Ghana's Regional Development in Economics, Education and Natural Resources, with a Case Study on Customers' Preferences for Household Water Treatment & Safe Storage Products

by

Weini Qiu

B.S. Environmental Engineering
B.S. Natural Resources and the Environment
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Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Civil and Environmental Engineering
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Signature of Author:_____
Weini Qiu
Department of Civil and Environmental Engineering
August 10, 2012

Certified by:_____
Susan Murcott
Senior Lecturer of Civil and Environmental Engineering
Thesis Supervisor

Accepted by:_____
Heidi M. Nepf
Chair, Departmental Committee for Graduate Students

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ABSTRACT

Ghana is one of the few countries that was re-classified from low-income country to low-middle income country in 2011 by the World Bank (World Bank, 2011a). At the same time, Ghana is still in the process of achieving the Millennium Development Goals (MDGs). This thesis uses the MDGs as a guide and backdrop against which to analyze the relationships between economics, education and natural resources. The analysis helps provide recommendation for regional development in economics, education and natural resources for 10 regions in Ghana. The second part of the thesis uses a case study in the water sector to explore the relationship between the MDG targets for poverty, water accessibility and water quality. The case study is a market survey on Household Water Treatment and Safe Storage products, which seeks to understand customers' preferences for safe water in the home and to find out economic opportunities in this sectors.

The author found that each of the economics, education and natural resources indicators: proportion of the population under the poverty line, percentage of population completed primary and secondary schools, selected natural resources (mean time to drinking water source, annual precipitation, oil palm and cocoa) are moderately to strongly correlated with each other. Each region has its own distinct advantages and disadvantages that can help direct priorities for regional development. Among the six HWTS products (*Aquatab, CrystalPur™/Tulip Siphon Water Filter, Kosim Classic, Kosim Deluxe, PUR and LifeStraw® Family*), *Kosim Deluxe* received the highest total preference score with and without the impact of the price. In general, particle removal products are more popular than the chemical products. Interviewees are concerned about the size (either too big or too small) of the particle removal product and are aware of the side effects of chemical products. MDG Target 7.C is likely to be achieved in urban Tamale shown in this data. The market research shows that HWTS products can contribute to potential post-2015 MDG for water as well as the current MDGs Target 1.A for poverty. Market recommendations are also provided for the six HWTS products.

Thesis Supervisor: Susan Murcott
Title: Senior Lecturer of Civil and Environmental Engineering

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ABBREVIATIONS AND ACRONYMS

CDC	Centers for Disease Control and Prevention
CIA	Central Intelligence Agency
CIDA	Canadian International Development Agency
GDP	Gross Domestic Product
GNI	Gross National Income
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
HDI	Human Development Index
HWTS	Household Drinking Water Treatment and Storage
IDA	International Development Association
IFAD	International Fund for Agricultural Development
IHDP	International Human Dimensions Programme on Global Environmental Change
MDG	Millennium Development Goal
NREL	National Renewable Energy Lab
SRID	Statistical Research and Information Directorate
STWSSP	Small Town Water Supply and Sanitation Project
SWE	Small Water Enterprise
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
UNU	United Nations University
USGS	United States Geographic Survey
UWP	Urban Water Project
W.A.T.E.R	Water in African Through Everyday Responsiveness
WCF	World Cocoa Foundation
WDI	World Development Indicators
WHO	World Health Organization

1. INTRODUCTION

In January of 2012, the author has the privilege to travel with thesis supervisor, Susan Murcott and other MIT students to Ghana as a project fulfillment for the degree of Master of Science in Civil and Environmental Engineering. We stayed at a local non-profit organization, Pure Home Water (PHW), founded by Ms. Murcott. The author's work was to conduct market research on customers' preference on Household Water Treatment and Safe Storage (HWTS) products. After the Ghana trip, the research continued at MIT primarily focusing on data collection on economics, education and natural resources to better understand these components of Ghana's situation in achieving the Millennium Development Goals (MDGs) on a regional scale. The intention is to use the field study to consider better methods for one target, water quality that might potentially complement the MDG target 7.C "Access to improved water" as well as potential post-2015 MDG water target "safe drinking water".

