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Contents

Editorial

The Malawi Journal of Applied Sciences and Innovation welcomes you, our esteemed reader, to this inaugural issue. In this first issue the research papers published depict the diversity of science and its application. Through the articles the reader will experience techniques and values of environmental assessment, journey through household water treatment and sanitation, appreciate environmental health risks and cherish employment of satellite imagery in natural resources management. The editorial board is indebted to our authors and reviewers who put their worthwhile time towards MJASI. We take this opportunity to acknowledge our collaborating partners, The Malawi Bureau of Standards (MBS) and The National Commission of Science and Technology (NCST), and all members of the editorial board. We look forward to exciting progress of work as we travel together to bring to our readers the science and its application through this outreach forum.

The Malawi Journal of Applied Sciences and Innovation is a forum for sharing knowledge on applied scientific research. The journal accepts articles and reports that are within the field of applied sciences such as Applied Biology, Applied Physics, Artificial Intelligence, Biochemistry, Built Environment, Communication & IT, Community Health, Computer Science, Ecology, Energy, Engineering, Entomology, Environment, Epidemiology, e-services, Food Safety & Hygiene, Food Technology, Grid Computing, Infectious Diseases, Information Systems, Mathematics & Statistics, Microbiology, Nanotechnology, Nutrition, Occupational Safety and Health, Robotics, Telecommunications, Water Supply and Sanitation, Web Technology and their applications.

The Journal is based in the Faculty of Applied Sciences of the Polytechnic, one of the constuent Colleges in the University of Malawi. The Polytechnic focuses on Applied Sciences, Building Sciences, Engineering, Commerce, Education and media. This journal will additionally inform our reader of the scientific research and outreach activities occurring at the College for mutually benefiting relationship with you.

We trust that MJASI will add value to your science in 2014 and the many years to come.

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Household use of Water Guard for treating drinking water in Chikhwawa District, Southern Malawi

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Abstract

This cross-sectional study assessed the use of WaterGuard for treatment of drinking water at household level in Chikhwawa district in the Southern Region of Malawi. WaterGuard is a local chlorine product being promoted by Population Services International (PSI) Malawi for disinfection of drinking water at household level in the country. Quantitative and qualitative methods were used for data collection. A questionnaire was administered to 349 households. Four Focus Group Discussions (FGDs) were conducted with women with at least an under-five (u/5) child. At household level, collection and storage of water was assessed. Samples of drinking water were tested for residual chlorine.

About two-thirds (59%) of the total households surveyed were collecting their drinking water from boreholes, and the remainder from communal taps (16%), protected wells (15%), private pipe (9.6%)and unprotected well (0.3%). A variety of water storage containers were observed. Clay pots (60%) were commonly used followed by plastic buckets (16%), metal buckets (11%) and 13% households who used other containers including jerry cans, basins and cooking pots. Of those with storage containers (n=272), 78% were observed to have completely covered their containers, while the remainder had either partially covered their containers (9%) or not covered at all (12%). Of the 349 households, 95% (330) reported ever used waterGuard for treatment of their drinking water. Of the 330 households ever used waterGuard, 72% (238) were able to explain how they treated their water. Under half {45% (107)} of the mothers used the right dose of waterGuard for treating their water; that is one bottle top per 10 litres, 2 bottle tops for 10 litres and 3 bottle tops for 30 litres. When asked if they stir their water after adding waterGuard, 42% (139) of mothers said they do, while 58% (191) did not stir their water after dosing. Participants in the FGDs indicated that they do not use water guard because of its cost, bad taste of treated water and not being aware that the product exists for sale in their village.

This survey has shown that there is need for community awareness on the right doses of waterGuard depending on source of water and size of container used for treatment.

1.1 Introduction

Diarrheal diseases kill an estimated 1.8 million people each year, and accounts for 17% of deaths of children under the age of five years in developing countries (Clasen et al., 2012). Ninety-four percent of this disease burden is related to use of contaminated water, lack of sanitation and unhygienic practices in food preparation(Clasen et al., 2012; Ministry of Health., 2005). Apart from causing death, diarrhoea leads to loss of family income, loss of productive time and malnutrition. In Malawi, dehydration caused by severe diarrhoea is a major cause of morbidity and mortality among young children. The prevalence of diarrhoea in the under-five (U/5) children two weeks preceding the 2004 Malawi Demographic and Health Survey (MDHS 2004) was estimated at 22% (National Statistical Office & ORC Macro, 2004).

There is evidence that unprotected water sources are greatly contaminated with indicator bacteria than protected ones (Moyo, Wright, Ndamba, & Gundry, 2004). This agreeswith articles and a report which indicate that high diarrhoea cases were found among users of unprotected sources(Masangwi S,, MORSE, Ferguson N,, Zawdie G,, &Grimason A,, 2008; Masangwi, Morse, Ferguson, &Makumbi, 2007; National Statistical Office & ORC Macro, 2004; Thomson, 2002). In a study to evaluate microbiological quality of drinking water in Lithuania, drinking water from dug wells was often found to be contaminated and not fit for drinking according to standard requirements (Malakauskas et al., 2007). It was also found that 94.4% of tested drinking water samples from centralized drinking water supply systems was of high microbiological quality and fulfill requirements of drinking water standard HN 24:2003(Malakauskas et al., 2007). A study by Checkly W., et al, 2004 showed that at 24 months of age, children with the worst conditions for water source, water storage, and sanitation were shorter and had more diarrhoeal episodes than did those with the best conditions (Checkley et al., 2004). A meta-analysis commissioned by the World Bank showed that hygiene education and water quality improvements were effective at reducing the incidence of diarrhoea disease(Lantagne, Quick, &Mintz, 2006). It was also found in a randomized trial done in a refugee camp in Malawi, that water from safe source had little or no microbial contamination although the water collectors quickly contaminated their water, primarily through contact with their hands (Roberts et al., 2001).Past data in Malawi indicates an increase in access to safe water and sanitation from 1992 to 2006 and a corresponding decrease in the under-five mortality rate(Malawi Government, 2008; National Statistical Office, 2005a, 2006). However, diarrhoea prevalence in the under-five (U/5) children has not decreased as expected by the year 2004. The same number of cases (22%) was recorded in 2004 as in 1992. Despite some improvements in provision of water sources, hygiene during collection, storage and use of water in the home may affect its quality. WaterGuard makes sure that the water in the home is safe for drinking by killing microbial organisms.

Access to safe drinking water is one of the Millennium Development Goals (MDGs)(Ministry of Planning and Economic Development and UN-Malawi., 2007)and Malawi poverty reduction strategy targets (MPRS). The sole quantitative environmental target in the United Nations MDGs is the call to "reduce by half the proportion of people without sustainable access to safe drinking water"(Centre for Disease Control, 2005). Meeting this goal within a short period of time is impractical especially in a country like Malawi which has limited resources with different priority areas. Most people inaccessible to safe water are the poor living in rural areas of the country (National Statistical Office, 2005a). In these areas post collection contamination which is a significant cause of waterborne diseases such as cholera which cannot be prevented by provision of a 'clean' supply only (Thomson, 2002). Although provision of protected water supplies goes some way to reducing the incidence of diarrheal diseases within the population, the

hygiene practices associated with the collection and storage of water in households also has a significant impact (Centre for Disease Control, 2005; Taulo, Wetlesen, Abrahamsen, Mkakosya, &Kululanga, 2008). A Lancet article suggested that "if we can get people to use products like the purifier of water (PuR) to decontaminate water in their homes and store it safely, we can reduce the incidence of diarrhoea and illness and save thousands of lives" (Frankish, 2003).

A Safe Water System (SWS) is the treatment of water from unsafe sources with anti-infectives like chlorine based products to make it safe for drinking. The SWS was designed for populations that must obtain their water from surface water sources such as rivers or lakes, shallow groundwater that is potentially contaminated, particularly open shallow wells, piped systems in which the water is inadequately treated or flow is intermittent, allowing contamination through leaks where pipes are connected and piped water systems in which intermittent flow requires households to store water. Other potential target populations are those that exhibit poor hygienic behaviors in the collection and storage of water (CDC, 2008). Such behaviors would include not cleaning containers before filling them with water and using wide-mouthed containers to collect and store water. Disinfection is not always necessary in these cases (e.g., if the source water is safe) but the practice of disinfection ensures safe water and supports the essential improvements in behavior including the use of a safe storage container (CDC, 2008).

WaterGuard is a chlorine based product used for treating drinking water at household level in Malawi. It was launched by Population Services International (PSI) in November 2002(PSI/Malawi, 2007; Thomson, 2002). It is a bottled solution of liquid sodium hypochlorite, which when properly mixed, makes most water safe to drink. The product is in liquid form to ensure dosing flexibility and is sold in 200 milliliter bottles (PSI/Malawi, 2006). One cap-full (3.5ml) effectively treats 10 liters of water for 24 hours - which means that the standard 20 liter Malawian pail (ndowa) can be treated for a day with two caps of the solution. As of 2008, PSI/Malawi waterGuard formulation had changed; one cap-full effectively treats a 20 litre Malawian pail and each 150ml waterGuard can be used for five weeks in a family of six people. Sodium hypochlorite is safe for consumption over long periods of use, and even if ingested undiluted, it would cause no dangerous or lasting effects (Thomson, 2002). The bottle's label provides pictorial directions for use. A 200ml bottle of WaterGuard retails for subsidized price of MK30 (0.2 USD) in Chikwawa. The primary target according to PSI/Malawi, 2004 was anyone who stores drinking water at home, and was therefore susceptible to water-borne diseases.

Consistent use of waterGuard has proved to be effective in controlling some types of waterborne diseases like cholera, dysentery and typhoid (PSI/Tanzania, 2007). Chlorine has been used worldwide to treat water for over 100 years now and it still strongly trusted by the World Health Organization (WHO) for that capability(Alekal, 2005).Correct waterGuard usage reduces the objectionable taste and odour which comes about mainly due to over treating and consumption of the water immediately after treating. People should be encouraged to treat their water accordingly and not to under treat it so that residual chlorine can kill the germs in case of post treatment contamination. The recommended amount of residual chlorine in drinking water is between 0.2 and 0.7 ppm (Information Gateway for NPS Employees, 2008).

There were no data in Malawi on how people use waterGuard at household level despite being available on the market for more than four years. A household survey on women done in 2006 nationwide indicated that of the total population of the mothers in Malawi, 64% were aware of waterGuard use, 12% of the mothers who have heard about WaterGuard were currently using it, but only 7% were using WaterGuard during the time of study as compared to 42% of the mothers using it in neighbouring Zambia with similar socioeconomic conditions to Malawi (Stockman et al., 2007). The study suspected that cost of the product was the main barrier to use but did not have enough data to support this assertion (Stockman et al., 2007). In addition, the study showed a substantial gap between the percentage of mothers aware of waterGuard who had tried it and those who were using it (52% against 12%)(Stockman et al., 2007). The gap that exists may be due to several factors including incorrect dosing leading to objectionable smell and taste, storage in direct sunlight, cost, and perceived benefit among others. Assessment of such factors was of main concern in this study.

Results of this study will help organizations working in water and sanitation contribute towards reduction of under-five mortality as stated in the Millennium Development Goal (MGD) number three by reducing diarrhoea episodes. The aims of this work are also in line with the Malawi Essential Health Package (EHP) especially condition number six which is on "acute diarrhoeal diseases" (Ministry of Health, 2004).

2.1 Methodology

This was a descriptive cross-sectional study within the Chikwawa-Scotland Health Initiative catchment area. The study area has a population of 9,869 people (T. Morse et al., 2008). It consists of four villages: Mwanayaya with a population of 1231 (268 households), Sekeni with population of 3875 (842 households), Mwalija with population of 2803 (608 households) and Namila with 1960 people (426 households) (T. Morse et al., 2008). In these four villages waterGuard was distributed for free from November 2006 toAugust2007 and then sold at a subsidized price from September, 2007 by the Chikwawa-Scotland Health Initiative. The villages agreed on the price which they were comfortable to pay for the product. Chikwawa is one of the 28 Districts in Malawi located in the Southern Region of Malawi. It is one of the border districts sharing the country's international boundary with Mozambique to the West and district boundaries with Mwanza to the North, Thyolo to the East, Blantyre to North East and Nsanje to the South. The proportion of population in ultra-poverty rate in the district was 32% in 2005(National Statistical Office, 2005b). Below is the map of the district:Find the map of the district at the the last page of the manuscript.

The SCHI project periodically collected data by questionnaire administration to mothers of the under five children, testing drinking water for residual chlorine and Focus Group Discussionswith mothers in its catchment's area. In 2007, data were collected between the months of February and March during the free distribution project (Tracy Morse & Makumbi, 2007). Similarly, in January 2008 data was collected as a continuation of the first data collection using the same questionnaire to help assess use of the product at household

level.

The sample size of 324 participants was selected with an estimated 95% confidence level and 80% power to correctly estimate the prevalence of households using waterGuard within the anticipated 5% of 30% (25-35%) (Thomas, McKinley, Freeman, & Foy, 2001). Prevalence of households correctly using waterGuard of 30% was found using SCHI waterGuard reports. The available sample included in the study was 349 which wasmore than the calculated sample size.

Table 1: Sample size per village

Village	Population	Expected no. of mothers of under-five	Mothers of under-five enrolled	Calculated sample size	Calculated sample size
Mwanayaya	1,231	104	204	67	83
Mwalija	2,803	238	228	85	93
Sekeni	3,875	328	238	89	92
Namila	1,960	166	201	75	81
Total	9,869	836	871	324	349

Household namesby SCHI and HSA records were used to identify mothers with under-five children in each village. The households where these mothers stay were identified by the project HSA with the help of the Village Health Committee for each village a week preceding the survey. Computer generated random numbers were used to identify mothers to be included in the study.The study included 349 questionnaires administered to mothers of children less than five years of age in the four villages (Table 1).

3.1 Data collection techniques

Questionnaires were administered and at the end of the interview water samples were collected from a drinking pot to measure residual chlorine. One focus group discussion per village was conducted with women who have at least an under five (U/5) child but were not selected for questionnaire administration. This was done as a complementary tool to the questionnaire (Ministry of Health, 2012).

3.1.2 Questionnaire design

The questionnaire was designed to collect data through both interviewing and observations. The mothers were asked to mention their source of drinking water and the frequency of drawing drinking water per day. Daily collection of drinking water by mothers was assessed on the assumption that collection of drinking water on daily basis would reduce contamination in the home and it could be a good indicator of consumption rate especially if the household treats its water. Mothers were also asked if they store their drinking water in a special container. Storing drinking water in a special container different from the one used for collection helps to maintain good hygiene and prevent post collection contamination. Mothers were also asked if they used the water from drinking storage container for other uses apart from drinking. Figure 2 shows the two cup system which was observed during the study.

