation in the surveyed communities. This was supported by the fact that community structures (e.g. natural leaders) were in place in all the villages where triggering had been done. More importantly these structures were mainly established by the community members themselves. Latrine coverage in the surveyed communities was 91.5% and community members perceived an increase in latrine use and 96.1% of the households reported using hand washing facilities and community members attributed this to the CLTS

programme. However, there were variations in the way the process of triggering and post triggering were conducted. Follow-up visits were not being consistently done and gender considerations had been accidental rather than intentional. There was only limited evidence of specific efforts to ensure both women and men had equal access to the CLTS programme and benefits. There were no deliberate or systematic resource management initiatives to support construction of latrines using locally available resources. Faecal oral route transmission, medical expenses calculation, mapping and walk of shame were the major drivers for behaviour change. Before CLTS implementation, there is need for proper planning and making sure that all resources are available. This study has found that the variations in CLTS implementation were not aimed at adapting to local situation but rather cutting costs and solving the problem of lack of resources. Implementation of CLTS in this context makes it not to be viable.

Acknowledgements
This paper has been compiled from research on "The appropriateness, acceptability and viability of CLTS as an approach to eliminating OD in rural households in Malawi". The study was commissioned and funded by Concern Universal in Malawi. We would like to thank Concern Universal Malawi for allowing us to publish these results. The first author is pursuing a PhD with support from Consortium for Advanced Research Training in Africa (CARTA), CARTA is jointly led by African Population and Health Research Centre and University of the Witwatersrand. The other support comes from Scotland Chikwawa Health Initiative (SCHI), Southern African Consortium for Research Excellence (SACORE) and The Polytechnic.

References

Bartram, J., Charles, K., Evans, B., O'Hanlon, L., & Pedley, S. (2012). Commentary on community-led total sanitation and human rights: should the right to community-wide health be won at the cost of individual rights? Journal of Water and Health, 10(4), 499. http://doi.org/10.2166/wh.2012.205

Bevan, J. (2011). A review of the UNICEF roll out of the CLTS approach in West and Central Africa. In The future of water, sanitation and hygiene: innovation, adaptation and engagement in a changing world (pp. 1–4). Senagal: WEDC. Retrieved from http://wedc.lboro.ac.uk/resources/conference/35/Bevan-J-1247.pdf

Budge, F. (2012). The power of shit. Medische Antropologie, 24(2), 301–320. Retrieved from http://tma.socsci.uva.nl/24_2/budge.pdf

Cole, B., Pinfold, J., Ho, G., & Anda, M. (2014). Exploring the methodology of participatory design to create appropriate sanitation technologies in rural Malawi. Journal of Water, Sanitation and Hygiene for Development, 4(1), 51. http://doi.org/10.2166/washdev.2013.166

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and conducting mixed methods research. Los Angeles: SAGE Publications.

Fernandez, K. (2008). Children as agents of change: practitioners' perspectives on children's participation in Community-Led Total Sanitation (MSc Thesis). University of London, London. Retrieved from http://www.communityledtotalsanitation.org/resource/children-agents-change

Grimason, A. M., Davison, K., Tembo, K. C., Jabu, G. C., & Jackson, M. H. (2000). Problems associated with the use of pit latrines in Blantyre, Republic of Malawi. The Journal of the Royal Society for the Promotion of Health, 120(3), 175–182.

Hockin, A. (2011). The role of Health Surveillance Assistants in Community Led Total Sanitation in Malawi. Engineers without boardes. Retrieved from http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Role_of_HSAs.pdf

Hueso, A., & Bell, B. (2013). An untold story of policy failure: the Total Sanitation Campaign in India. Water Policy, 15(6), 1001. http://doi.org/10.2166/wp.2013.032

Kar, K., & Bongartz, P. (2006). Update on some recent developments in community-led total sanitation. University of Sussex, Institute of Development Studies, Brighton, UK. Retrieved from http://www.watersanitationhygiene.org/References/EH_KEY_REFERENCES/SANITATION/Community%20Led%20Total%20Sanitation/Community%20Led%20Total%20Sanitation%20(IDS).pdf

Kar, K., Chambers, R., & Plan UK. (2008). Handbook on community-led total sanitation. London: Plan UK.