1.1 Development History

1.1.1. Development Trajectories – Complex Issues

The topic of development trajectories is broad and complex, and has been a subject of debate for decades. Topics such as how natural resources affect economic development, and whether economic growth stimulates universal education and decreases in population inequality, have been studied by many researchers. To name a few, Sachs and Warner found that countries (such as Venezuela, Nigeria, Mexico, etc.) heavily relying on natural resources exports to GDP have a lower economic growth rate compared to resources-poor countries. This is called the "resources curse" (Auty, 1993; Sachs and Warner, 1995). Kuznets hypothesizes that relationship between economic inequality and income per capital follows an inverted "U" shape as economic inequality first increases then decreases with the increase of income per capita (Figure 1-1) (Kuznets, 1955). However, Stiglitz has a different opinion than Kuznets based on the East Asian countries (Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, Singapore, Taiwan (China) and Thailand), rapid economic growth has also simultaneously decreased population inequality and increased universal education, especially for skilled engineers to adapt advanced technology (Stiglitz, 1996).

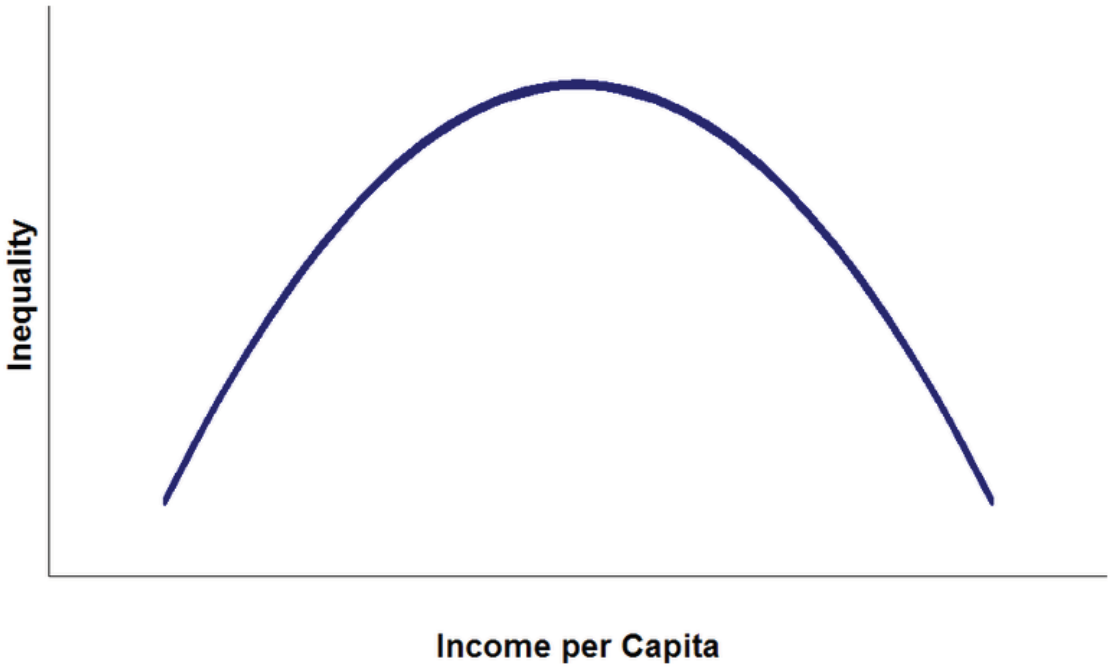

Figure 1-1 Relationship between economic inequality and income per capita (inverted "U" shape) (Kuznets, 1955)

The development paths of countries are complex and vary from country to country, and region to region. However, there are common key dimensions, although serve for different purposes, that many researchers believe are crucial to the development of a country.

1.1.2. Development Frameworks

As already mentioned, the development issues are complex and involve economics such as GDP growth, natural resources such as abundance of resources, human resources such as educational levels, and social issues such as population inequality. Therefore, various researchers and organizations have developed different frameworks and indicators to guide and balance development on a country level. There are a number of important frameworks that are commonly used for measuring the development level of a country and for better understanding the complex issue of development:

a. Sustainable Development

The Brundtland Report generated in 1987 by the United Nations, first defined *sustainable development, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. It is a balance between economic, environmental and social development, which are also the *three pillars* of *sustainable development* (UN, 1987).

b. Human Development Index

The United Nations Development Programme (UNDP) introduced a way of measuring development by combining three dimensions plus four indicators[1]. In the first Human Development Report in 1990, it pointed out that there are three dimensions (Health, Education and Living Standards) and four indicators (Life expectancy at birth, Mean years of schooling, Expected years of schooling and GNI per capita) that they used to calculate the Human Development Index (HDI) (Figure 1-2).