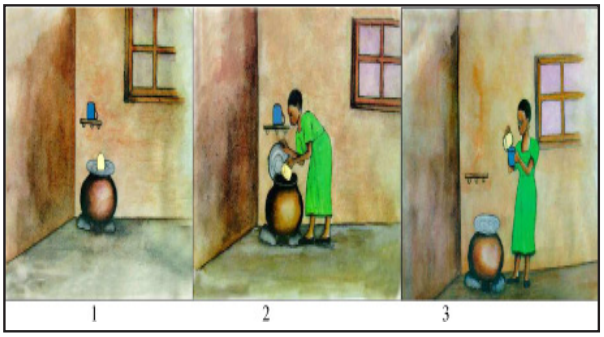

Figure 2: Two cup system (Thomson, 2002)

Observations were also done on waterGuard bottles to check if they were expired and if they were stored in suitable location (i.e. out of direct sunlight and out of reach of young children). Interviewers sought permission from the mother and anyone around the house before entering to do observations. Testing of water for residual chlorine was done using digital LaMotte 1200 Colorimeter from PSI/Malawi. Water was collected from drinking water storage container and poured into sample bottle after rinsing them with the same water. The colorimeter tubes were also rinsed and filled with sample water to the 10ml mark. The tubes were inserted into the colorimeter chamber. Pressing the 'read' button on the meter made it to turn it on and then pressing the 'zero' button and hold it until the word BLA (blank) was displayed. After releasing the button, a zero reading (0.00ppm) appeared. This was done for every different sample to take readings for a blank. Thereafter tubes with sample water with indicator were inserted to measure residual chlorine. The recommended residual chlorine in drinking water is between 0.2 to 0.7ppm.

3.1.3 Data analysis

Data was entered and analyzed using Statistical Package for Social Scientists (SPSS) 12.0. Epi Info 2002 (Statcalc) was used to calculate relationships between variables using the prevalence ratio (PR) (Thompson, Myers, &Kriebel, 1998). Chi Square test was used to test the significance of the relationships. Any relationship at P-value<0.05 were taken to be significant. The difference between proportions was tested using the 95% Confidence Interval (CI) calculated using the Confidence Interval Analysis (CIA) software version 1.2 (Gardner, Gardner, & Winter, 1989). Qualitative data obtained from the Focus Group Discussions was summarized according to thematic areas of interest. Themes and sub-themes were induced from the summary notes and ranked according to their importance. Significant quotes were noted and highlighted.

3.1.4 Ethical considerations

Since the study involved interviews with human subjects and collection of water samples from their drinking pots consent was sought from the respondent before administering the questionnaire and collection of water samples. The respondents who voluntarily consented to participate in the study after study objectives and methodology were explained to them signed a consent form.Information collected from respondents was treated confidential. No name of a respondent was asked nor recorded. For the focus group discussion, only those who gave consent were allowed to participate. Those whose water was under treated or over treated were advised accordingly before leaving the

household.

4.1 Results

4.1.1 Description of sample

The sample consisted of 349 women with at least one child under the age of five years. It was assumed that if a mother has an under five child, she is more likely to use waterGuard to protect her child from diarrhoea. All the mothers were aged between 15 years and 45 years. The villages included were Sekeni, a peri urban village in T/A Nchalo, Mwanayaya in T/A Makhuwira (rural area), Mwalija in T/A Kasisi (rural area) and Namila in T/A Mulilima (rural area) with sample sizes of 92, 83, 93 and 81 mothers respectively.

4.1.1.1 Source of drinking water used by households

The source of drinking water used by a village helped in determining the quality of water used for drinking. Results indicate that out of 349 households, 59% (206) used public boreholes as their main source of drinking water, 16% (56) used public tap, 15% (52) used protected wells, 9% (31) used piped water in their compounds with an outdoor tap, 0.6% (2) an indoor tap while 0.3% (1) used unprotected shallow wells. On village by village analysis, it was only Sekeni village which has piped water. This is because it is a peri urban area unlike the other three villages. The village is located close to Nchalo trading centre. For Mwalija and Namila all the respondents draw their drinking water from public boreholes. Protected wells were mostly used by 67% (56) of the households from Mwanayaya village for drinking water.

4.1.1.2 Collection of drinking water on daily basis

It was found that 76% (265) of the 349 households collected water on a daily basis and collected drinking water during the day of the survey. A greater percentage was shown in Sekeni village {78% (72)} followed by 76% (63) in Mwanayaya, 75% (70) in Mwalija and then 74% (60) in Namila.

Table 2: Separate container used for storing of drinking water

Is a separate container used for storing of drinking water?	Sekeni Vg	Mwalija Vg	Mwa-nayaya Vg	Namila Vg	Total
Yes	70 , 78%	74, 80%	74, 87%	56, 67%	272, 78%
No	16, 18%	17, 18%	8, 9%	22, 27%	63, 18%
Some-times	4 , 4%	2, 2%	3, 4%	5, 6%	14, 4%
Total	86, 100%	91, 100%	82, 100%	78, 100%	349, 100%

Most of the 349 households store drinking water in a different container than the one used for collection and general purposes (Table 2). This is indicated by 78% (272) of the households as compared to 18% (63) of the households who use the same container. A cross tabulation of use of separate container versus other uses of water from drinking water storage container showed that households who keep drinking water in a separate container are less likely to use it for other uses apart from drinking than those using same container (PR = 0.20, 95%CI: 0.11-0.37).

The most common drinking water storage container was the clay pot. This was found in 60% (209) of the 345 households. The second most common storage container was the plastic bucket {16% (56)} followed by metal bucket {11% (39)} and 13% (45) households used other containers including jerry cans, basins and cooking pots.

Table 3: Capacity of main drinking water storage container used by households

Drinking water stor-age container used	5 litres	10 litres	20 litres	30 litres	Other	Total
Metal bucket	0	2	27	11	0	40(11)
Plastic bucket	4	10	37	4	1	56(16)
Jerry can	1	6	21	2	1	31(9)
Barrel/drum	1	0	2	5	0	8(2)
Clay pot	2	14	146	41	6	209(60)
Basin	0	1	1	0	0	2(1)
Cooking pots/sauce pan	1	0	0	0	0	1(0)
Plastic basin	0	0	2	0	0	2(1)
Total (%)	9(3)	33(9)	236(68)	63(18)	8(2)	349(100)

Most households had storage containers of capacity 20 litres and more. This was shown by 86% of households (Table 3). Less than a quarter (12%) of the households had storage containers with capacity of 10litres or less. More than half (68%) of these drinking water storage containers had a capacity of20 litres. It was therefore clear that the 20 litres container was the most common in the villages.

4.1.1.3 Covering of drinking water storage containers

Upon observation of the drinking water storage containers, 78% (272) of the households had their containers completely covered, 12% (42) were not covered and 9% (31) were partially covered. On a village basis, Namila had the highest percentage of uncovered storage containers {20% (16)} followed by Sekeni at 13% (45). It was also shown that most clay pots {91% (190)} and plastic buckets {69% (39)} were completely covered. The metal bucket storage container was the most kept uncovered by the households {55% (22)}. Clay pots were seven times more likely to be covered than other types of storage containers [Prevalence Ratio (PR) =7.1, 95%CI: 3.8-13.4].

4.1.1.4 Use of two cup system

It was found that 82% (216) of the households use the same cup for scooping and drinking water while 18% (63) of households use a two cup system. Usage of the two cup system was highest in Namila (31%, 95% CI: 25-37%) as compared to other villages like Sekeni village (21%) which was second highest.

The FGD conducted in Namila revealed that mothers using the two cup system also face the risk of contamination through some members of the household who still use same cup as one of the mother explained: "my younger children feel it is difficult and time consuming to use the two cups system, when there is no one watching them they always use same cup for drawing and drinking water. Sometimes even us old people when we are tired, we use the same cup." It was also observed that 70% (244) of the mothers use the

water in a drinking storage container only for drinking while 30% (105) also use the water for other purposes. On other uses of water from the drinking water storage container, out of the 105 mothers who used water from drinking pot for other uses, 11% used it for washing, 8% for bathing, 4% for cleaning things and 4% for cleaning things. On washing, mothers mentioned washing vegetables, plates and hands. Since households mostly treat drinking water only, it becomes safe if they use the same water for washing cups, plates and foods eaten raw, for example, fruits.

4.1.1.5 Frequency of waterGuard use by mothers

Mothers were asked if they have ever used waterGuard for treating their drinking water. Of the 349 households, 95% (330) reported ever used the product for treatment of their drinking water. On frequency of use when the product was available in the house, 88% (290) said every day, 7% (23) used it when they remembered while 5% (17) were not sure.

4.1.1.6 Amount of waterGuard used for treating water

Mothers were asked to show the container that they used for dosing waterGuard and also to indicate the number of waterGuard bottle tops that they added to the container. The right amount of waterguard was one bottle top for 10 litres of water. Of the 330 households ever used waterGuard, 72% (238) were able to explain how they treated their water.

*Table 4: Size of container and quantity of waterGuard added to drinking water**

Size of container	1 bottle tops	2 bottle tops	3 bottle tops	4 bottle tops	5 bottle tops
5 Litres	3, 6%	3, 2%	0, 0	0, 0	0, 0
10 Litres	8, 16%*	16, 12%	3, 10%	0, 0	2, 100%
20 Litres	31, 62%	93 68%*	20, 69%	11, 52%	0, 0
30 Litres	7, 14%	21, 15%	6, 21%*	9, 43%	0, 0
Other	1, 2%	2, 2%	0, 0	1 5%	0, 0
Total	51 100%	135 100%	29 100%	21 100%	2 ,100%

% number of households dosing their drinking water using the right number of bottle tops

Table 4above indicates that the most common dosage for treating water was two bottle tops {68 % (93)}while the most common storage container was the 20 litre bucket. Just under half{45% (107)} of the mothers used the right dose of waterGuard for treating their water; that is one bottle top per 10 litres, 2 bottle tops for 20 litres and 3 bottle tops for 30 litres.

4.1.1.7 Time taken to finish using a waterGuard bottle and storage place for the bottle

When asked about the period it takes for the mothers to finish one waterGuard bottle, 43% (142) of the mothers indicated it takes more than 4 weeks to finish a bottle, 28% (92) said it takes between 2 to 3 weeks while 14% (46) mentioned between 1 to 2 weeks. About 40% (26) of respondents in Namila said it takes between 2 to 3 weeks. During routine inspection of waterGuard bottles' storage place by Health Surveillance Assistant, it was that almost all respondents {99%(327)} store the bottle properly except for 1%(3) who stored the product uncared for outside the house. When the bottles containing WaterGuard were inspected, none was expired despite some being in poor state with stickers difficult to read.

4.1.1.8 Stirring of water after adding waterGuard

When asked if they stir their water after adding waterGuard, 42% (139) of all the mothers said they stir, while 58% (191) did not stir their water after dosing. Out of all the women included in this survey, 35% (116) used the storage container for treating water while 33% (108) use the collection container and then transfer it to the storage container after treating. Out of 191 mothers who did not stir their water after treatment with WaterGuard, 81% (155) store the water in a different container from the one used for treatment. The pouring of water into a storage container may act as a form of stirring. This means only 36 respondents did not stir their water after treatment because they neither stir their water nor store it in a different container.

Table 5: Test results in parts per million (ppm) for water samples

Test result	Frequency	Percent (%)
Under treatment (Less than 0.2 ppm)	228	91.9
Correct treatment (0.2 to 0.7 ppm)	8	3.2
Over treatment (More than 0.7 ppm)	12	4.8
Total	248	100

It is shown that 92% (228) of the households had residual chlorine of less than 0.2ppm which is less than the required amount of between 0.2 to 0.7 ppm. Out of the 248 samples tested, 3.2% had the right amount of residual chlorinewhile4.8% had over treated their drinking water with residual chlorine more than 0.7ppm (Table 5).A cross tabulation of quantity of waterGuard added to water and residual chlorine indicated that all households who overdosed their water used two cups or less to treat their water. Their storage containers had capacity of between 10 to 30 litres and were mostly using tap water which already had residual chlorine of about 0.2ppm before treatment.

4.1.1.9 Reasons given for not using waterGuard

From the FGDs conducted, those who did not use waterGuard indicated that water was already safe, had no money to buy, did not like the taste of waterGuard and were not aware of the presence of waterGuard in their village. Others indicated that they boil their drinking water while one respondent during the Sekeni FGD indicated selling the product to make money as the reason for not using the product. The FGDs also revealed that some mothers had an understanding that diseases are caused by "bad winds" which cannot be controlled. During Namila FGD one mother said: "Disease come because of change in winds, the water that we use does not have any problems. We have been using the same water for several years without getting sick". The mothers agreed that they had been drinking the same water for years and they know that it is safe but the change in winds is the one which bring diseases like diarrhoea, cholera

and the colds.

5.1 Discussion

5.1.1 Source of drinking water by village

All but 0.3% used improved water sources. The main source of drinking water was the borehole in all the villages except in Sekeni village, a peri-urban area, where the main source was the public tap. These results are consistent with survey results by PSI/Malawi which found that the main source of drinking water in Malawi was borehole (54%) followed by public tap at 17% and well at 16%(PSI/Malawi, 2006). Also the Integrated Household Survey puts national access to boreholes at 51% (National Statistical Office, 2005a). Access to boreholes is higher in rural areas than in peri-urban and urban areas which rely mostly on piped water. The high access to improved sources does not indicate high usage and availability of safe water at household level. Improved water sources generally deliver 'safe' water at the point-of-supply, however, studies have shown that water from such sources get contaminated with E. coli (Gundry et al., 2006). According to Wright J.A., et al, (2006) quality of water from improved sources deteriorates significantly after collection. Their findings suggested that providing an access to an improved source does not necessarily provide access to 'safe' drinking water and supported the call for point-of-use storage and treatment interventions such as home filtration and chlorination by Quick et al.,2002 and others(Chikwawa District Assembly, 2006; Gundry et al., 2006; Moyo et al., 2004). Because of the risk of post-collection water contamination, communities with improved supplies should also be targeted by such interventions (Gundry et al., 2006).

5.1.2 Mothers' practices on collection, storage, use and treatment of drinking water

Studies have documented the process of contamination of drinking water within the home (Roberts et al., 2001). Most mothers (81%) were using a special separate container for storing their drinking water. Storing drinking water in this way helps to maintain good hygiene and prevent post collection contamination. In a study initiated by PSI/Malawi a lower percentage [70%, (95% CI: 60-79%)] of households storing their drinking water in a separate container was found (Thomson, 2002). The higher use may be explained by the hygiene and sanitation education provided by the SCHI project. The most common drinking water storage container was the clay pot.This was consistent with PSI/Malawi, 2006 survey which found that the main method of water storage in Malawi was the clay pot at 56% followed by plastic bucket at 24%, 20L metal bucket (8%), 14L metal bucket (7%), Jerry can 4% and other at 1% (PSI/Malawi, 2006). In a study done in Malawi by Thomson, approximately all of the people in rural areas stored their drinking water in containers in the home [6].