Kar, K., & Pasteur, K. (2005). Subsidy or self-respect?: community led total sanitation ; an update on recent developments. Brighton: Institute of Development Studies. Retrieved from http://www.ntd.co.uk/idsbookshop/details.asp?id=899

Keraita, B., Jensen, P. K. M., Konradsen, F., Akple, M., & Rheinländer, T. (2013). Accelerating uptake of household latrines in rural communities in the Volta region of Ghana. Journal of Water, Sanitation and Hygiene for Development, 3(1), 26. http://doi.org/10.2166/washdev.2013.035

Kumwenda, S., Samanyika, Y., Chingaipe, E., Mamba, K., Lungu, K., Mwendera, C., & Kalulu, K. (2014). The Emerging Environmental Health Risks and Challenges for Tomorrow: Prospects for Malawi. Malawi Journal of Applied Sciences and Innovation, 1(1), 21–26. Retrieved from www.poly.ac.mw

Malawi Government. (2011). Malawi Open Defecation Free Strategy (Strategy Paper).

Lilongwe, Malawi: Ministry of Water Development.

Mara, D., Lane, J., Scott, B., & Trouba, D. (2010). Sanitation and Health. PLoS Med, 7(11), e1000363. http://doi.org/10.1371/journal.pmed.1000363

Mehta, L., & Movik, S. (2010). The dynamics and sustainability of Community-Led Total Sanitation (CLTS): mapping challenges and pathways (STEPS Working Paper No. 37). Brighton, Sussex, England: STEPS Centre. Retrieved from http://opendocs.ids.ac.uk/opendocs/handle/123456789/2280

Ministry of Irrigation and Water Development. (2008). Draft National Sanitation Policy. Malawi Government.

Mukherjee, N., Robiarto, A., Effentrif, S., & Wartono, D. (2012). Factors Associated with Achieving and Sustaining Open Defecation Free Communities: Learning from East Java. East Java: Water and Sanitation Program. Retrieved from http://www.wsp.org/sites/wsp.org/files/publications/WSP_Indonesia_Action_Research_Report.pdf

National Statistical Office. (2014). Malawi MDG Endline Survey 2014, Key Findings (MDG Endline Survey). Zomba, Malawi: National Statistical Office of Malawi. Retrieved from www.nso.mw

Nepal, G. D. (2014). Impact of Open Defecation Free (ODF) Campaign - a case study of Ranipani VDC, Parbat/Nepal. CLTS knowledge hub. Retrieved from http://www.communityledtotalsanitation.org/resource/impact-open-defecation-free-odf-campaign-case-study-ranipani-vdc-parbatnepal

Phiri, G. C., Kalulu, K., Kumwenda, S., Chidziwisano, K., & Kalumbi, L. (2014). Attainment of Open Defecation Free Status Among Villages of Nthondo Area in Ntchisi District, Malawi. Standard Research Journal, 2(13), 743–748. Retrieved from http://www.standresjournals.org/journals/SSRE/Pdf/2014/december_special_issue/Phiri%20et%20al.pdf

Selendy, J. M. H. (2011). Water and Sanitation Related Diseases and the Environment: Challenges, Interventions and Preventive Measures. John Wiley & Sons.