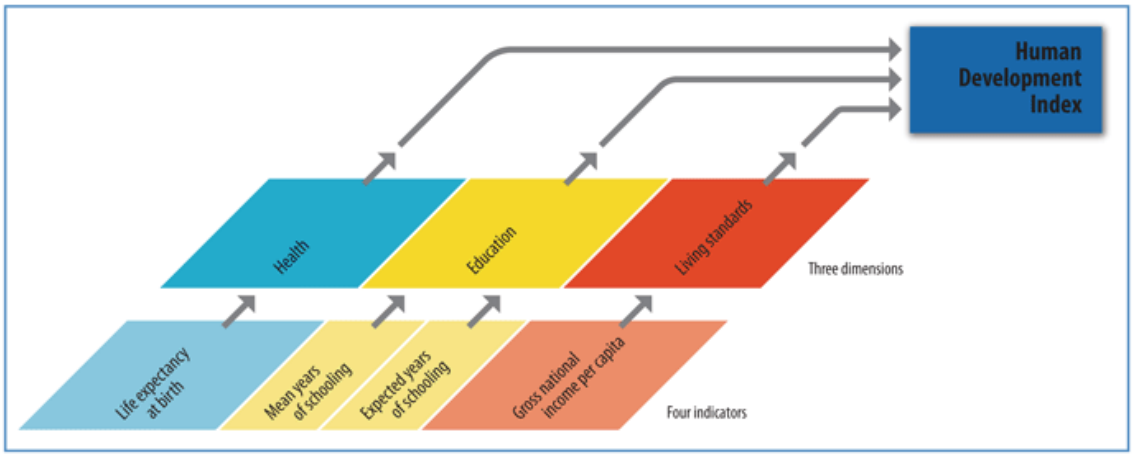

Figure 1-2. Four indicators of the three dimensions composed of the HDI (source: UNDP[2])

c. Sustainable Livelihoods Framework

The International Fund for Agricultural Development (IFAD) developed the Sustainable Livelihoods Framework (Figure 1-3) that places the poor at the center with a focus on five assets: ***human capital*** (health, nutrition, education, knowledge and skills, capacity to work, capacity to adapt), ***natural capital*** (land and produce, water and aquatic resources, trees and forest products, wildlife, wild foods & fibers, biodiversity, environmental services), ***financial capital*** (savings, credit/debt, remittances, pensions, wages), ***physical capital*** (infrastructure, tools and technology) and ***social capital*** (networks and connections, relations of trust and mutual support, formal and informal groups, common rules and sanctions, collective representation, mechanisms for participation in decision-making, leadership). Their original framework was expanded and scrutinized to another alternative to emphasize people's motivations, health, education, etc., and include more and more social concerns such as gender, age, class, ethnic, ability, etc. (Figure 1-4) (IFAD, 2012[3]).

[1] Sources come from UNDP, Human Development Report from 1990 to 2011 can be found at: http://hdr.undp.org/en/statistics/hdi/

[2] Source comes from: http://hdr.undp.org/en/statistics/hdi/. Online accessed: July 30th, 2012

[3] More information about the workshops and the framework can be found at: http://www.ifad.org/sla/framework/index.htm, online accessed: August 8th, 2012