It was noted that most households had considerable bigger storage containers than those found in similar studies done in Malawi [9]. Small containers have been found to be more commonly contaminated than larger containers [9]. It was also observed that more than half of the household had drinking water storage containers with a capacity of 20 litres. Thus size of storage container makes simple the use ofwaterGuard. A 20 litre storage container needed two cups of waterGuard for a period of 24 hours (PSI/Malawi, 2007). Lessons on how to treat water can concentrate on the right dose for most common storage containers found in the community. As for the waterGuard powder, a packet in a package of many to treat exactly 20 litres can be made for convenience sake. This could reduce the struggle of coming up with right doses for the water.

Covering of drinking water storage container has been shown to reduce contamination at point-of-use (Roberts et al., 2001) and the larger the size of storage container, the less likely it is to be contaminated (Checkley et al., 2004). Study results indicated that more than three quarters of the mothers cover their drinking water storage containers and also more than half use bigger containers (20 litres or more). A survey by PSI/Malawi in 2006 showed a higher figure on covering of drinking water pots. It found that 88% [as opposed to 78%, (95%CI: 74-83%) in this survey] of the households completely cover their drinking water pots.

5.1.3 Correct waterGuard use at household level

This was determined by considering amount of waterGuard used for dosing water, size of container, stirring of water after dosing, time taken to finish waterGuard bottle and the amount of residual chlorine in treated water. In general it has been shown that mothers have knowledge on how to use waterGuard when they have it but however, these mothers were unable to adjust dosage of waterGuard used when they change water source. This was evident in Sekeni where households are using tap water as main source of drinking water. They still use the same dosage as if they are using unprotected well or a borehole. This led to over treatment of drinking water as indicated by results of most samples tested in this village. Tap water in the village already had the right amount of residual chlorine and adding one cup of waterGuard per 10 litres as recommended by PSI (PSI/Malawi, 2007) meant water had high levels of residual chlorine. In a study by Clasen et al, 2007 in Bangladesh, residual chlorine showed that households consistently used the treatment tablets but 12% (as compared to 5% in this study) of the samples exceeded the WHO guideline value, underscoring the need to ensure that tablet dose and vessel size are compatible (Clasen, Schmidt, Rabie, Roberts, & Cairncross, 2007).According to Blantyre Water Board, treated water at source needs no further treatment unless further testing has been done which shows low levels of residual chlorine. In line with this, it is therefore important to advise people not to treat water from a tap where it has been treated at source since PSI does not provide a specific dose for such water sources. People should therefore be encouraged to keep waterGuard for use in case the taps dry out or break down. It has however, been argued in an article by Morse T.D (T. Morse et al., 2008), that despite the provision of safe water at the source, in many cases mains water in Malawi is faecally contaminated by the time it reaches the home. To reduce the risk of waterborne disease transmission by this route, chlorine can be added to household containers. Morse T.D. in her article reported a reduction in diarrhoeal disease in the years 2006 and 2007 in the villages studied which she partly attributed to the chlorine treatments.

The perceived benefits were that waterGuard reduces diarrhoeal diseases and makes water safe to drink. These are in line with those of Frankish H., (2003). He indicated that if we can get people to use products like PuR to decontaminate water in their homes and store it safely, we can reduce the incidence of diarrhoea and illness and save thousands of lives (Frankish, 2003).

6.1 Conclusions

All except 0.3% of the households included in this study use an improved water source. Previous waterguard use, availability of waterGuard in the house, perception about vulnerability to diarrhoea and cholera, perception about water source and cost are the main factors that affect use of waterGuard in the area. There is need for community awareness on the right doses of waterGuard depending on the source of water used and the size of container used for treatment. Those using safe water sources, for example, a borehole should use lower doses mainly to check post collection contamination than those using unsafe water sources, for example, unprotected wells and rivers as a source of drinking water.

6.1.1 Limitations of the study

The study was descriptive cross sectional. Most of the questions depended on the ability of the mothers to remember the past events. This may be a source of information bias. Despite the above limitations, the study triangulated the data collected with the results from FGDs and other studies done in the area. In addition, testing of water samples for residual chlorine also helped to reduce information bias.

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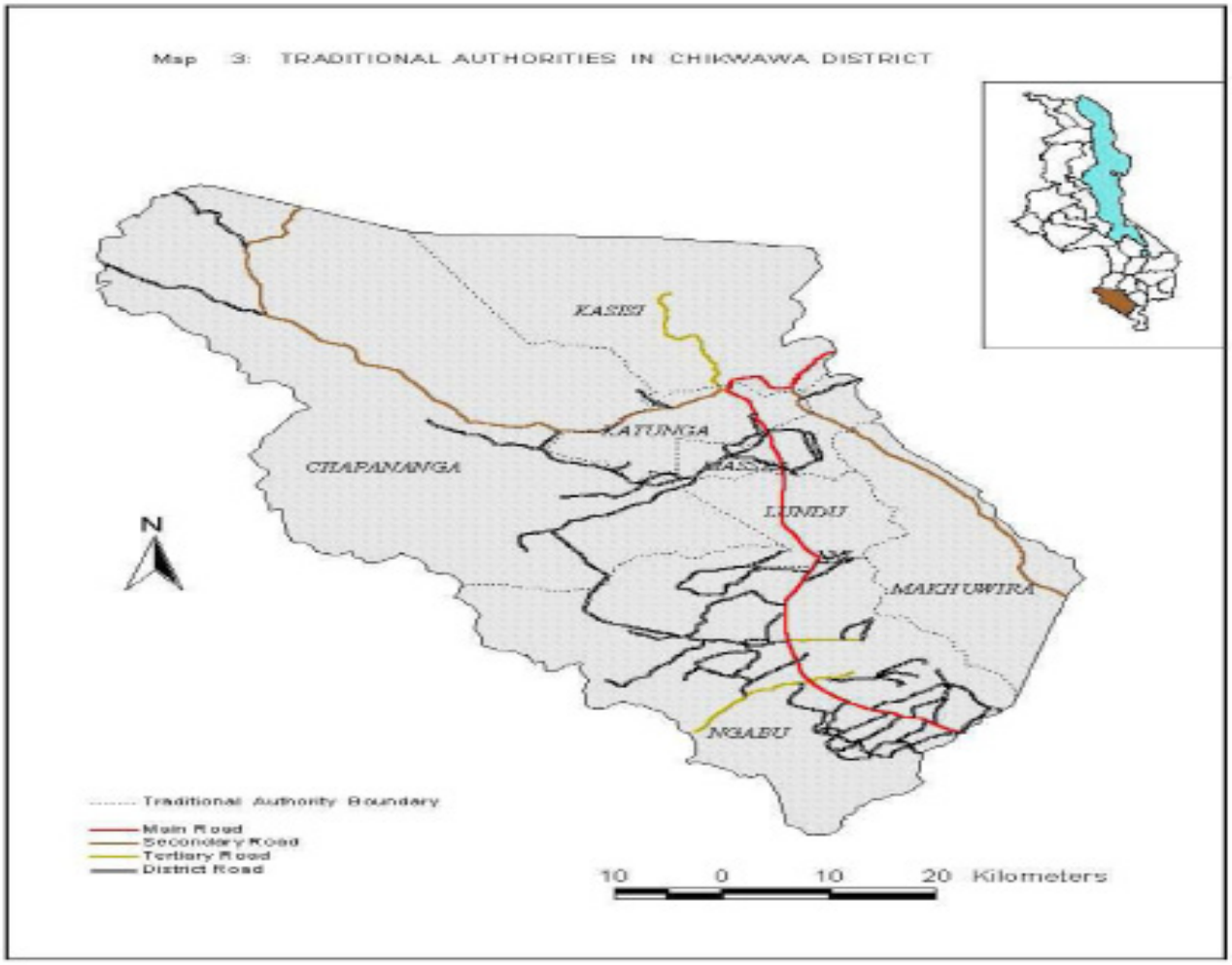

A regression analysis to assess the potential of google earth satellite imagery in estimation of forest structural parameters

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Abstract

Carbon trading is emerging as one of the world's largest markets. Malawi is involved in preparatory projects to benefit from this market. However, one basic requirement is the ability to produce regular assessments of the forest resource. Satellite remote sensing has opened a more effective way to collect forest data than the traditional field inventory. Unfortunately, the high cost of commercial satellite imagery limits their systematic use. One emerging solution is the use of free Google Earth imagery. This study was carried out with the main aim of determining if Google Earth satellite image indices can accurately estimate forest structure of a typical miombo forest.

A field inventory was carried out to establish stocking density (number of trees/ha), basal area (total ground area covered by tree stems) and total tree volume per hectare in different areas of a miombo forest. A satellite image covering the forest was extracted from Google Earth. First order statistics characterizing tone and texture were derived from corresponding areas on the satellite image. A regression analysis was run, involving the derived image indices vs. the measured forest parameters.

The results show strong relationships between image tone and stocking density (R2 = 0.9868); texture and basal area (R2 = 0.9176); and texture and volume (R2 = 0.9227). Overall, texture appears to have stronger relationship with forest indices than tone. This study demonstrates the applicability of Google Earth data in estimating forest structural parameters, a requirement for participating in carbon trading.

1.0 Introduction

Deforestation and forest degradation have been shown to contribute 20-25% of global carbon dioxide emissions (IPCC, 2007, cited in Ploton et al., 2012, p. 993). In response to this, the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD) introduced the Reductions in Emissions from Deforestation and Degradation (REDD-plus) initiative. Under the provisions of the programme, developing countries receive economic incentives to reduce emissions by protecting their forest resources. This is considered to be a cost-effective means to mitigate climate change. In addition, the Doha Amendment to the Kyoto Protocol of December 2012, offers countries additional means to meet their carbon targets through International Emissions Trading (UNFCCC, 2013, online). As a result of this, carbon trading is emerging as one of the world's largest markets and according to Mhangara and Odindi (2013, p. 35), it has the potential to significantly improve livelihoods in Third World communities. At regional level, the Southern Africa Development Community (SADC) Support Programme on REDD has provided a comprehensive framework for member states to actively participate in and benefit from the carbon market. According to the SADC REDD Network (2013, online), the Malawi Government is involved in preparatory projects to find appropriate methodologies for implementing REDD-plus. To achieve this, as well as optimize the economic return from carbon trading, the basic requirement is to have a mechanism to produce rapid, regular and reliable assessments of the forest resource.

In Malawi, forest inventories, based on field sample plots, have been the traditional method of collecting most forest data. However, this conventional method is not suitable for detecting the changes in forests with sufficient speed because it is tedious, time-consuming and expensive. Satellite remote sensing has opened an effective way to collect forest data and make reliable estimates of forest biomass (Rosenqvist et al., 2003, cited in Muukonen, 2007, p. 617). Several studies have attempted to utilize satellite imagery to provide estimates of forest structure and the results generally suggest that exploiting the properties of very high resolution (VHR) satellite imagery could provide a significantly quicker method of forest assessment (Ploton et al., 2012, p. 994).

Forest structure can be estimated by means of direct radiometric measurements, which involve establishing regression relationships between data derived from satellite images as independent variables, and measured parameters at corresponding positions in each forest stratum (Viana et al., 2011, p. 108). However, the models developed may not be universally applicable due to spatial and temporal variations in forest ecosystems. This, therefore, calls for the development of models at local or regional levels.

Nichol and Sarker (2011) have successfully used regression techniques on a texture-based method for estimation of forest biomass. Texture can be described as the visual perception of coarseness or smoothness of image features. When defined in a quantitative sense, texture is a measure of the variation in intensities of image pixels (picture elements) that are represented by digital numbers (DNs) in all digital images. A smooth texture will contain small changes in DN values over an area while a coarse texture would contain large changes in DN values. Variance of DNs on an image may therefore be used to indicate the level of coarseness. The use of variance as a measure of texture was successfully attempted by Collins and Woodcock (1999) and Franklin et al. (2001). Another property of satellite imagery that has been used but to a lesser degree in forest assessment is image tone. The limitation in the use of tone is that the results may not be reliable for a different forest system or when a different satellite image is used for the same forest stand. Tone refers to the various shades of gray observed on the black and white photograph (Howard, 1991). With reference to image pixels, tone is the measure of the degree of pixel brightness. This means that areas with dark shades of gray on an image will have low DN values while light shades will have high DN values. Quantitatively, the mean DN of visually uniform areas on an image is indicative of the level of grayness.

Most studies attempting to estimate forest structure from satellite imagery have generally utilized multi-spectral and hyper-spectral images (Javed et al., 2012, p. 2206). However, the high cost associated with acquiring commercial high to medium resolution satellite imagery limits their systematic use. In Third World countries such images are not readily available. One emerging solution is the use of the Google Earth (GE) global mosaic of freely available VHR satellite imagery. Although GE data are of slightly lower quality than genuine commercial images, they have, in many cases, proven sufficient to derive useful forest data (Barbier et al.,

2009, cited in Ploton, 2012, p. 994).

This study was carried out with the main aim of determining if Google Earth satellite image indices of texture and tone can accurately estimate forest structure in terms of stocking density, basal area, and volume in a typical miombo forest. This would be achieved through development of regression equations linking image measurements to field measurements and examining coefficients of determination (R2). The specific objectives of the study were to (1) establish the biophysical status of a miombo forest stand in terms of stocking density (number of tree stems per hectare), basal area (ground area per hectare occupied by tree stems), and total tree volume per hectare through a field forest inventory; (2) glean spectral and spatial properties (texture and tone) of different parts of the forest from Google Earth satellite imagery using Geostatistical techniques; and (3) calculate R2 of the relationships between ground and image indices through regression techniques.

2.0 Materials and Methods

2.1 Description of the Study Area

The study was carried out in Soche Forest Reserve (FR). The forest lies between X 715527 and 718058 metres; and Y 8246902 and 8249218 metres in Zone 36L on the Universal Transverse Mercator Grid. It is located 10 kilometres south of the centre of Blantyre, the largest and major commercial city in Malawi, and 5 kilometres southwest of Limbe Town, in the Southern Region of Malawi. The FR lies on Soche Hill and covers a total area of 363 hectares. A small portion of the reserve was excised in 1958 to allow for the establishment of a quarry mine. Soche FR was gazetted in 1922 primarily for watershed protection and scenic beauty. The reserve is a designated public land under the Land Act of the Laws of Malawi. The Department of Forestry manages the reserve under the 1997 Forestry Act. The reserve serves a variety of environmental purposes, of which watershed protection is probably the most important. A total of eleven streams originate from the reserve, one of which feeds the Chimwankhunda Dam. The streams supply water to the bordering villages and townships while the dam is used as a reservoir for emergency water supply to Blantyre City.

Soche Forest Reserve lies at an altitude ranging from 1 100 to 1 650 metres above sea level. It is a typical "miombo" woodland dominated by Julbernardia and Brachystegia species. The reserve is surrounded by Misesa, Somba, Mselemu and Njambe Villages on the eastern side; Muleso and Nyamazani Villages on the southern side; and Chilobwe, Chimwankhunda and Manja Townships on its western and northern sides.