Tilley, E., Strande, L., Lüthi, C., Mosler, H.-J., Udert, K. M., Gebauer, H., & Hering, J. G. (2014). Looking beyond Technology: An Integrated Approach to Water, Sanitation and Hygiene in Low Income Countries. Environmental Science & Technology, 48(17), 9965–9970. http://doi.org/10.1021/es501645d

Tiwari, C. (2011). Taking Community Led Total Sanitation to Scale. Institutional Support for Scaling Up CLTS. Retrieved from http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Lukenya_Notes.pdf

Tsinda, A., Abbott, P., Pedley, S., Charles, K., Adogo, J., Okurut, K., & Chenoweth, J. (2013). Challenges to Achieving Sustainable Sanitation in Informal Settlements of Kigali, Rwanda. International Journal of Environmental Research and Public Health, 10(12), 6939–6954. http://doi.org/10.3390/ijerph10126939

Tyndale-Biscoe, P., Bond, M., & Kidd, R. (2013). ODF sustainability study for Plan International. Kenya: Plan International. Retrieved from http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Plan_International_ODF_Sustainability_Study.pdf

UNICEF. (2009). Barriers to sanitation and hygiene promotion: case study from Madagascar [TearFund]. Retrieved March 16, 2015, from http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/4000.pdf

Water and Sanitation Program. (2011). Factors Associated with Achieving and Sustaining Open Defecation Free Communities: Learning from East Java. Retrieved from http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Factors_ODF_EastJava.pdf

Whaley, L., & Webster, J. (2011). The effectiveness and sustainability of two demand-driven sanitation and hygiene approaches in Zimbabwe. Journal of Water, Sanitation and Hygiene for Development, 1(1), 20. http://doi.org/10.2166/washdev.2011.015

WHO/UNICEF. (2014). Progress on Drinking Water and Sanitation: 2014 Update.

Wilbur, J., & Jones, H. (2014). Disability: Making CLTS Fully Inclusive. Innovations and Insights, (3). Retrieved from www.communityledtotalsanitation.org

Investigating Fresh and Hardened State Properties of Building Materials Incorporating Rice Husk Ash (RHA)

Maxwell L. Chisala[a]

[a]Lecturer, Civil Engineering Department, The Polytechnic, P/Bag 303, Blantyre 3, Malawi email: mchisala@poly.ac.mw

Abstract

The demand for low-cost renewable source-based alternative building materials has been growing worldwide. This paper presents results of an investigation carried out at the Materials Laboratory in the Civil Engineering Department at The Polytechnic to assess the performance of building materials incorporating Malawi rice husk ash (RHA) as partial cement or clay replacement in percentages ranging from 5-35%. Control samples had no RHA replacement. The key properties of the building materials investigated included: compressive strength, unit weight, slump, water absorption rate, shrinkage rate and crack resistance. The results show that, in general, building materials with RHA replacement not exceeding 20% meet industry performance requirements and show promise as low-cost alternatives to the more expensive cement dependent building materials.

Keywords: Compressive Strength, Rice Husk Ash, Malawi Standards, Control Mixes

1.0 Introduction

Rice husk is an agro-waste material found on every continent except Antarctica. It contains about 75 % organic volatile matter and the balance converts to ash during combustion. Rice husk ash (RHA) contains a high amount of silicon dioxide responsible for its reactive properties and its fairly amazing properties (depending on the content of the non-crystalline silica and its specific surface): it is highly resistant to moisture penetration, it is not corrosive to aluminium, copper and steel, it does not smolder or flame easily, it does not transfer heat easily, it does not smell or emit gases, it is resistant to fungal and mold growth at ordinary temperatures and has excellent sound proofing properties [1, 2]. In its raw and unprocessed state rice husk constitute a Class A (or Class 1) insulation material and therefore can be very economically used to insulate the walls, floors and roof cavities. Incorporated in cement dependent building materials rice-husk ash (RHA) can impart significant improvement in workability and durability properties of building units.