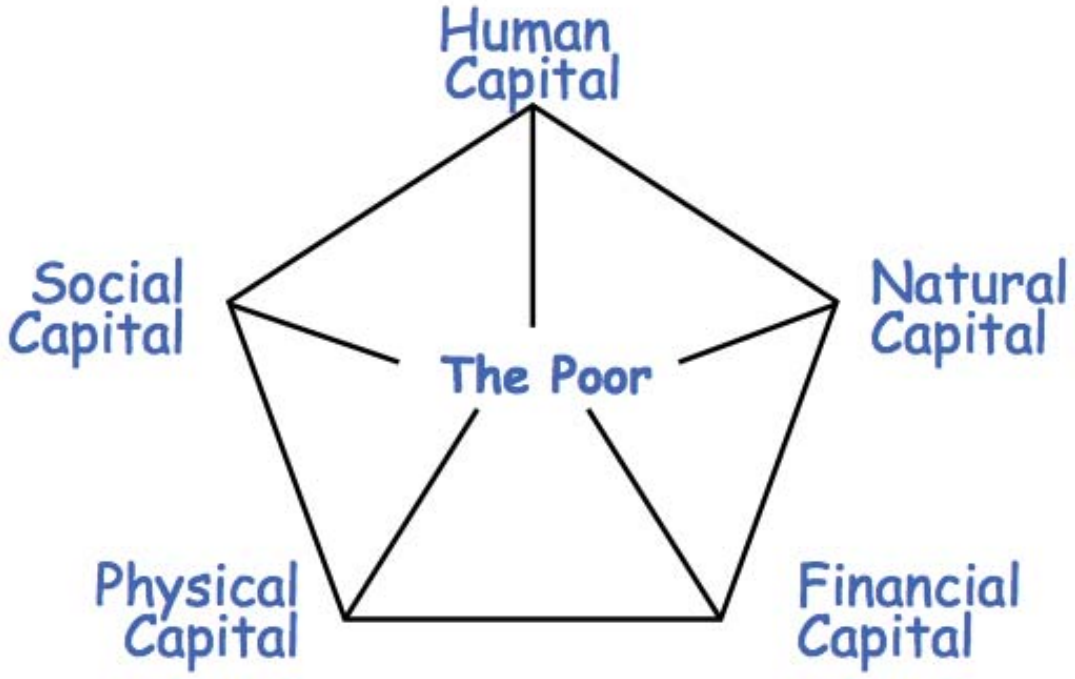

Figure 1-3. Livelihood pentagon developed for the Sustainable Development Framework (IFAD, 2012)

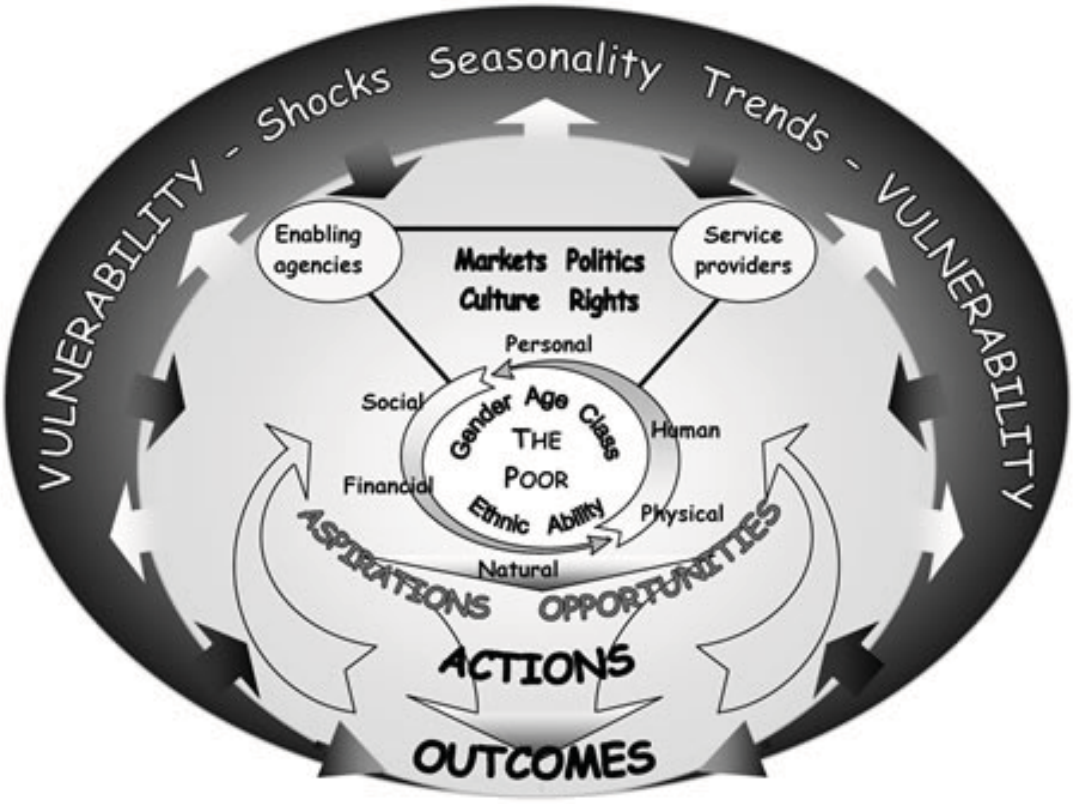

Figure 1-4. Alternative Sustainable Framework (IFAD, 2012)

d. Inclusive Wealth Index/Framework

Inclusive Wealth Report 2012 is the first of a series of biennial reports on sustainability of countries generated under cooperative efforts from the United Nations University International Human Dimensions Programme on Global Environmental Change (UNU-IHDP) and United Nations Environmental Programme (UNEP). The 2012 report was produced because it was felt that the conventional indicators such as gross domestic product (GDP) and the Human Development Index (HDI) failed to capture the full wealth of a country such as environmental decline. Additionally, the report argued that the *sustainable development* framework did not make specific reference to human well-being. Therefore, the Inclusive Wealth Index includes seven assets: ***manufactured capital*** or ***produced capital*** (roads, buildings, ports, machinery, equipment), ***human capital*** (education, skills, tacit knowledge, health), ***knowledge*** (science and technology), ***natural capital*** (local ecosystems, biomes, sub-soil resources), ***population*** (size and demographic profile), ***institutions*** (the rule of law, social norms of behavior, habitual social practices) and ***time*** (UNU-IHDP/UNEP, 2012[4]).