2.2. Forest Inventory

2.2.1 Stratification and Sampling Design

Stratification is the separation of a mixed population into its component sub-populations, which have a smaller standard deviation than the original population. Stratification of Soche FR was done using a three-stage stepwise classification procedure as described by Howard (1991). Classification was based on a SPOT satellite image and a reconnaissance field survey that had been carried out prior to inventory data collection. Parameters considered for the stratification were photo elements (texture, tone and association) assessed from the SPOT satellite image and stocking density estimated from the reconnaissance field survey. Polygons representing the strata were built by on-screen digitizing using GIS software, ArcView 3.3 (Figure 1).

2.2.2 Field Data Collection

A sampling intensity of 1% was subjectively initially adopted. The use of a minimum accepted sampling intensity, in the absence of prior inventory data, was used by Ngalande (1995) and is supported by Kayambazinthu (1999) and Folving, et al., (1995). However, during the reconnaissance survey, it was noticed that there was considerable variation in stocking densities and species composition. The sampling intensity was therefore increased to 2%.

Sample plots were laid out following a systematic sampling scheme to ensure all parts of the five strata were covered uniformly and to increase the precision of estimates. Using a Global Positioning System (GPS) receiver, the sample plots were laid at approximately 200 metre intervals along parallel transects running through each stratum. The shape of the plots was concentric circular with a maximum radius of 30 metres. The size of the outer circle of the plot was 0.27 ha which, in forest inventories, could be considered large. The use of large plots in tropical forest inventories is generally recommended (e.g. Alder and Synott, 1992). This is due to the large variation of species.

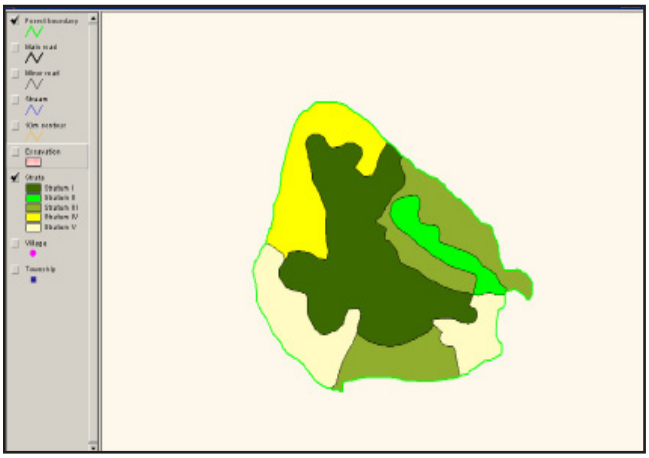

Figure 1: ArcView Window showing Stratum Layout

The following single tree and stand parameters were measured and recorded for all selected trees on field inventory recording sheets:

(1) Diameter at Breast Height (dbh). This was measured using diameter tapes at a height of approximately 1.3 metres above the ground.

(2) Tree Height. A calibrated height-measuring rod was used to measure height.

(3) Stratum number and plot number, and UTM location using the GPS receiver.

All the data collected in the sample plots were grouped by stratum in Microsoft Excel Spreadsheet. Data analysis for the inventory involved:

(1) Development of a height/diameter equation using the sample trees that were measured for height. A regression analysis of tree height in metres against dbh in centimetres was run in MINITAB to produce a site-specific height/diameter equation. This equation was used estimate the height of the rest of the trees.

(2) Calculation of stand density in terms of number of stems/ha (N), basal area (G – m2/ha) and volume (V – m3/ha). Single tree basal area was calculated using the formula gi = 0.00007854 Di2/A

Where: gi = basal area of the ith tree (m2)

Di = dbh of the ith tree (cm)

A = plot area in which ith tree occurs (ha)

Single tree volumes were calculated using the universal formula Vi = 0.5 ghi

Where Vi = volume of the ith tree (m3)

hi = total height of the ith tree (m)

g = tree basal area (m2)

The general volume formula was used due to the absence of a local volume equation for Soche Forest Reserve.

(3) Computation of regenerating stems/ha by stratum. Since the size of the sample circle for regeneration was uniform (2m) in all plots, it was possible to use a single formula for computing number of regenerating stems per hectare. The formula used was R = (ni / k) * 795.78

Where R = number of regenerating stems/ha

k = number of plots in stratum

n = number of regenerating stems in plot p

p = plot number

2.3 Measuring Texture, Tone and Canopy Density on GE Satellite Imagery

A 2 metre by 2 metre spatial resolution satellite image of the study area was extracted from GE (Plate 1). The image size was 1024 x 576 pixels and user view was set at 5.47 km above the surface. The image was reduced in size by cropping to 772 x 625 pixels. Google images are true colour and limited to the visible band of the electromagnetic spectrum. The Red, Green and Blue constituent bands were combined, by averaging, into a single panchromatic band. The image was then georeferenced in ArcGIS 10 and overlaid with the vector shapefile of the five demarcated strata. The sample plots were co-located on the image using coordinates collected by GPS on the ground. Using Image Classifier in ArcGIS 10, the following pixel parameters were extracted from the image for each of the 25 sample plots located throughout the five strata: pixel variance and pixel mean. Averages for the five strata were computed in Microsoft Excel.

Plate 1: Google Earth Satellite Image of Soche Forest Reserve

2.4 Regression Analysis

A regression analysis was run in MINITAB and involved each image index i.e. tone and texture vs. each of the forest parameters i.e. stocking density, basal area and volume.

3.0 Results And Discussion

3.1 Forest Inventory

The height/diameter equation developed from the regression analysis and used to estimate height of the rest of the trees was: Height = 1.57 + 0.479 dbh. The R2 for the regression analysis was 0.91 indicating a high correlation between dbh and tree height. Stand parameters in terms of stocking, basal area and volume per hectare based on the 25 plots measured in the five strata are shown in Table 1.

Table 1: Average stand parameters shown by stratum

Stratum	Stocking (stems/ha)	Basal area (m2/ha)	Volume (m3/ha)
1	267	16.31	138.78
2	190	4.57	30.14
3	27	3.39	46.96
4	633 (regeneration)	2.56	6.58
5	0	0	0

The highest stocking density was recorded in Stratum 4 at 633 stems/ha (Table 1). However, all these are young regenerating tress with low wood volume and a poorly developed canopy structure. The stocking for Stratum 4 was not used in developing the final regression equations. The results for basal area and average total volume per hectare for each stratum show remarkable differences among the five strata. The basal area of 16.31 m2/ha in Stratum 1 is the highest among the strata and is also higher compared to that of 10 m2/ha obtained in miombo woodlands elsewhere (Malimbwi and Mugasha, 2001). Stratum 1 also has the highest volume per hectare among the strata at 138.78 m3/ha.

3.2 Image Parameters

Table 2 summarizes results of measurements from the GE satellite imagery. When compared to Table 2 results, the mean, indicative of tone, is inversely related to stocking, basal area and volume whereas variance, a measure of texture, is directly proportional to the forest indices.

Table 2: Image indices shown by stratum

Stratum	Tone Index	Texture Index
1	41.29	327.9721
2	48.94	205.3489
3	67.46	200.7889
4	67.25	150.3076
5	66.54	95.6484

3.3 Regression Results

Tables 3 and 4 show results from the regression analysis. Table 3 summarizes R-squares while Table 4 shows regression equations that may be used for predicting forest parameters from image indices.

Table 3: Summary of R-Squares

	Tone Index	Texture Index
Stocking	0.9868	0.7445
Basal Area	0.7226	0.9176
Volume	0.6080	0.9227

Table 4: Regression equations linking forest and image indices

	Tone Index (Mean)	Texture Index (Variance)
Stocking (N)	N = 670.66 – 9.81*Mean	N = – 121.16 + 1.17*Var
Basal Area (G)	G = 30.85 – 0.44*Mean	G = – 8.46 + 0.07*Var
Volume (V)	V = 250.62 – 3.54*Mean	V = – 77.78 + 0.62*Var

The results show a very strong relationship between image tone index and stocking density (R2 = 0.9868). The relationships between texture index and basal area and volume are also very strong (R2 = 0.9176 and 0.9227 respectively). Tone appears to be more strongly related to stocking density than texture whereas texture more strongly relates to basal area and volume than tone. The relationship between canopy texture index and stocking is weaker but still significant (R2 = 0.7445). Similarly, the relationship between tone and basal area and volume is much weaker but nevertheless significant (R2 = 0.7226 and 0.6080 respectively). However, the difference in accuracy between tone and texture for volume prediction is relatively large. Overall, texture appears to have stronger relationship with forest indices than tone. Since both indices are equally easily derived from satellite imagery, tone could be used for stocking estimates while determination of volume could rely on texture data. Forest biomass estimates and ultimately carbon stocks which rely on tree volume data, are, therefore, more accurately estimated by image texture than image tone.

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Environmental performance in the Malawian road construction industry

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Abstract

Malawi as a land locked country depends on the road and rail networks for its freight and passenger traffic. Therefore, the development of road infrastructure is regarded as critical and an accelerator of economic growth. However, such development poses threats of environmental degradation. The study addresses the influence of road construction on the environment in Malawi. A survey of contractors in the road sector shows that while most of the local contractors are not familiar with environmental laws and guidelines set by the government and international standards bodies, they are aware of the Roads Authority guidelines. The result is a high level of non-compliance, which they attribute to lack of financial resources, training, and well trained environmental officers, and institutional support. Road-works contractors also attribute this situation to structural factors such as procurement of works, which do not take into consideration costs of environmental mitigation measures. The study recommends that government should review the current legislation, conduct regular training and periodic environmental audits, introduce environmental assessment on all projects, establish key environmental performance indicators, and apply stiff penalties for non-compliance. The study results point to significant consequences of failure to address environmental issues, including the continued destruction of the environment and subsequent acceleration of global warming.

Keywords: Malawi, Environment, Performance, Road Construction

1.0 Introduction and Background

The International Road Federation (IRF) approximates that road-works contribute to over 15% of the world's environmental degradation (IRF, 2010), thereby contributing significantly to global warming. In most developing countries, roads are the dominant mode of transport and constitute the single largest government asset as a large amount of money is invested in this endeavour. In addition to the construction of new roads, other roads are rehabilitated or routinely maintained, in order to accelerate development. It is estimated that over 90% of all international freight and passenger traffic is handled by road transport, while 70% of internal freight and 99% of passenger traffic relies heavily on road transport (Transport Sector Investment Programme (TSIP), 2011). Paradoxically, development of the road sector contributes towards environmental degradation and global warming. To mitigate the negative environmental effects from road construction, the Roads Authority (RA) produced Environmental Management Guidelines (EMG), which all contractors are obliged to follow. This study set out to establish levels of compliance therewith, and factors that account for the status quo. The specific objectives of the study were to:

- Analyse the levels of contractors' compliance with various international and domestic environmental mitigation instruments, namely the EMG, RA Guidelines, and ISO 1400;
- Investigate factors that account for the existing level of compliance, and
- Identify barriers to adherence of the set environmental guidelines.

2.0 Literature Review

The total length of the classified road network in the Southern Africa Development Community (SADC) is just over 930 000 kilometres, of which approximately 186 000 kilometres is paved. In addition, SADC has a large network of rural roads, which stretch to an approximate length of 430 000 kilometres (SATCC, 2006). The RA estimates that Malawi has a total road network of 15 451 kilometres of which 26% (about 4 038 kilometres) is paved roads (RA, 2009). However, Ministry of Transport and Public Infrastructure (2010) reported an additional 9 478 km of undesignated road network that serves the rural communities, which equates to a total road network of 24 929 km.

2.1 Environmental Management in Malawi - Legal Framework

Environmental management in Malawi involves several institutions. The RA is responsible for the construction, rehabilitation and maintenance of all designated roads in terms of an Act of Parliament No. 5 of 2006. In addition the RA's road management functions, the National Construction Industry Council (NCIC) is mandated to regulate the industry under an Act of Parliament of 1996 (NCIC, 1996). Contractors and consultants are supposed to register with the NCIC and pay annual subscription fees. In Malawi, the Framework for Sustainable Environmental Management (FSEM) is enshrined in the constitution of the Republic of Malawi (1994). The FSEM calls for prudent management of the environment and accords future generations their full rights to a sustainable environment. The provision in the constitution is operational in the National Environmental Action Plan (NEAP), which identifies areas of concern such as soil erosion, deforestation, water resources depletion and degradation, high population growth, depletion of fish stocks, threats to biodiversity, human habitat degradation, climate change, and pollution (NEAP, 2002). The NEAP highlights the areas of priority including efficient utilisation and management of natural resources. The Environmental Management Act (EMA) of 1996 enforces the FSEM through the Environment Impact Assessment (EIA) process. The Act defines the powers, functions, and duties of the Directorate of Environmental Affairs (DEA) and the Environmental Affairs Department (EAD) in implementing the EIA process (EMA, 1996). The EAD in 1997 developed guidelines for EIA in order to ensure compliance with the EIA process by project developers. It provides a list of prescribed projects for which an EIA is mandatory and those that may not require an EIA (Guidelines for EIA, 1997). The EIA process in Malawi is outlined in Figure 2.1 below.

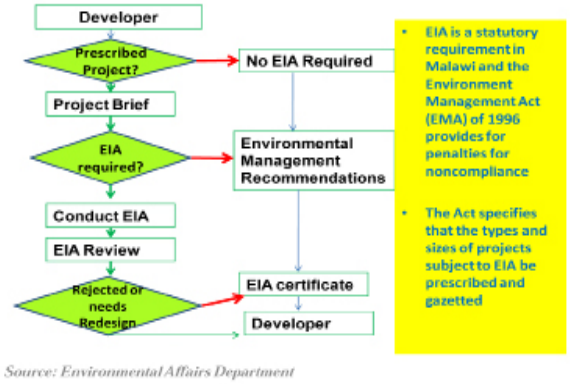


Fig 2.1: The EIA Process in Malawi

Glasson et al. (2005) define EIA as to the "need to identify and predict the impact on the environment and on man's health and well being of legislative proposals, policies, programmes, projects and operational procedure, and to interpret and communicate information about impacts." The United Kingdom Department of Environment (UKDOE) (1989) describes environmental assessment as "a process by which information about the environmental effects of a project is collected, and taken into account by the planning authority in forming their judgments on whether the development should go ahead or not."

Scholars have identified an array of factors that impede implementation of environmental management. They also assert a variety of impacts of environmental degradation that could inform the role of road-works in environmental management. Due to differences in understanding key barriers to and impact of environmental degradation resulting from road-works, researchers tend to recommend different interventions.