In Malawi (and most other developing countries) proper utilization of agricultural waste such as rice husk has not been given due attention with the result that the rice husk constitutes an environmental nuisance from the rice milling industry as it forms unsightly heaps where it is improperly disposed of. The twin problems of looking for an efficient utilization of large amounts of agricultural waste (not utilized as food, fertilizer or fuel) and the unavailability of low-cost building materials for acute housing needs have fueled the need to consider using rice husk as a partial replacement to cement to provide an economic use of this cereal by-product and answer calls from various quarters for seriously considering substituting imported building materials with local building materials with a high component of local raw materials in the face of mounting unsustainable import bills [3]..

2.0 Previous research

Previous research on mud units, sandcrete units and concrete incorporating rice husk ash (RHA) was confined to studying improvements in mechanical and durability properties but there are no studies to assess performance of hydraform units incorporating rice husk ash (RHA). [3, 4]

3.0 Study significance

For industry-wide use of RHA building materials as alternatives to more cement dependent building materials, the performance of RHA building materials must be shown to meet industry minimum performance requirements.

4.0 Experimental programme

4.1 Constituent materials

4.1.1 Rice husk ash

Rice husk ash was obtained from burning 30 kg of raw rice husk in a perforated drum for 48 hours and cooled to room temperature for another 48 hours to obtain ashes which were removed for grinding in a ball mill to the required fineness of passing through the 150 μm zone of British Standard test sieves for use in the study (see Figure 1-4).

4.1.2 Soil

Clayey soil mined at a depth of not less than 150 mm, free of organic and vegetable matter sourced from The Polytechnic grounds was used for mud brick production used in the study while sandy loamy soil free of organic or vegetable matter was sourced from a Bee-Hive (Malawi) construction site in Blantyre. Soil sampling and testing was in accordance with the relevant clauses of Malawi Standards MS: 175─ 2007[5]

4.1.3 Sand

Sharp clean river sand that is free from clay, loam, dirt and any deleterious or organic or chemical matter as required by Malawi Standards MS 777─2007 [6] and passing through 3 mm zone of British Standard test sieves and a particle size distribution meeting the requirements of British Standard 1377: 1993[7] was used in the study.

4.1.4 Cement

The cement used in the study was Lafarge 32.5N Type I Ordinary Portland Cement (OPC) complying with Malawi Standard 77─2007 [13].

4.1.5 Water

Drinkable water (fresh, colourless, odourless, unpolluted and tasteless and free from organic matters of any type) in compliance with Malawi Standard 777: 2007[13] from Blantyre Water Board (BWB) was used as mixing water for preparing samples in the study.

Figure 1 Raw Rice Husk.

Figure 2: RHA after combustion

Figure 3: A sample ball mill.

Figure 4: Sample of RHA after grounding

5.0 Tests

5.1 Mud bricks

Tests conducted include: compressive strength tests and water absorption tests sampled and conducted in accordance with relevant clauses of Malawi Standard 777: 2007[13]; general soil classification tests, bulk density test, unit weight test, dimensional stability test, and crack resistance test sampled and conducted in accordance with relevant clauses of BS EN 12390-3: 2002 [14]. Rice husk ash was replaced clay in increments Mud brick test specimens with rice husk replacing clay in the provided percentages were produced to the dimensions 225 mm.±5mm x 105 mm.±10mm x 65 mm.±5mm.

5.2 Sandcrete blocks

Tests conducted include: compressive strength tests and water absorption tests sampled and tested in accordance with relevant clauses of Malawi Standard 777: 2007[13]]; particle size analysis on sand, bulk density tests and unit weight tests sampled and conducted in accordance with relevant clauses of BS EN 12390-3: 2002 [14]. Sandcrete block test specimen blocks with rice husk replacing cement in the provided percentages were produced to the dimensions 220 mm x 130 mm x 120 mm.±5mm.

5.3 Hydraform blocks

Tests conducted included: compressive strength tests and water absorption tests, sampled and conducted in accordance with relevant clauses of Malawi Standard 777: 2007[13]], general soil classification tests comprising of wet sieve analysis, moisture content (plastic index and liquid limit) tests, bulk density tests, unit weight tests and linear shrinkage tests conforming to BS EN 12390-3: 2002 [14],. Hydraform block test specimen were produced to the dimensions 240 mm x 220 mm x 120 mm x 325 mm (diagonal).