These frameworks provide guidance for governments on the development of society, economics, environment as well as humans. They help to answer what should be paid extra attention to during the development process.

e. Millennium Development Goals and Execution in Ghana

The Millennium Development Goals (MDGs) are the agenda and key income poverty monitoring measure of the United Nations Development Programme (UNDP) and the World Bank (Saith, 2005). A developing country that is the member Nations of the United Nations can use the MDGs as a guideline to measure the success of the development plan. There are eight Millennium Development Goals that the member Nations seek to achieve by the year of 2015 (UN, 2012a):

Goal 1: Eradicate Extreme Poverty and Hunger
Goal 2: Achieve Universal Primary Education
Goal 3: Promote Gender Equality and Empower Women
Goal 4: Reduce Child Mortality
Goal 5: Improve Maternal Health
Goal 6: Combat HIV/AIDS, Malaria and other Diseases
Goal 7: Ensure Environmental Sustainability
Goal 8: Develop a Global Partnership for Development

The difference between the MDGs and the previous four frameworks/indicator is that the MDGs set specific targets, within a specific deadline and the MDGs are agreed upon by the member status of the United Nations.

[4] More information about Inclusive Wealth Index/Framework can be found at the Inclusive Wealth Report: http://www.ihdp.unu.edu/article/iwr/. Online accessed: August 8th, 2012

1.2. Focus and Particular Interest of the First Half of the Thesis

In order to limit the scope of the thesis, the author has selected four targets of three MDGs. These targets overlap and are closely related to the other frameworks *three pillars* of sustainable development, HDI, Sustainable Livelihood Framework and Inclusive Wealth Index/Framework.

1.2.1. The Focal Goals

The MDGs' targets as the focus of this thesis are:

- Goal 1 Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day;

Target 1.A is closely related to three of frameworks listed in the previous section: economic development is one of the *three pillars of sustainable development*, average living standard is one of the HDIs and "place the poor at the center" is a key aspect of the Sustainable Livelihood Framework.

- Goal 2 Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling;

Target 2.A approximately corresponds to the education dimension in HDI as well as to the human capital in both the Sustainable Livelihood Framework and Inclusive Wealth Index.

- Goal 7 Target 7.A: Integrate principles of sustainable development into country policies and programmes and reverse the loss of environmental resources;

Target 7.A is one of the key elements for environmental sustainability, the *three pillars* of sustainable development, natural capital in Sustainable Livelihood Framework and in Inclusive Wealth Index. Environmental sustainability is not one of the contributors of the HDI, but its importance has been mentioned in the Human Development Report 2011 as well as at the UN Conference on Sustainable Development in Rio de Janeiro in June of 2012[5] (UNDP, 2011[6]).

- Goal 7 Target 7.C: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water[7].

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[5] More information about the Earth Summit can be found at: http://www.uncsd2012.org/index.html, accessed on July 30th, 2012.
[6] Source comes from Human Development Report in 2011. Online access on July 30th, 2012 at: http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf
[7] Note: *Sanitation* is not included in the thesis because the author would like to focus on natural resources, which is one of the key components of the environment.

Target 7.C links directly to the natural capital in Sustainable Livelihood Framework as well as manufactured capital in Inclusive Wealth Index. Target 7.C is related to more than just the environment, but also to the health of human beings. Although target 7C is not one of the indicators of the HDI, it links between the environment and the health of human, which both HDI is looking at.

In Section 1.2.2 the author will look at problems of the three MDGs Goal 1, 2 and 7, listed in the United Nations documents as well as other published articles, to identify important indicators of the four targets and three goals for the analysis of the thesis.

1.2.2 Problems of Achieving Three Targeted Millennium Development Goals

Currently, the MDGs that this thesis is focusing on (Goals 1, 2 and 7) are not on track in sub-Saharan Africa.

Goal 1: End Poverty
Target 1.A: Halve, the proportion of people whose income is less than $1 a day

According to the MDGs Progress Report 2012, extreme poverty is falling in every region (UN, 2012a). However, most of the achievements for Goal 1 are contributed by Asia; however, only little progress has been made in sub-Saharan Africa. Although large countries such as China have made a large progress in terms of ending poverty, when considering the whole world, the goal of ending poverty is unlikely to be reached by 2015. It is estimated that approximately 920 million people around the world will live under $1.25 a day in 2015 (UN Summit, 2010).