2.2. Constraints to environmental management implementation

Ofori (2009), Chilipunde (2010), Spong and Walmsley (2003) and Kakonge (2006) assert that environmental management problems in developing countries exist side by side with lack of managerial experience, financial resources and legal and administrative systems necessary to deal with the issues (Trethanya et al., 2008). Kakonge (2006) in turn reports that constraints facing the EIA processes include: lack of local skilled manpower to conduct effective EIA studies; trans-boundary EIAs are complex; lack of strong partnership between stakeholders; government lack of commitment on environmental issues, emphasis on poverty reduction and fighting the HIV and AIDS pandemic, while initial EIA may be funded, monitoring and auditing are left out; lack of public participation and involvement in the EIA process, and availability of data to effectively carry out the EIA process. In Malawi, Kalindekafe (2011) identified the following constraints in the EIA process: developments proceeding without any EIA process; inadequate information on alternative design; EIAs conducted just prior to the onset of implementation and not at planning or feasibility stages; EIAs being done by the same firm that designed or is constructing the project, and coercion from the client. Spong and Walmsley (2003) observed the following constraints: limited transport and monitoring equipment; inadequate EIA awareness and lack of referral to the EAD by licensing authorities forcing developers not to comply with EIA requirements; limited services and facilities for effective environmental monitoring for example waste disposal facilities and no hazardous waste sites; socio-economic growth development priorities and basic needs override environmental issues, unclear policies and there are no environmental standards (Trethanya et al., 2008). While these studies illuminate general constraints in implementing EIAs, they are too general to provide sector specific predictions.

2.3 Environmental Management in the Roads Sector

Several studies indicate that road-works affect the environment in various ways. The SMEC report (1998) identifies several effects: extraction of earth, sand gravel and rock; changing the local drainage along the road and in stream beds; restricting flows in streams; use of bitumen, paint, fuels and other hazardous materials; introduction of paved surfaces; construction work activities including earth works, and stockpile, work camps and other temporary work sites. These effects are known to lead to: destruction of wild habitants; loss of biodiversity along the road environment; increased soil erosion during road works; leading to siltation of rivers and streams; soil contamination by chemical oil, bitumen and fuel spillage both during road works, use and increased deforestation (SMEC, 1998). The SMEC study (1998) also reports on social impacts such as: drains ending and flooding people's gardens; dumping of scrapped bitumen and other debris in people's gardens; road widening disrupting farming and commercial activities, and disruption of social and economic activities, particularly during execution of the works. To mitigate these effects, the RA under the World Bank's Roads Maintenance and Rehabilitation Project (ROMARP) developed an Action Plan for Environmental Management. The ROMARP further identified the following weaknesses in the existing RA standard contract document: most of the specifications were too brief and did not give enough details for the implementation of mitigation measures; specifications gave a lot of latitude to the supervising engineer to make environmental management decisions; no remedies in the conditions of contract for dealing with defaulters, and bills of quantities do not contain items that are directly intended for activities for implementation of mitigation measures.

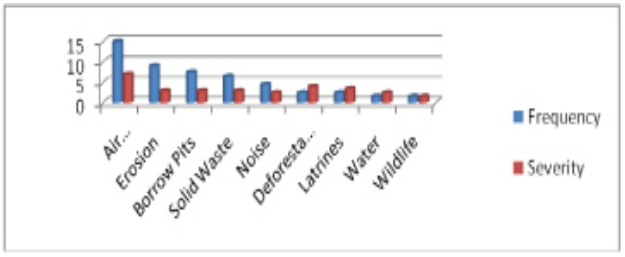


Figure 2.2: Environmental Issues in the Roads Sector

Source: National Roads Authority Action Plan for Environmental Management in the Roads Sector 2001

Figure 2.2 indicates that air pollution is the most important environmental impact derived from the sector initiatives and wildlife as the least important (NRA, 2001). Further to the action plan RA in 2008 developed its own generic environmental and social management guideline. Table 2.4 below outlines the major environmental and social impacts to be addressed.

Table 2.4: Environmental and Social Impacts in the Roads Sector

	Environmental Impacts	Social Impacts
1	Air related impacts	HIV and AIDS pandemic
2	Soil related Impacts	Traffic congestion
3	Borrow pits and quarry reinstatement	Theft and vandalism of road furniture
4	Solid waste disposal	Improper and inefficient signage
5	Noise disturbances	Public participation
6	Ecosystem disturbances	Dumping of construction materials
7	Sanitation	Aesthetics
8	Water quality degradation	Encroachment of road reserves
9	Landscape disturbances	
10	Community activity	
11	Displacement and resettlement	
12	Cultural heritage	
13	Human health and safety	

Source: RA – Environmental and Social Guidelines for the Roads sector

2.4. Enhancing Environmental Performance in the Construction Industry

Varnäs et al. (2009) identify EIAs and Environmental Management Systems (EMS) as the two most important tools to influence a project environmental management success. While EIAs may mainly be used for identifying environmental impacts, the EMS is more suited to managing environmental aspects (Gluch et al., 2005) However, Tse (2001) argues that implementing an EMS leads to less efficient production, and further argues that to successfully implement standardized EMS in the industry, collaboration between the governments, professional bodies and training institutions is very crucial. In addition, Tam and Le (2007) observed that there is no evidence regarding the effectiveness of EMS, and suggested that the best approach is the application of Environmental Performance Assessment (EPA) as a tool for making regular assessment on site. In defence for EMS, Varnäs et al. (2009) observe that although application of EIAs in Sweden is regulated by legislation and a lot of money and time is spent on the EIA process, the environmental commitment described in the EIA is not always fulfilled in project implementation. Varnäs et al. (2009) therefore argue for the requirement of EIA follow ups; and states that a proper EIA follow up gives the responsible actors the opportunity to take adequate measures to prevent negative environmental effects. It is recommended that several monitoring approaches, which range from simple monitoring techniques to more rigorous scientific monitoring approaches. Since EIA follow ups require human and financial resources, Ofori (2009) recommends that: "where there is legislation and regulations on environmental performance, there is requirement for licenses and approvals; subsidies, tax incentives and grants; certification and labelling of products; market forces - where the client will insist on better environmental performance; institutional initiatives. There should be professional bodies offering advice and support services to members; operational environment - there should be action from pressure groups and well informed users."

3.0 Research Methodology

The study adopted a quantitative research approach, through a census of road-works contractors. The method is appropriate for the study because it necessitated the collection of a large amount of data from a sizeable population sample in a highly economical way (Saunders et al. 2009). The sample was only confined to senior managers of the road construction firms who have been participating in road construction and maintenance activities with the RA.

3.1 Data Collection Method

A questionnaire instrument was designed for data collection. It had 38 questions based on the key variables from the reviewed literature and was divided into six parts. Part A focused on the general information of the organisation, part B focused on the level of legal knowledge of the organization, part C focused on the extent to which the organization strives to mitigate environmental impacts during project implementation, part D focused on the extent to which the organization tries to manage environmental aspects in its daily operations, part E focused on strategies to enhance environmental performance and part F focused on the challenges faced in trying to enhance environmental performance.

3.2 Definition of the Study Population

The sample population for the research was the firms who undertake road construction and maintenance activities for the RA. Currently the NCIC has 760 firms registered as civil engineering constructors in different categories. However, the RA procurement database has only 185 civil engineering construction firms which were active in the past 3 years. Thus the sample population was 185 firms which have been engaged in road maintenance and construction in the past 3 years.

3.5 Data analysis method

SPSS 11.5 statistical software was used to compute frequencies. Deductive reasoning was employed to arrive at conclusions in the final analysis.

3.6 Data analysis, findings and discussion

A self-administered questionnaire was sent to 108 contractors because it was getting difficult to get all the contractors to receive questionnaires given the timeframe for the study, randomly selected from the sample population of 185 contractors. 65 completed questionnaires were returned, representing a response rate of 60%. Saunders et al. (2009) argue that a response rate of 35% is acceptable.

4.0. Results

4.1 Availability of a Qualified Environmental Officer

Only 10.8% of contractors employed a qualified environmental officer as shown in Table 4.1. This is too low, because most projects were small to medium scale with little adverse environmental impacts and are not under the prescribed list of projects which require mandatory EIA studies. Furthermore, government funded maintenance

and rehabilitation projects make no provision for an environmental and H&S Officer as part of the key personnel on a project. This requirement is mostly enforced on donor funded projects

Table 4.1 Availability of Environmental Officer in terms of Registration categories

Registration Category	Yes – Response of total (%)	No – Response of total (%)
5 million (MK)	0	3.1
15 million (MK)	1.5	16.9
50 million (MK)	3.1	29.2
100 million (MK)	3.1	18.5
200 million (MK)	0	6.2
500 million (MK)	1.5	10.8
Over 500 million (MK)	1.5	4.6
Total (%)	10.8	89.2

4.2.5 Knowledge of Legal Requirements

Using a Likert Scale 1 to 4, where 1 represent lack of familiarity and 4 represents high levels of familiarity, the levels of knowledge and awareness of environmental laws and guidelines were analysed and presented in Table 4.2. The overall results indicate that 35.4% of contractors have limited or no knowledge at all about the relevant environmental laws and guidelines, whilst 36.9% have some knowledge, and the remaining 27.7% have high knowledge of these environmental laws and guidelines of Malawi.

Table 4.2: Registration category against level of legal knowledge

		Registration category							
Level of Knowledge	Average	5 million	15 million	50 million	100 million	200 million	500 Million	unlimited	% respondents
	High	2	2	7	5	3	3	2	36.9
	Average	0	2	6	6	0	2	2	27.7
	Low	2	8	8	3	1	3	0	35.4
Total		2	12	21	14	4	8	4	100

From Figure 4.1 shows the variations in knowledge with respect to different environmental regulatory instruments. Contractors are more aware of domestic than international instruments. 29.1% of the contractors are aware of the RA's environmental and social guidelines mainly due to the fact that the guidelines are available in all RA offices and are distributed free of charge to all contractors. A sensitization workshop was conducted prior to the launch of the guidelines which enabled many stakeholders to be aware of the guidelines.

Source: Author's field data,2011

Fig 4.1: Legal requirements and relevant guidelines

The low level of knowledge regarding ISO 14000 series can be attributed to the fact that ISO certification standards have not been adequately publicised and reinforced in the Malawian construction sector. Lack of awareness of the EMA, NEP and NEAP, may be accounted for by lack of knowledge dissemination to stakeholders. Sensitisation workshops are common for specific donor-driven projects as opposed to government initiative.

4.2.6 Mitigation of Environmental and Social Impacts on Projects.

Using a scale of 1 to 4 where 1 represents very low and 4 stands for very high impact perception, contractors are more concerned with the impact of HIV and AIDS than noise pollution project implementation. Fig 4.2 below presents the overall level of mitigation of individual impacts during project implementation as perceived by the contractors. Overall, HIV and AIDS has a higher level of mitigation at 16.7% followed by solid waste disposal at 15.1%, then deforestation at 15%, soil erosion at 15%, with water pollution 14.2%, then dust pollution at 13%, and the least is noise pollution at 11%.

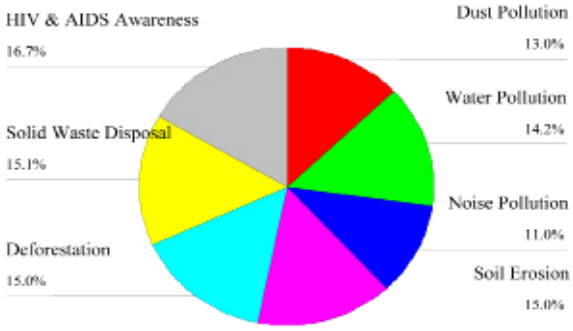


Fig 4.2: Extent of Mitigation of Impacts

The responses show that the issue of HIV and AIDS is taken seriously. The current rate of people living with HIV and AIDS in Malawi is 12.5% in the 15-49 years age group (NAC, 2010). It is understood that better mitigation efforts are in place against deforestation, soil erosion, and water pollution because of the measures government has taken to ensure that these natural resources are protected. Increased public awareness has made it possible for this improvement.

4.2.7 Management of Environmental Aspects

Figure 4.3 below shows how the different environmental aspects were rated by the contractors in terms of their level of managing them. It shows that H&S measures are rated highest at 21.4 % of all aspects. This is mainly due to the high prevalence of HIV and AIDS, which has affected the industry severely. Disposal of solid wastes realised a response rate of 20.5%. This is because mechanisms exist, especially in urban areas, for disposal of solid wastes. Municipal Councils manage and enforce compliance to the set bye-laws. Energy and fuel consumption have been rated at 18.3% and 16.7% respectively. This is due to the current energy crisis prevailing in the country. Electricity has been rationed since 2009 to date due to inadequate generating capacity (Malawi Government, 2010). In terms of fuel consumption the country has been experiencing fuel shortages since 2009, and consumers have been forced to optimize the usage of fuel.

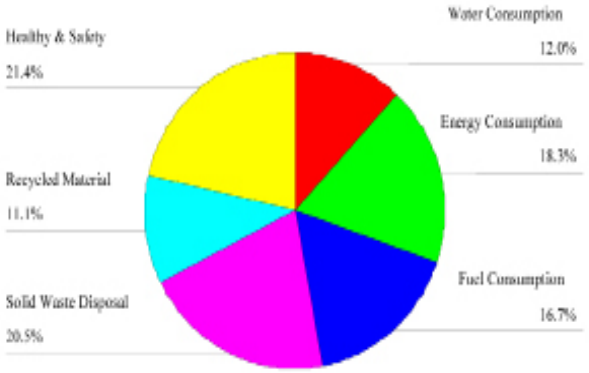
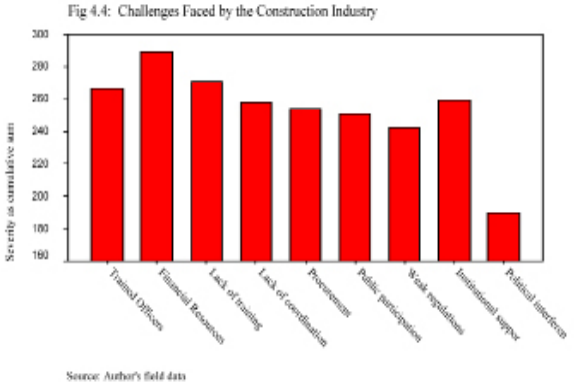


Fig 4.3: Extent of Management of aspect

Fig. 4.3 indicates that water consumption conservation has been rated at 12 %. This is mainly due to the fact that water is not a problem in the country. There are many available alternative sources. Not much effort has been put to sensitize people on the importance of conserving water. The same applies to usage of recycled materials especially paper as a means of managing environmental aspects of solid waste disposal.



4.2.8 Challenges Faced by the Construction Industry in Environmental Management

Figure 4.4 above summarises the challenges: lack of financial resources to effectively carry out environmental management measures is ranked first; lack of training of construction staff to understand environmental issues during project implementation is ranked second; whilst lack of well trained environmental officers is ranked third; lack of institutional support from organizations responsible for environmental management compliance is ranked fourth; environmental issues are not clearly outlined by the client during project procurement is ranked fifth; ranked sixth is poor general public participation during project implementation which sometimes to lead to frictions with the project implementation team; weak regulations which creates loopholes from which non compliance is never penalized, and finally political interference is ranked the last.