5.4 Concrete

Tests conducted include: coarse aggregate tests, sieve analysis on sand, particle size analysis of sand, slump test on fresh concrete, bulk density tests and 7-day and 28-day compressive strength tests on 150 mm concrete cubes were performed in accordance with BS EN 12390-3: 2002 [14].

6.0 Control mix proportions

Proportion of control mix for the sandcrete units was 1:6, the proportion of control mix for the concrete was 1:2:4 with a water to binder ratio of 0.66 and an 8% cement binder-mix was used for the RHA Hydraform units used in the study. For mud units, rice husk ash replaced clay in proportions ranging from 5-25%.

6.1 Preparation of Specimens.

Samples for the study were prepared in strict conformance with relevant standards [5, 6, 10]

6.2 Curing regimes

The sandcrete units were covered with elephant grass after production and cured by sprinkling water over the samples in the morning and late in the day for the duration of the curing period. The hydraform block samples were covered with polythene sheets after production and watered in the morning and late in the day for the first seven days. The mud units were air-dried under a shade for the duration of the curing period. The concrete units were covered with plastic sheet after casting and stored in the laboratory environment and the specimens demoulded after 24±3 hours of casting and left to cure until the day of testing.

7.0 Test results and discussion

Table 1: Results for mud units

Replacement %	28d Strength N/mm^2	28d Water Absorption Rate %	Crack Length mm	No. of Cracks	Crack Width mm	Unit Weight Kg/m^3	Dimensional Stability %
0	0.108	30.77	44	7	4	16.7	3.4
5	0.118	20.3	17	2	2	15.16	4.5
15	0.094	20.62	—	—	—	14.67	1.4
25	0.092	22.15	—	—	—	15.3	0.7

Table 2: Results for sandcrete units

Replacement %	7d Dry Strength N/mm^2	14d Dry Strength N/mm^2	28d Dry Strength N/mm^2	28d Water Absorption Rate	28d Bulk Density Kg/m^3	28d Unit Weight Kg/m^3
0	1.94	2.67	3.74	9.50	1812	17.8
5	2.30	3.30	4.25	12.00	1738	17.1
10	1.97	2.82	3.71	12.40	1726	16.9
15	1.68	2.37	3.05	14.40	1674	16.4
20	1.42	1.97	2.51	17.00	1667	16.4
25	1.10	1.54	1.96	17.20	1686	16.5
30	0.73	1.02	1.58	17.60	1654	16.2

Table 3: Results for hydraform units

Replacement %	7d Compressive Strength N/mm^2	28d Compressive Strength N/mm^2	7d Unit Weight Kg/m^3	28d Unit Weight Kg/m^3	28d Water Absorption Rate %
0	2.29	4	18.443	18.098	1.64
5	2.46	4.26	18.609	18.104	1.74
10	2.39	4.11	18.531	18.029	1.76
15	2.18	3.92	18.453	17.919	1.86
20	2.12	3.78	18.256	17.847	1.88
25	1.86	3.13	18.158	17.678	1.91
30	1.36	2.88	18.080	17.547	1.92
35	1.29	2.73	17.933	17.400	2.51

Table 4: Results for Concrete Units

Replacement %	7d Dry Strength N/mm^2	14d Dry Strength N/mm^2	28d Dry Strength N/mm^2	7d Density Kg/m^3	14d Density Kg/ m^3	28d Density Kg/ m^3	Slump Test mm
0	14.1	17.8	20	2513	2509	2580	25
10	14.9	19.2	22.1	2485	2484	2532	30
20	14.6	18.3	20.4	2436	2445	2516	38
30	13.1	14.3	20	2431	2357	2446	65