The Millennium Development Goal 1 for "ending poverty" is a big challenge for countries with low elasticity (the percentage reduction in poverty rates associated with a percentage change in mean per capita income) yet most of whose people are under the poverty line (Easterly, 2009; Imai et al, 2010). Easterly shows how low-income countries with low elasticity require much more effort to reduce poverty compared to middle income countries (Figure 1-5). Every country had a different economic starting point when the MDGs came into play. That is to say, for a country with more population under the poverty line, it requires a higher growth rate for such a country to reach the MDGs Target 1A by 2015 (Easterly, 2009). Such a target has put more burdens on countries such as those in sub-Sahara Africa due to initial large amount of people with income below the poverty line. In addition, Saith points out that countries might utilize their own resources to benefit areas at the edge of the poverty line rather than those that are poorest (Saith, 2005). The incomes of the people with extreme poverty do not grow one-for-one with increases on average income in a country (Foster and Székely, 2001).

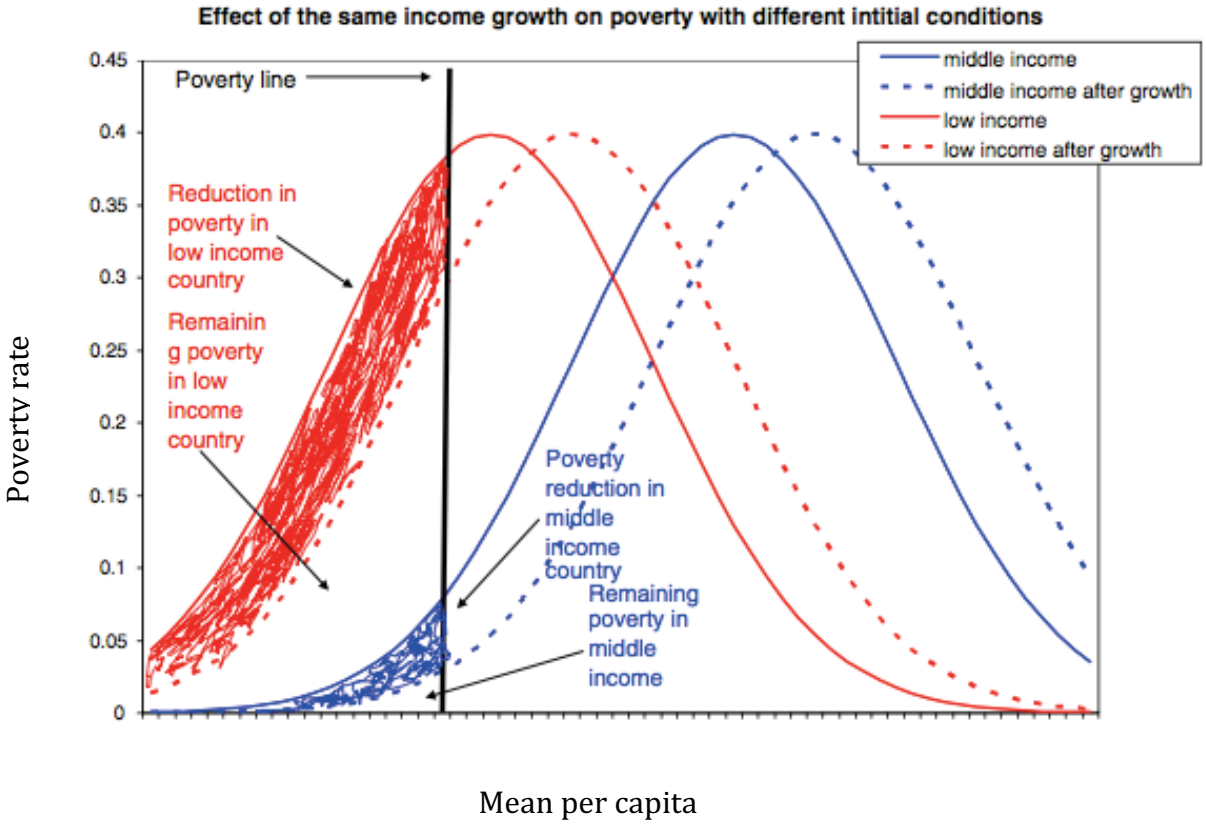

Figure 1-5. Comparison between low and middle-income countries before and after growth (Source: Easterly 2009, original title: Figure 2. Nonlinear effects of growth on poverty)

Goal 2: Universal Education
Target 2.A: Ensure that children everywhere will be able to complete a full course of primary schooling

Although enrolment rates of children of primary school age increased markedly in sub-Saharan Africa from 58-76 per cent between 1999 and 2010 (UN, 2012a), the goal of achieving universal primary education is unlikely to be met by 2015 according to the Fact Sheet. Currently, more than 69 million school-age[8] children are out of school and almost half of them are in sub-Saharan Africa.