4.2.9 Measures to Enhance Environmental Performance

To enhance environmental performance some mitigating measures need to be taken. Contractors were asked to rate measures according to the level of effectiveness they attach to each intervention. Most contractors have faith in systematic monitoring and behavioural change management among staff and communities as the most effective interventions strategies as shown in figure 4.5 below:

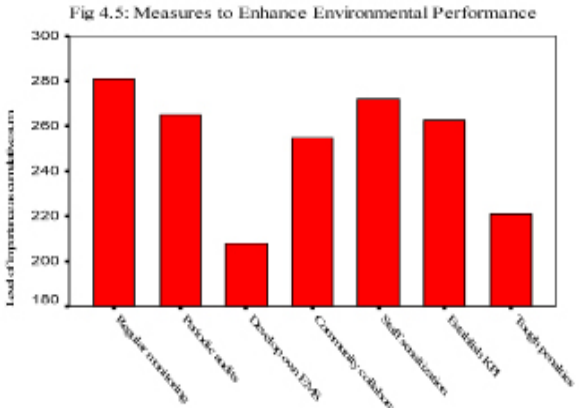


Fig 4.5: Measures to Enhance Envionmental perfomance

Figure 4.5 above summarised the measures as follows: regular monitoring of project sites by the relevant authorities; conducting periodic environmental audits to ensure compliance; conducting sensitisation workshops to both the project staff and the surrounding communities; developing key performance indicators to create a benchmark for assessing level of compliance; closer community participation; application of stiff penalties for non-compliance, and contractors should develop their own EMS. Application of stiff penalties and development of EMS have been ranked the least mainly because it involves costs to the contractors, while the rest of the measures will be costs to the contracting authorities.

5.1 Summary of key findings

The industry is characterised by mostly small to medium scale contractors with average experience in the industry of 12 years. Only 10 % of the sampled contractors indicated that they employ a qualified environmental officer. The level of environmental legal knowledge amongst respondents is low. However, contractors have better knowledge of RA environmental and social guidelines unlike ISO 14000 certifications. The majority of respondents undertaker activities which do not fall under the prescribed list of projects which require mandatory EIA study. Despite the lack of EIA studies on small and medium scale projects mitigation of impacts is done following the guidelines produced by the RA and is distributed to all contractors in the construction industry free of charge. Current social economic activities have forced the construction industry to manage some environmental aspects like optimal consumption of energy and fuel due to power shortage and scarcity of fuel in the country. The HIV and AIDS pandemic has affected the sector very hard and everybody is taking drastic measures to contain the pandemic. All these measures are taken without contractors establishing environmental management systems or having a formal environmental policy. Lack of financial resources and lack of training of the construction staff are the major challenges facing the construction industry in enhancing environmental performance. In addition, environmental performance can be enhanced if better mechanisms for monitoring of environmental management can be put in place, conducting periodic environmental audits to ensure compliance and if key performance indicators can be developed which can be used as the benchmark for measuring environmental performance.

5.2 Conclusion

There is limited knowledge among contractors on environmental laws and guidelines in the industry. However, mitigation of impacts and managing environmental issues during project implementation the industry is performing well. Therefore, it is concluded that the industry is influencing positively in enhancing environmental performance. Development of key performance indicators may give quantitative data which can be used as a benchmark for measuring environmental performance. The constraints faced include; lack of financial resources, lack of environmental management training, lack of well trained environmental officers; lack of institutional support for environmental issues; procurement of works contracts do not take into costs incurred during mitigating environmental impacts; review of current legislation can address most of the challenges faced. In order to enhance environmental performance there is need to: improve monitoring mechanisms by relevant authorities; conducting periodic environmental audits to check on compliance; conducting sensitisation workshops; establishing key performance indicators; closer collaboration with the communities; application of stiff penalties for non compliance, and review of current legislation on environmental management.

5.3 Recommendations

It is recommended that the government should review the current legislation and address all the gaps which are in the current Act. This calls for stiffer penalties for environmental offenders. In addition penalties should be reinforced and pegged in US$ dollars. Non complying projects should be heavily fined to instil discipline. Projects which do not follow the prescribed list for mandatory EIA should have an Environmental Assessment carried out. There is need to develop key performance indicators for the industry. These will be used as a benchmark for measuring of environmental performance. EIA studies should be carried out by an independent consultant without the input from the design consultant. The client should ensure that the project should compensate all the costs associated with mitigation of environmental impacts. The project costs should include training for environment, health and safety issues. Sensitisation workshops should be carried out regularly and the communities surrounding the projects. Closer collaboration with the communities should be encouraged with the right channels of presenting grievances. Awareness of the need to have an environmental policy and develop individual environmental management systems should be encouraged. Green procurement should be encouraged where eco-friendly construction materials should be used on all projects.

5.4 Further Study

Future studies should be directed towards finding-out how each of the key stakeholders individually influences environmental performance. In addition how stakeholder as a group influence environmental performance. Doing a case study on an individual project would be ideal for a start up.

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The Emerging Environmental Health Risks and Challenges for Tomorrow: Prospects for Malawi

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Abstract

This paper gives an overview of the current and emerging environmental health risks and the projected challenges for the future. The aim is to create awareness and incite debate among Environmental Health Professionals on solutions for the risks and challenges as they celebrate the "World Environmental Health Day" to be held on 26th September, 2013. Internet search using key words and expert knowledge was used to come up with risks and challenges. The environmental health risks have been classified according to the five pillars of environmental health with climate change risks and challenges cutting across all the pillars. These include emerging risks and future challenges related to food consumption, pollution of water resources, air and soil, use of electronic products and electronic waste, poor sanitation, poor housing and those arising from peoples' occupation. If not controlled, these risks and challenges may result into increased prevalence of accidents, injuries, communicable and non-communicable diseases. We propose partnerships, stronger political will, innovations and research as key factors in solving such problems.

1.0 Introduction

According to the World Health Organization (WHO), environmental health addresses all environmental (physical, chemical and biological) factors external to a person, and all the related factors impacting behaviours. It encompasses the assessment and control of those environmental factors that can potentially affect health and is targeted towards preventing diseases and creating health-supportive environments (WHO | Environmental Health n.d.). While most countries, especially those in the developing world like Malawi, are still struggling to address the existing environmental health problems, new challenges and risks are emerging which require complex solutions. Advances in technology, population growth, changes in standard of living, increase in industrialization, climate change, globalization and microbial evolution are some of the factors that lead to emergence of challenges in environmental health (Aluwong and Bello 2010). Emerging risks and challenges are those that are coming into existence because of changes in the environment. We present these factors according to the five pillars of environmental health. These pillars include: community health, environmental pollution control, built environment, occupational health and food safety and hygiene (FSH). While these will be discussed, attention will also be given to how issues surrounding these pillars are being affected by climate change.

2.0 Methods

Relevant literature was searched from environmental health journals, Government policy documents, Malawi Government website, general internet search using keywords and websites for Non-Governmental Organizations and from unpublished literature from other Organisations in Malawi. Information was also gathered through consultations with experts in the field of environmental health, environmental science and engineering. References from key articles retrieved were also searched and analyzed. The search was repeated every week for a period of four weeks. Retrieved literature was grouped according to the environmental health pillars. Inclusion of articles and expert information was based on relevance to the topic under discussion. Reports and articles written in other languages other than English were not included.

3.0 Community Health

Under community health, we discuss the current, emerging and future risks and challenges relating to communicable and non-communicable diseases, epidemiology, health promotion and water, sanitation and hygiene.

3.1 Disease Control

"Emerging infections can be defined as those that have newly appeared in a population or have existed previously but are rapidly increasing in incidence or geographic range" (Morens, Folkers, and Fauci 2004). Currently, Malawi faces a double burden of both communicable and non-communicable diseases (Ministry of Health and World Health Organisation 2010) in the sense that while prevalence of communicable diseases is still high i.e. malaria related fever at 35% and diarrhea at 17.5% in the under-five children and 10.6% prevalence of HIV among those aged 15 to 49 years (National Statistical Office and ICF Marco 2010), the risks relating to non-communicable diseases are also high. A recent study showed that at least one in four men smoke tobacco, one in five people drink alcohol excessively and at least one in four women is overweight (Msyamboza et al. 2011). It also showed that a third (32.9%) of the adult population aged 25–64 years had raised blood pressure or were on antihypertensive medication, 5.6% had raised fasting blood glucose or were on medication and 8.7% had raised cholesterol (Msyamboza et al. 2011). The prevalence of diabetes was estimated at 5.6%, while injuries, other than road traffic accidents, were at 8.9%. The prevalence of cardiovascular diseases was 8.9% and that of asthma was 5.1%. The prevalence of road traffic accidents was estimated at 3.5% (Ministry of Health and World Health Organisation 2010). As for children, the environmental diseases in developing countries including Malawi are aggravated by poverty, malnutrition and adverse social condition. These children are faced with both traditional and modern environmental health challenges (Pronczuk, Bruné, and Gore 2011). Figure 1 below gives an estimated of the burden of non-communicable diseases including injuries as compared to communicable diseases (Ministry of Health and World Health Organisation 2010).

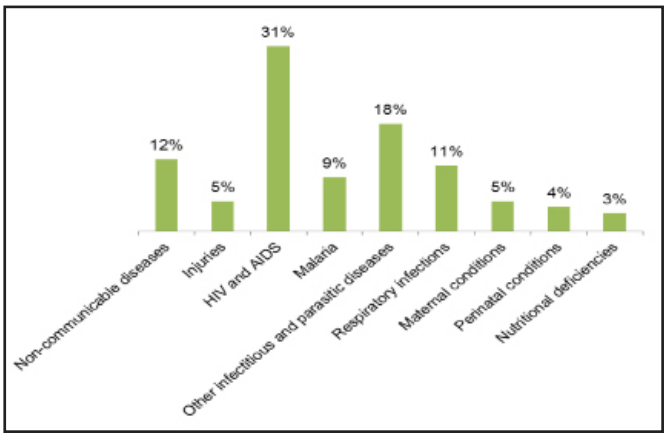

Figure 1: Estimated Disability Adjusted Life Years by cause for Malawi (Source: Malawi STEPS Survey Report, 2009)

It can be observed from evidence above that Malawi is facing a double epidemic of communicable and non-communicable diseases. The risks associated with communicable diseases include inadequate safe water, sanitation and hygiene especially in rural and peri-urban areas (including institutions like schools and other public places), poor adoption of safe health behaviours (e.g. sleeping under treated mosquito nets, treating unsafe water, participating in immunizations and mass drug administration exercises), poor housing conditions, poverty and poor access to basic health information and facilities. The high burden of non-communicable diseases is partly due to increased drug and alcohol addiction, smoking, bad eating habits, poor food choices, pollution and environmental exposures. While these risks are already in existence, we observe that more are emerging including deforestation which will lead to reduction of quantities and pollution of water in water bodies, overcrowding, extreme temperatures due to climate change, pollutants from industries, use of genetic products and radiation from electronic products. Therefore, there is need for preparedness on how to tackle such risks.

The World Health Organization observed that diseases like dengue, leishmaniasis and African trypanosomiasis are serious in Africa but lack effective control measures. Due to such unsustainable control measures, the prevalence of dengue is expected to increase due to increase in urbanization which increases contact between Aedes aegypti mosquito, the vector, and human beings. For other diseases with a vector of low reproductive rate like leishmaniasis, the prospects for sustainable control measures seem to be promising (Cattand et al. 2006). For malaria control, despite significant progress in distribution of insecticide treated nets, access to intermittent preventive treatment for pregnant mothers and indoorresidual spraying, the prevalence remains high especially among the poor (Mathanga and Bowie 2007). The main challenges have been lack of integration of control strategies with environmental management and inaccessibility of control strategies by the poor population (Mathanga and Bowie 2007). For Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS), the prevalence is stabilizing which shows less people are being infected (National Statistical Office and ICF Marco 2010). There are several strategies that might have led to the decline including condom use, behaviour change, prevention of mother to child transmission, antiretroviral therapy and voluntary male medical circumcision (VMMC). Up to now, it is not clear as to which strategy is contributing the most to the decline of HIV prevalence. The effectiveness of VMMC, which is less effective than the existing condom use, will need to be investigated in light of other existing strategies. Despite the advantages of VMMC being widely known, less knowledge is available on the disadvantages (WHO | Voluntary Medical Male Circumcision for HIV Prevention n.d.), hence need for further research.

Control of diseases through health promotion will be challenged by technology where information leading to poor health and that which promotes health is available on the internet and issues like high cost of healthy foods, confusing food labels and others (Temple 2007). Technology will reduce the need for people to work as a group and the need to gather as a result there will be need to empower people on how to choose the right information. Despite the emerging challenges, some of the strategies have not been extensively tested like the healthy settings as highlighted in the Health Sector Strategic Plan by Ministry of Health (Malawi Government 2011). Those doing epidemiological studies will also be challenged by complex risk factors. It will be difficult to know the risk factors as they will become complex due to vast use of chemicals and modified products. There will be need for complex epidemiological methods to determine risk factors for ill health in the society.

3.2 Water, Sanitation and Hygiene

Water supply, sanitation and hygiene mostly affect children and women living in rural and peri-urban areas of the country. People travel long distances to access water and in most cases the water sources are contaminated with chemical, physical and biological contaminants. These contaminants arise from unplanned settlements and associated poor sanitary conditions, as well as improper disposal of waste. The other sources are human settlements established in river catchment areas mainly because many households either do not have latrines or general waste disposal facilities. There is also discharge of inadequately treated sewage from some institutions into rivers and streams. Lack of authority to control sanitary installations and of maintenance of sewer reticulation networks have led to overflow of septic tanks and sewers. On this pillar we discuss emerging environmental health risks and challenges relating to access to safe water, rural and peri-urban sanitation, urban sanitation, environmental pollution and hygiene.

3.2.1 Access to safe water

It is estimated that access to improved water sources is at around 78% of the population for the rural and 92% of the population for the urban areas (National Statistical Office and ICF Marco 2010). Though the coverage seem to be very high, it is important to note that most of the Malawians (85%) live in rural areas (National Statistical Office 2008) where water is collected from communal water points and then transported to homes through various means and vessels. Water is not normally used directly upon reaching the households. Water is stored for a period ranging from few hours to several days. This is also the case with households that do not have regular water supply despite having in-house pipe connections. If not handled properly, water will get re-contaminated during collection, transportation and storage. Stored water can become unsafe when it is touched by people with dirty hands, when it is poured into a dirty container, when dirt or dust gets in the water, and when

dirty cups are put into it. This fact necessitates inclusion of point of use treatment in order to holistically deal with water borne diseases. Another important area to note on water supply is the management of the water point. Waste water from water points needs to be taken care of in order to avoid breeding of mosquitoes as part of Malaria control and avoid contamination of groundwater through seepage.