The required average test strength for a specified required minimum average compressive strength requirement is given by:

$$f_{cr} = f_{s\ pecd}\ \text{min} + 0.34\ (\text{Standard deviation})$$

As observed in the Tables 1-4 above, the required sandcrete test specimen average 28-day compressive strength of 3.6 N/mm^2 (with a test results standard deviation of 0.1 N/mm^2 and a minimum strength requirement for sandcrete units of 3.5 N/mm^2

[12]) was attained for cement replacements not exceeding 10% with water absorption rate limited to 15%; the required 28-day strength of 3.3 N/mm^2 (with a test results standard deviation of 0.8 N/mm^2) was attained for clay replacements not exceeding 20%; the required strengths of 20.3 N/mm^2 (with a test results standard deviation of 0.3 N/mm^2 and a minimum strength requirement for sandcrete units of 3.5 N/mm^2 [12]) was attained for cement replacements not exceeding 20% and the required 28-day strength of 3.53 N/mm^2 (with a test result standard deviation of 0.03 N/mm^2) was not attained with any cement replacement percentage although other measures of durability improved with increased cement replacement percentage for the units.

8.0 Conclusions

The study shows that although materials incorporating RHA as replacement for cement or clay exhibit improved engineering properties for replacements up to 35% and meet most Malawi Standards performance requirements, the minimum strength requirements are met for cement dependent building materials (hydraform, sandcrete and concrete) for replacements not exceeding 20% and the minimum strength requirements is not met for mud units incorporating rice husk ash as clay replacement. Generally, materials incorporating RHA have shown good promise for use in the local construction industry as low-cost alternative building materials for the more expensive cement dependent building materials.

9.0 Further research

Further research is required to ascertain: 1) the chemical compositions of both the local rice husk ash and the local Lafarge cement 2) particle size distribution characteristics of local rice husk ash 3) sound insulation and thermal insulation performance of RHA building materials for maximizing beneficial uses of RHA materials as surface finishes. There is also need to develop a more efficient furnace for controlled combustion of rice husk and for quickly handling sizeable volumes of rice husk combustion for conducting research on RHA building panels.

10.0 Acknowledgement

The programme was funded by the Civil Engineering Department at The Polytechnic (a constituent college of the University of Malawi) and constituted student research projects (supervised by the author) for the following 2013 Civil Engineering graduants: Alick E. Munthali, Luke G. Kanjira, Steve Ghambi and Tuntufye Mwabumba. The author is also grateful to Bee-Hive (Malawi) for making available hydraform block production machines used in this research.

11.0 References

Muthadhi, A., Anitha, R., and Kothandaraman, S., Rice Husk Ash — Properties and its Uses: A Review. Department of Civil Engineering, Pondicherry Engineering College, Puducherry. I. E (I) Journal, 2007.

Mehta, P.K. Rice husk ash—a unique supplementary cementing material. In 1992 Proceedings of the International Symposium on Advances in Concrete Technology, CANMET/ACI, Athens, Greece, pp. 407–430.

Wolley, G. R.; Goumans, J. J. J. M.; Wainwright, P. J. Waste Materials in Construction, wascon 2000. Amsterdam: Pergamon. p.493-503. Waste Management Series, 1, 2000. Cisse, I.K. and Laquerbe, M. Mechanical Characterization of Sandcretes with rice husk ash additions: study applied to Senegal. Cement Concrete Research, 2000. 30 (1): p.13– 18.

Malawi Standards, MS 175, Burnt Bricks-Code of Practice for Moulding and Firing, Malawi Bureau of Standards, 1997

Malawi Standards, MS 777. Soil Stabilized Blocks-Specifications, Malawi Bureau of Standards, 2007

British Standards, BS 1377, Soils for Civil engineering Works, Part 2, 1990
British Standards, BS 882, Grading of Aggregates, Part 2, 1983
British Standards, BS 812, Testing Aggregates, Part 2, 1990
British Standards, BS 1881, Testing Concretes, Part 2, 1983