Although some countries have done an extraordinary job in reducing the number of school-age children out of school, such an approach is being criticized for not considering the primary completion ratio, which is a better measure for full primary education (Easterly, 2009). Additionally, researchers found that it takes far more than completion of primary school to fulfill the needs for rapid growth and development of developing countries, especially since sustainable development has been considered important in the past decade (Palmer, 2005; Alam et al., 2009; Ashley and Maxwell, 2001). With less land available per

[8] According to UNICEF, school aged children is from 6-12 years old. Information can be found at: http://www.unicef.org/djibouti/children_3609.html

capita as the population grows fast in developing countries, the demand for food increases and the challenge now is to develop technologies that increase agricultural productivity without an impact on the environment (Gowling and Palmer, 2008). Technology requires participation of a quantity of educated and/or trained individuals, whereas primary education can only provide basic literacy, which is not enough for the development of countries that need at least 7% of GDP growth per year in order to reach the MDGs (Africa Progress Panel, 2007). Furthermore, engineering, science, business, marketing and other key disciplines also require specific training (McElwee and Bosworth, 2010; Ministry of Food & Agriculture (Ghana), 2011[9]).

Goal 7: Environmental Sustainability
Target 7.A: Integrate principles of sustainable development;
Target 7.C: Halve the proportion of the population without sustainable access to safe drinking water

The goal for environmental sustainability is difficult to reach (UN, 2012a). Under the stress of survival and without formal and advanced education on environmental sustainable development (such as land preservation and suitable land use) as well as constraints on environmental protection targets, people in developing countries are likely to undermine conservation (Moore, 2001; Adams et al., 2004).

One of the important targets in Goal 7 Target C – sustainable access to safe drinking water, is likely to be met or exceeded by 2015 if current trends continue on a global scale. However, access to improved drinking water in rural areas is slow and far behind urban areas. Additionally, Clasen points out that the claim to have achieved Targe 7C (for water) *exaggerates the achievement* (Clasen, 2012). WHO and UNICEF also mention that the number of people with safe water supplies is likely to be *over-estimated* (WHO/UNICEF, 2012a). The current world status on improved drinking water means that there are yet 780 million people who do not have access to safe drinking water (JMP 2012). Although it is estimated that 86% of the population in the world will have access to an improved source of drinking water by 2015, acknowledged by the United Nations in the Millennium Development Goals Report (2012a), expanded activity in agriculture and manufacturing has increased the demand for water (UN, 2010). Full household coverage with water and sanitation infrastructure can lead to a total reduction of *2.2 million child deaths* every year, which require US $1,000 investment per life-year saved (Günther and Fink, 2011). Globally, it is estimated that the cost to meet the MDG water target is $42 billion (Hutton and Bartram, 2008). Financial issues have made the improved drinking water target harder to reach in low and low-middle income countries that have more population living under the $1.25 per day poverty line.

Although not been mentioned in the MDGs, regional disparities are enhanced and execution of one goal does not work well without execution of another. In the United Nations System Task Team generated in 2012 for the post-2015 MDGs agenda, regional disparity is

[9] Information provided by 2011 Ministry of Food & Agriculture, Republic of Ghana. Online Access: http://mofa.gov.gh/site/?page_id=70

recognized and it might jeopardize economic development of a developing country (UN System Task Team, 2012). Disparities become obvious with regard to investment in rural and urban regions, such that the urban area gets a higher percentage of public expenditure even though the percentage of population live in urban region is less than rural areas (van Ginneken, et al., 2011).

With these specific MDGs' problems in mind, the author will now look at the MDG challenges and problems in Ghana, a country where the author conducted research in January of 2012.

1.3. Ghana and its MDGs Execution

1.3.1. Ghana

There are 54 fully recognized countries in Africa, all members of the United Nations[10]. Ghana, a member of the UN since 1957, is one of the 47 developing countries in the sub-Saharan Africa that has been re-classified as low-middle income countries in July 1st of 2011 by the World Bank (World Bank, 2011a). There are a total 10 administrative Regions in Ghana: Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong Ahafo, Northern, Upper West and Upper East Regions (Figure 1-6). Accra is the national capital of Ghana located in Greater Accra Region. According to the World Bank, total population in 2011 is 24,965,816 (World Bank, 2012).

[10] Most updated membership information last updated in 2006 from the United Nations: http://www.un.org/en/members/. Online accessed on July 30th, 2012.