3.2.2 Hygiene

Hygiene coverage is the lowest as compared to water supply and sanitation. Hygiene is an important factor on transmission of diseases despite having hardware components like latrines and boreholes or taps. Most diarrhoeal and parasitic diseases are due to lack of hygiene. Currently, interventions are focusing much on water supply and sanitation while losing focus on hygiene. This will lead to increase faecal-oral diseases despite increase sanitation and improved water sources. It is encouraging to see increased funding from international organizations and local Non-Governmental Organizations (NGOs) directed towards water supply, sanitation and hygiene with a focus on sanitation. Despite the increased funding, there is still lack of coordination and integration between NGOs and government departments especially on strategies used for implementation of projects. Currently, the Government of Malawi is advocating for community led approaches in implementing its projects. We would therefore like to agree with the conclusions that any meaningful development in low income countries requires strategies which promotes research and takes into account local realities over and above global priorities (Konteh 2009; Moe and Rheingans 2006).

4.0 Environmental Pollution Control

Environmental pollution can be effectively controlled in people in both rural and urban areas are properly using toilets and also properly managing their solid and waste water. It also included prevention of air and soil pollution.

4.1 Rural and Peri-Urban Sanitation

It is well known that only 8.8% of the population in Malawi have access to improved faecal disposal facilities (National Statistical Office and ICF Marco 2010). Most of the households (60%) use basic sanitation facilities while 8% of the households do not have any form of faecal disposal facilities meaning they defecate in the open. Open defecation exposes the rest of the population to excreta related diseases like diarrheal and helminthic diseases. Most public places including schools and markets do not have adequate faecal disposal facilities putting all children, patrons and surrounding communities at risk of related illnesses.

Some of the complications in making progress on rural and peri-urban sanitation are depletion of natural resources that is making suitable construction materials to be scarce and unstable soil conditions in other parts of the country causing frequent facility collapses. As deforestation continues to occur due to increases population, addressing sanitation problems will be more challenging as the majority of the nation relies on pit latrines whose floor is supported by logs. The current ecological sanitation latrines like the arbor loos, skyloos and forsa artenna are come as a solution to the problem but their uptake is low due to perceived risks and cultural issues related to handling and use of human faecal sludge (Morgan and Mekonnen 2013). The low uptake to technologies, including the community led total sanitation approach, and lack of proper evaluation mechanisms poses a new challenge to environmental health professionals. The low uptake means the technologies have been brought into use with little awareness, knowledge and acceptance of the intended population.

4.2 Urban Sanitation

The risks and challenges related to environmental pollution in urban areas include those related to liquid waste management, solid waste management and outdoor air pollution. The sewage system breakdown in the cities of Blantyre and Lilongwe and to a lesser extent, Zomba is the major causes of water resources pollution. The causes of breakdown include vandalism of pipes, vandalism of pillars that support pipes, high load for pipes, old pipes which have outlived their design life; and lack of knowledge and carelessness on what to throw in a water closet latrine. The other causes include disposal of general and industrial waste into the rivers, sand mining, farming along the catchment area and defaecation along the river banks. The most affected are the poor people who use the stream waters for domestic uses in the cities and downstream while the lesser affected are urban dwellers who buy vegetables and other products grown and/or washed by this polluted water. Despite such existing problems, it is expected that without overhauling the system and putting in place integrated pollution measures, we expect more pollution of water resources. These will lead to more and new diseases associated with pollution water.

Figure 2: Polluted Mudi River (Picture by Save Kumwenda)

Improper solid waste management in the cities and district councils leads to environmental pollution and contributes to pollution of water bodies as well. The emerging risks from solid waste are mainly due to nature of the waste. Hazardous wastes may be inflammable, corrosive, explosive, toxic, mutagenic, carcinogenic and eco-toxic. They pollute water and diminish public health safety when improperly managed. They are highly corrosive and a potential threat to public sewers. Discharging them into waterways means pollution of drinking water and threats to aquatic life. Disposal of hazardous wastes on land renders arable land unsuitable for farming and destroys vegetation. The waste from electronic products like computers, computer batteries, phones and their batteries, though less researched in Malawi, seem to be more dangerous as they contain chemicals that are reactive in nature. Donations of used electronic equipment that have no value are likely to encourage Malawi to be a dumping site for such waste. Other common types of wastes include plastics, used airtime vouchers, diapers and other sanitary waste for babies. The most affected include scavengers at dumping sites, people living around dumping sites, market users and waste collectors in City and District Councils. The general public is affected if the waste contaminates

the soil and ground water. Every year thousands of tons of industrial wastes are discarded and the quantity, complexity and toxicity is increasing.

Solid waste management is also a major concern especially in the peri-urban areas and trading centers across the country. The most serious problem in relation to solid waste management is that most of the peri-urban areas are unplanned as such they are not serviced by the districts and city councils. The current situation in Malawi is that almost all districts and city councils do not have proper refuse disposal systems in place. Their disposal systems are indiscriminate and serious hazard to public health as they are breeding paradise of vectors and sources of water contamination.

Figure 3: Solid waste in a skip (Picture by Save Kumwenda)

4.3 Air and Soil Pollution

Air pollution is mainly a result of industries producing fumes, car exhaust fumes, smoke and dust that are released into the atmosphere (Ostro B. 2004). The increasing number of vehicles in Malawi is posing a threat to air pollution just like in other countries (Slezakova, Morais, and Carmo Pereir 2012). The particles in air are later inhaled by people and may affect their health depending on the nature of the particulate matter therein and the personal factors. In rural areas, the major sources of air pollution include bush fires and indoor burning of wood fuel (Fullerton et al. 2009). Air pollution also arises from construction, quarrying and coal mining activities. With the increased scope of these activities, air pollution could be a serious problem especially in nearby areas. In rural areas, the increasing use of artificial fertilizers and pesticides are the major causes of water resources pollution. The pollutants affect people who use these waters. They also help insect vectors that breed in the rivers i.e. mosquitoes and black flies to develop drug resistance because of pre-exposure to chemicals (Poupardin et al. 2012). We expect high resistance of mosquitoes to indoor residual spraying chemicals and those used as larvicides for black flies due to pollution of river waters and other water resources. Cancer related diseases will also increase because of overuse of chemicals.

5.0 Occupational health and safety

Under this pillar, our concern is on the workplace, people who work there, the visitors and the general population. People at workplaces are at risk of diseases and injuries due to unsafe working environments. Occupational diseases are those that workers get as a result of exposure in their work places. Occupational health and safety deals not only with health and safety of people in the work place but also visitors, customers and also the general public by making sure the activities from work places or industries do not affect the environment. It looks at the health and safety of people who happen to visit places like shops, hotels, stadia, play grounds, restaurants and many other places. These places have to guarantee safety of the patrons in terms of accident and disease prevention. The safety issues include dangerous equipment, poor room conditions and physical hazards including fire, light, sound radiation and extreme temperatures. Although data on the exposure levels and prevalence of occupational diseases are not available in Malawi, several diseases are known to occur as a consequence of hazardous work environments. The occupational health risks are common in mines and industries. The Department of Occupational Health and Safety in the Ministry of Labour carries out routine factory inspection of all factory premises in Malawi with the aim of improving the working conditions. However, the frequency and extent of the inspections are hampered by lack of and inadequately trained personnel and financial resources. Lack of proper inspections by Safety, Health and Environment Officers in workplaces leads to companies putting the health of their workers at risk and polluting the environment. If not properly checked, the Government will continue losing scarce resources towards treating diseases that are due to ones' occupation and also as a result of pollution from industries and mines. There is need for collaborative effort by The Ministry of Labour and Ministry of Health to overcome the labour shortage in implementing the Occupational Safety, Health and Welfare Act of 1997. There is need for revision of the Act to include current and emerging challenges. The Government of Malawi and other governments in similar situations need to exert more pressure on workplaces (Joubert 2002) to comply to existing healthy and safety regulations and in order to reduce the impact of occupational health and safety issues on the health of people.

The current weaknesses in the current system of implementing occupational health and safety systems include the weak management system, failure to run basic occupational health services effectively and lack of equipment and enforceable standards (Bernard 2011).

6.0 Built environment

Housing conditions in Malawi are generally poor. The population and housing census of 2008 indicated that on average, 21% of the houses were permanent, half of the households in rural areas were temporary and 75% of the households had mud floors (National Statistical Office 2008). It was also observed that 38% of houses used either burnt or unburnt bricks for walls while the main source of energy for lighting was paraffin (85%) and that for cooking was firewood (87%) followed by charcoal at 8.5% and electricity at 2% (National Statistical Office 2008). It is expected that both rural household and the shortage for rural housing will double in the next 10 - 15 years. The demand for shelter and housing in peri-urban areas is expected to rise due to population growth and migration. This will lead to over-crowding in existing traditional housing and peri-urban areas. There is also a problem of unplanned construction of substandard houses. The dwelling units lack basic infrastructures and services such as roads, electrical and water supply and wastewater disposal systems.

Emerging environmental health risks in the built environment include the increased respiratory infections and diseases due to high reliance on wood for cooking and use of paraffin

for lighting. The problems are exacerbated by people's behaviours like cooking in structures with poor ventilation and with under-five children at their backs. It is also common to find households where family members share the dwellings with livestock for the fear of losing them to theft. The other challenges on housing include poor structures with no windows or small windows in the wrong place. This results to poor ventilation which promotes transmission of diseases like tuberculosis.

7.0 Food Safety and Hygiene

Food safety and hygiene is of immediate concern based on awareness and perceived issues with genetically modified foods, the use of cloned animals as food sources and the risk for new dietary allergens, eating habits and microbial contamination of foods. Other issues viewed as falling within this broad topic are the re-evaluation of food additives and other chemicals, food quantity and sources, patterns of food consumption and the distribution of food, the regulation of botanical products, the adulteration of food ingredients and possible chemical contamination (FAO and WHO 2005; Rheinlander et al. 2008).

There is little evidence on the health effects of genetically modified foods. We expect more challenges associated with genetic modification in future as these are not currently monitored. The high consumption rates of only processed foods where several chemicals have been added as preservatives and colourants or flavourings plus the fertilizers and pesticides in the fields put consumers at risk of cancers and skin diseases. The high consumption rates of sugars and oils means that diabetes prevalence will continue to increase and will also affect school going children. The low surveillance of restaurants and informal sector on food hygiene means an increasing prevalence of foodborne diseases. The increase in street vended foods presents a new public health challenge as most vendors do not practice safe food hygiene practices hence putting consumers at risk of diarrhoeal diseases (Rheinlander et al. 2008).

On emerging risks relating to meat safety, there are more emerging animal related diseases partly due to changes in lifestyles and climate change which leads to emergence of new disease causing agents. The other risks include consumption of meat or its products not consumed before i.e. dog and horse meat due to illegal business leads to new diseases, globalization of trade, increased movement of animals among other factors. T

It is estimated that over 70% of diseases affecting man in the past ten years originated from animals or animal products (Aluwong and Bello 2010). About 60% of these diseases are zoonotic and include Swine flu (H1N1), avian influenza, severe acute respiratory syndrome (SARS), Ebola haemorrhagic fever and others implicate Human Immune Deficiency Virus which leads to Acquired Immunodeficiency syndrome (Aluwong and Bello 2010). These diseases may not be in existence in Malawi, but once they occur in other countries pose a threat to the country and leads to use of scarce resources in getting prepared for them. There is need for environmental health officers to work together with other stakeholders including veterinary department to sensitize people on risks from animal-human interaction and develop a joint program that will make sure that all meat sold in both formal and informal markets is inspected.

8.0 Climate change

The effects of climate change are felt across all the pillars of environmental health. Climate change is defined as any significant variation in temperature, precipitation, wind, or other type of weather that lasts for decades or longer (Centre for Disease Control 2013a). Over the last 50 years, human activities have released sufficient quantities of carbon dioxide and other greenhouse gases to trap additional heat in the lower atmosphere and affect the global climate (World Health Organization 2012). Evidence suggests that the world's climate is becoming warmer, increasing the potential for extreme weather events around the world (Centre for Disease Control 2013a; World Health Organization 2012). The challenge to climate change remains poor enforcement of both local and international legislation on factors that contribute to climate change including environmental pollution and use of local methods of cultivation (Malawi Government 2013; Thomas, Seager, and Mathee 2002).

If not controlled, the effects of climate change will be a major contributor to the emerging environmental health risks and challenges for tomorrow in most countries in the world (Murad and Pereira 2011). In Malawi, the current environmental health challenges that are closely linked to climate change and these include: lack of sanitation to those affected by floods, diarrhoeal and parasitic diseases due pollution caused by flooding, increased insect vectors (i.e. mosquitoes, cockroaches, flies etc.) due to increased temperatures, droughts and extreme temperatures. The floods destroy food stocks, livestock and other property leaving families in hunger and poverty which leads to high prevalence of malnutrition in the under-five children. It is more likely that flood, rather than drought, would lead to more mosquitoes which will lead to high prevalence of like malaria, dengue, yellow fever, etc. The other effects of climate change include production and allergenicity of aeroallergens such as pollen and mold spores and increases in regional ambient concentrations of ozone, fine particles, and dust. This leads to increased respiratory diseases such as asthma (Centre for Disease Control 2013b).

We anticipate more and complex environmental health challenges relating to climate change because the increasing population will still have a negative impact on the environment. Below are pictures of floods and drought in Malawi.

Figure 3: Drought Zomba, Malawi (Picture by Elizabeth Chingayipe)

9.0 Conclusion

The issues discussed above are just a few of the current and emerging environmental health risks and challenges that Malawi is facing. Environmental health professionals need to be aware of them and create a holistic approach involving all stakeholders to effectively combat them. There is need for all sectors to play their role in order to sustainably control environmental health risks.

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The Malawi Bureau of Standards

The National Standards Body (NSB) in Malawi is The Malawi Bureau of Standards (MBS). MBS is a statutory organization established in 1972 by an Act of Parliament (Cap 51:02) of the Laws of Malawi. The MBS is governed by a Board of Directors (Malawi Standards Board) which is appointed by Government. It is the policy-making body for supervising and controlling the administration and financial management (governance issues) of the MBS.

The Director General is the Chief Executive Officer responsible for the day-to-day administration of the MBS within the broad guidelines formulated by the Malawi Standards Board.

The functions of the MBS are undertaken by five departments as follows:

1. Finance and Administration Department – Responsible for the financial and administrative matters.
2. Standards Development Department – Responsible for the development of Malawi standards and the dissemination of standards and standards related information.
3. Quality Assurance Services Department – Responsible for the implementation of standards through inspection and certification services.
4. Technical Services Department – Provides testing services for product certification services as well as testing of client samples from the industry and the general public.
5. Metrology Services Department – Provides verification and inspection services as well calibration services.

The MBS Act outlines the following objectives which have to be executed by the organization in order to fulfil its mandate:

1. To promote standardization in industry and commerce;
2. To prepare, frame, modify or amend specifications and codes of practice;
3. To recommend the adoption in whole or in part, with or without amendment, of any specification or code of practice;
4. To make arrangements or provide facilities for the testing and calibration of precision instruments, gauges and scientific apparatus for the determination of their degree of accuracy by comparison with standards approved by the Minister on the recommendation of the Board, and for issue of certificates in regard thereto;
5. To make arrangements or provide facilities for the examination and testing of commodities and any material or substance from or with which they may be manufactured, produced processed or treated, and of the manner in which this may be done;
6. To control, in accordance with provisions of the Act, the use of standardization marks and distinctive marks;
7. To encourage or undertake educational work in connection with standardization;
8. To provide for co-operation with any person, association or organization outside Malawi having objectives similar to those of the Malawi Bureau of Standards;
9. To frame, amend or substitute draft building regulations for the benefit of local authorities;
10. To provide for co-operation with the representatives of any branch of industry, ministry, government department, local authority or any statutory corporation or with any person with a view to bringing about standardization in connection with commodities;
11. To provide for the testing of locally manufactured or imported commodities with a view to determining whether such commodities comply with the provisions of the Standardization Act or any other law relating to st

The role of NCST towards the development and application of STI in Malawi

1.0 Introduction

Government of Malawi established the National Commission for Science and Technology as provided for in the Science and Technology Act (No. 16 of 2003) to advise Government and other stakeholders on all matters related to science and technology in order to achieve a science and technology-led development. It was instituted on 14th November 2008 following a Gazette notice of 20th February 2009. The Commission started full operations in 2010 following the employment of the Director General in December 2009.

2.0 Programmes of the NCST

In order to implement the legal provision espoused in the Science and Technology Act (2003), the NCST is executing programmes in the following strategic areas: Research and Development and Technology Transfer; Information and Knowledge Management; Planning, Monitoring and Evaluation; and Resource Mobilization.

2.1 Research and Development (R&D)

R&D is at the centre of human civilization and advancement. Significant developments that have been made in the natural and social sectors have largely been attributed to research and development. The NCST's efforts are therefore focused on promoting, supporting, coordinating and regulating R&D in the country through the following programmes.

2.1.1 Development of National Research Agenda programmes

The NCST is promoting the development of national research agenda for different sectors of the economy. The overall goal of the National Research Agenda is to guide researchers, policy makers, program implementers, academic institutions, development partners and other stakeholders on research priorities for Malawi. For instance the commission spearheaded the developed of the national health research agenda which was launched in 2012, a national research agenda for engineering, design, industry and energy sector which is in the final stages and has initiated the development of a research agenda for the agriculture and the natural sciences sector. NCST will soon initiate the development of a research agenda in the ICT sector.

2.1.2 Biotechnology and Biosafety Programme

A growing number of countries and research institutions are now undertaking research in modern biotechnology because of the realization that application of traditional biotechnology has limited benefits in the wake of rapid population growth and emergence of new challenges such as climate change, drug resistant diseases and globalization. Malawi is one of the few countries in Africa that have started doing research in Biotechnology. The first Confined Field Trial (CFT) started in January 2013 having developed a Biotechnology and Biosafety regulatory system. The CFT involved Bt cotton and was conducted at Bunda College of Agriculture of the Lilongwe University of Agriculture and Natural Resources (LUANAR). This is a technological breakthrough since only a few countries in Africa have fully adopted biotech crops. The Program for Biosafety Systems (PBS) which is based in USA supported the development of the regulatory system and the CFTs in Malawi through the NCST.

2.1.3 Engineering, Design, Industry and Energy Programmes

Engineering, industrial and energy research plays an important role in development of new technologies and adaption of technologies to suit local conditions. One of the programmes the NCST is currently pursuing is the Malawi Ethanol. The Programme resulted from the Ethanol Driven Vehicle Project (EDVP) which was initiated in 2006 to assess the use of ethanol as an alternative vehicle fuel to petrol in Malawi. The project was a direct response to a Cabinet directive made in 2004 that Malawi should explore other sources of fuel for vehicles. The use of locally produced ethanol could replace a certain proportion of petrol imported resulting in savings in foreign exchange, reduce the reliance on imported petroleum fuel, contribute to fuel price stability, reduce vehicle running costs, growth of agriculture sector and poverty alleviation. The project was first implemented by the then Department of Science and Technology under the Ministry of Education, Science and Technology and from July 2010 the project was taken over by the National Commission for Science and Technology (NCST). The project was implemented in collaboration with Lilongwe Technical College, Ethanol Company Limited, Malawi Energy Regulatory Authority, Plant and Vehicle Hire Organisation and Malawi Bureau of Standards. The project was successfully completed in 2011 and following Cabinet approval of the recommendations of the research project in 2012; the country is now geared up to roll-out the Malawi Ethanol Programme to be implemented under the leadership of the Ministry of Energy.

2.1.4 Health, Social Sciences and Humanities programmes

NCST is also focusing on R&D programmes in health, social sciences and humanities. Implementation of programmes

in this area centers on development and review of national research guidelines and ethical procedures, regulations and standards; R&D promotion and support; capacity building; and many others as determined by stakeholders needs. The programmes include:

i. The Health Research Capacity Strengthening Initiative (HRCSI)

HRCSI is one of the programmes that the Commission is implementing in this area. It is aimed at building and strengthening health research capacity in Malawi. It is a 5 year (2008-2013) programme being implemented by the NCST. It is jointly funded to the tune of £10 million by the UK-DFID and the Wellcome Trust each contributing 50% of the funding.

The four anticipated key outputs of the programme are;

- Enhanced institutional capacity for research
- Evidence-based policy and programme formulation
- Effective sharing of scientific knowledge
- Improved regulation and coordination of national health research

The programme is now in its final year of implementation. However, a number of achievements have been registered. HRCSI has so far offered 18 small grants, 10 internships, 21 research grants, 590 undergraduate research grants and 47 training fellowships for post graduate training (16 PhDs and 31 MSc.) in various health related fields such as basic sciences, clinical to social sciences including medical anthropology. At institutional level HRCSI has offered 10 institutional grants for infrastructure development in the form of systems, laboratory and ICT equipment.

ii. Traditional Medicine Research (TRAMED) Programme

The NCST is also implementing a Traditional Medicine Research (TRAMED) Project with Bunda College of Agriculture, Chancellor College, College of Medicine, Forestry Research Institute of Malawi, National Herbarium and Botanic Gardens of Malawi, and MTHUO as collaborating institutions. It is being funded by the National AIDS Commission (NAC) to the tune of K K178 million. The overall objective of the project is to promote research and development in traditional medicine with particular reference to HIV and AIDS and related opportunistic infections. Activities for the research programme include a survey of knowledge in traditional medicine; preparation of test medicines and products; selection of best bet plants used against HIV/AIDS and opportunistic infections; clinical trials; positive identification of active principles and their enhancement; product development, patenting, registration and marketing; and bio-conservation and procurement of capital assets. The project started in 2008 and the main focus up to 2013 was on the procurement of capital assets which included computers, high-tech laboratory equipment and machines and vehicles (2). The project is now set to start laboratory based activities.

2.1.5 Regulatory Framework

Effective implementation of STI programmes among others requires a well defined regulatory framework. For this reason, the NCST through its standing committees is developing and reviewing guidelines and procedures for the conduct of research in Malawi in various fields including health, social sciences and humanities; energy, industry and engineering in Malawi; agriculture and natural sciences; and ICT.

2.1.6 Technology Transfer programmes

There are a number of new technologies in Malawi, however, most of these technologies are not being utilized due to lack of proper technology transfer and commercialization mechanisms. The NCST is therefore working towards establishing a system that would promote an innovation culture which requires identifying local and national development problems, creating conducive environment for converting new ideas into successful business ventures, and providing rewarding mechanisms that recognize individual achievements through the following programmes.

i. Science competition and awards

Under the science competitions and awards programme the NCST implements science competitions that aim at encouraging pursuance of science careers as well as recognizing scientific excellence. The following activities are implemented under this programme.

- Secondary School Science Competition

The NCST annually organizes the secondary school science competition, aimed at promoting the teaching and learning of sciences in all secondary schools in Malawi. Through this competition, students are encouraged to pursue science subjects seriously in order for Malawi to have a strong human resource base capable of advancing the development and application of research, science and technology for improved socio-economic development of Malawi.

- The AU-TWAS Young Scientist national Award

The NCST administers the AU-TWAS Young Scientist national Award. This award is open to both male and female young

researchers (40 years and below) meant to recognize the scientific achievements of young researchers and to encourage them to continue to strive for excellence in their careers. The awards acknowledge researchers' contribution to progress in science. The prize money is provided by the Academy of Sciences for the Developing World (TWAS) with approval by the African Union.

- Malawi Scientific and technological Achievement Award (MASTA)

This is a prestigious national award honouring achievement and excellence in scientific research. It is conferred upon any person or institution that makes an innovation, invention or discovery within Malawi which is likely to promote and accelerate the social and economic progress of the country.

- Malawi outstanding Innovation and Designer Award (MOIDA)

The main thrust of the award is to encourage endogenous development of technologies and entrepreneurship for poverty reduction, wealth creating and sustainable development. The main objective of the Award is to identify, select and reward individuals, groups or institutions exhibiting creativity an entrepreneurial characteristics.

ii. Science and Technology Fairs and open days

NCST periodically organises national science and technology fairs and open days so as to promote national science and technology awareness and culture, documentation, consolidation and dissemination of relevant science and technology information and generally promote the role of information technology. The last fair was held in 2012 under the theme, Science and Technology for Industrialization.

- National schools science fair

This is held annually and targets public and private secondary schools. The objective is to promote the teaching and learning of science subjects in secondary school besides encouraging a practical approach to science.

iii. Technology and innovation

This programme aims at inculcating a culture that utilizes research results; promote creativity and innovativeness through the following.

- Provision of competitive grants

This is aimed at promoting technology transfer and commercialization of research results. The grants are offered to both institutions and individuals who have developed technologies and innovations which require promoting, transfer and commercializing.

- Annual research dissemination conferences

This is an annual event organised and funded by NCST that brings together researchers from various disciplines to present their research findings. The last conference was held in March 2012.

NCST also supports research dissemination conference organised by other research institutions. For instance supported a College of Medicine research dissemination conference held in 2011 and 2012 and co-funded the 2013 social sciences research dissemination conference. It also provides some financial support for the production of Journals. One of the Journals which has benefitted from this support is the Journal of Social Sciences.

- Training of science teachers

The training targets science teachers in both public and private secondary schools. The objective of the training sessions is to impart skills to science teachers to enable them effectively deliver science lessons. Emphasis is placed on the innovative approach to teaching science through locally available resources. This is in recognition that many secondary schools do not have science laboratories though they offer science subjects.

iv. Gender mainstreaming in STI

NCST is committed to promoting women and youth participation in STI. This programme was developed to recognize the role that women and youth play in the development and application of science, technology and innovation. A number of initiatives are underway and include:

- Support to women in science and technology network (WISTNET)

The NCST supported the formulation of WISTNET, a network of professional women scientists. The objective of the network is to provide a platform to promote the participation of female scientists but also nature the young girls to pursue science careers.

- Supporting science youth groups

The NCST also supports the formulation of science youth groups which provide a platform for the youth to dialogue and develop programmes for implementation in the area of science and technology.

2.1.7 Networking, Partnerships and Collaboration

Networking, collaboration and partnerships have the advantage of securing greater value from expenditure through STI structures. NCST as an umbrella body on STI issues in Malawi works towards facilitating networking, partnerships and collaboration between and among local and international STI institutions for the advancement of STI.

2.2 Information and Knowledge Management programmes

STI Information and knowledge needs to be properly packaged and managed if it is to be optimally utilized. Furthermore, adequate dissemination mechanisms of STI information lead to a better public understanding of STI issues. As a result decision makers and the general public are able to appreciate the role of STI in development endeavours. NCST is therefore making deliberate efforts to promote the acquisition, organization, dissemination, repackaging and translation of STI information for socio-economic development through the following.

2.2.1 Review of the National Policy on Library, Documentation and Information Services

The Commission is promoting the development and review of policies to guide the development of library, documentation and information services in Malawi. Currently the NCST is spearheading the review of the 1996 National Policy on Library, Documentation and Information Services and developing the accompanying implementation strategies.

2.2.2 Malawi Sustainable Development Network Programme (SDNP)

The Commission continues to execute the Malawi SDNP which was established in 1996 as an Internet Service Provider to assist with the development of Internet and Information Services in Malawi with emphasis on sustainable development. Malawi SDNP is also administering the top level country domain (.mw) for Malawi. It was licensed in 1999 and launched its commercial Internet services in 1999. It was initially a UNDP supported Malawi government programme executed by the then National Research Council of Malawi (NRCM). After a remarkable period of operation, efforts are now underway to register the program as a legal entity. This is in order to ensure the sustainability of the programme.

2.2.3 Development of national digital repositories and inventories

The NCST is mandated in the S&T Act no. 16 of 2003 to produce national digital repositories, directories and specialised bibliographies on research, science and technology. The directories are meant to update the scientific and technological community about recent scientific publications, research projects, the state of laboratory equipment, profiles of scientists and information management specialists and consequently foster collaboration and networking among scientists and institutions in Malawi and abroad. Under the same programme the NCST is also promoting the development of institutional digital repositories.

2.2.4 Creating science and technology awareness

NCST is also involved in creating science and technology awareness at the political and other levels of society and thereby obtain their commitment towards the value of science and technology as integral parts of national development strategies.

2.2.5 IST AFRICA programme

IST-Africa initiative is a strategic collaboration between IIMC (Ireland) and ministries and national councils responsible for information society, ICT and/or science, technology & innovation adoption, policy and research in 18 African Countries. Malawi is a member of the initiative through the NCST. The initiative is supporting the information society in Africa through:

- international research cooperation, innovation and entrepreneurship
- knowledge sharing and skills transfer between IST-Africa partners
- supporting implementation of 8th Africa-EU Strategic Partnership (science, information society, space) including hosting JEG8 meetings

IST- Africa is supported by the European Commission (EC) and African Union Commission (AUC), and co-funded under FP7.

2.3 Planning, Monitoring and Evaluation

The NCST is developing a monitoring and evaluation framework in the STI system meant to assess the progress of various policy interventions. In addition, the current STI indicators have not been well developed and coordinated to provide evidence based information to guide policy makers in the STI sector. In order to guide the implementation of STI policy and assess contributions of various collaborating partners and performance of the STI sector, planning, monitoring and evaluation is a necessary tool in the medium term. NCST is therefore, required to produce the State of Science and Technology Report every 2 years for presentation to the National Assembly. The report aims at tracking STI performance in all the key sectors of the economy and measuring its contribution to the national economy. The first report is almost ready for publishing.

2.4 Resource Mobilization

The S&T Act provides for the establishment of an S&T fund for the advancement of science and technology in Malawi including promotion of various research initiatives. The NCST is in the process of developing instruments for operationalizing the fund. Sources of funds shall include money appropriated by Parliament for the purposes of the Fund, levies and other sources.

3.0 Conclusion

The establishment of the National Commission for Science and Technology is a key strategy for enhancing the development and application of S&T in Malawi's development endeavors in order to accelerate the socio-economic development of the nation and improve the quality of life of the people. The NCST therefore requires maximum support from both the Government and stakeholders to successfully execute its mandate.