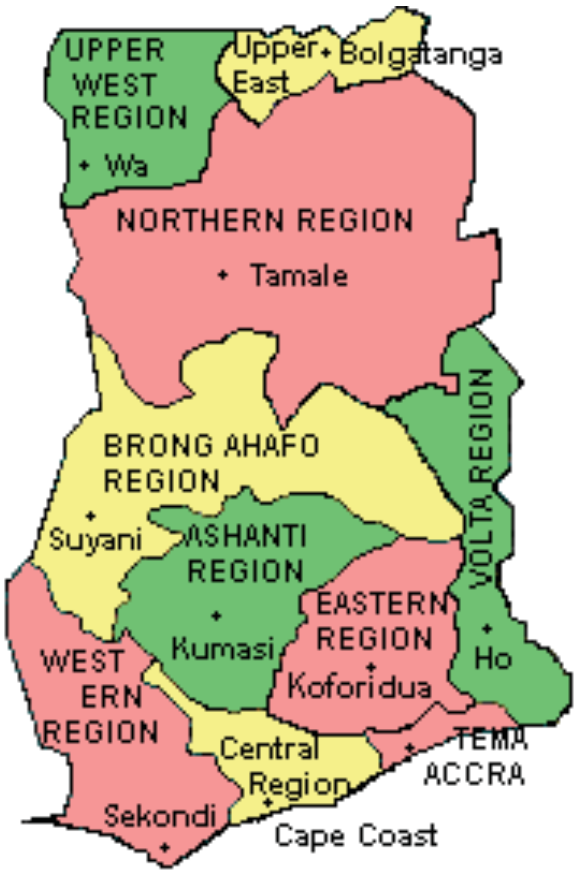

Figure 1-6. Ten administrative Regions and Capitals in Ghana. Photo courtesy: Ghanaweb.com

Ghana is rich in natural resources such as cocoa, diamonds and gold[11]. According to the Central Intelligence Agency (CIA) World Factbook, Ghana is a country with ample mineral, hydropower, and resources of commercial importance that make *a significant contribution to the economy*[12]. A significant amount of oil (approximately 1.5bn barrels) is recently found off shore at the Jubilee Field of Ghana (BBC, 2012). Such a natural resources rich environment largely benefits Ghana in agriculture, mining and energy sectors since these sectors play important roles in employment, economic development, etc. (Ministry of Finance and Economic Planning, 2012; UNDP, 2004). For example, agriculture is a key for employment, as it employs 60% of the Ghanaian workforce[13]. Additionally, the mining industry accounts for about 7% of Ghana's GDP and 41% of total merchandised export

[11] Sources come from International Development Association (IDA), the World Bank's Fund for the Poorest. Online retrieved on July 30th, 2012 at: http://www.worldbank.org/ida/profile-ghana-water.html

[12] Sources come from Central Intelligence Agency, online retrieved on July 30th, 2012: https://www.cia.gov/library/publications/the-world-factbook/fields/2111.html

[13] Sources come from Ghana Embassy in Washington DC, USA. Online available: http://www.ghanaembassy.org/index.php?page=a-country-of-natural-wealth. Assessed on: July 30th, 2012

(Hammah, 2012). Water resources rich areas such as Volta River Basin include the Akosombo Dam and hydroelectric facility, which was built in 1965. Ghana draws over 80% of its energy supply from this dam (Global Water Partnership, 2012).

As one of the few countries that just been re-classified from a low to low-middle income country in 2011 (other countries include Lao PDR, Mauritania, Solomon Islands and Zambia), Ghana's success in moving "*out of the poverty trap"* has caught the worlds' attention (World Bank, 2011c; Kenny and Sumner, 2011; MacDonald 2011). Ghana has Gross National Income (GNI) exceeding US $1,006 per capita[14] in 2011 (World Bank, 2011b). According to the CIA World Factbook, the GDP of 2011 is composed of agriculture (28.3%), industry (21%) and services (50.7%) (CIA, 2012).

In education, Ghana has put in lots of effort to provide *relevant and quality education for all Ghanaians especially the disadvantaged*[15]. Since Ghana's most recent education reform began in 1987, basic schools and secondary school enrollment rate has increased by 4.5% and 4.7%, respectively between 1990-2002 and with an additional 20 vocational institutions equivalent to 2 in each region[16]. The most updated Ghana Budget Report 2012 also mentions that GHC 15.3 million was released in the year of 2010/2011 to assist over 5.2 million pupils complete their academic year and GHC 36.8 million was used for building infrastructures at schools (Ministry of Finance and Economic Planning, 2012).

However, Ghana is still a target country that is in the process of achieving the MDGs. The MDGs are derived from the United Nations Millennium Declaration of adopting *development and poverty eradication, Protecting our common environment, Human rights, democracy and good governance, Protecting the vulnerable and meeting the special needs of Africa* (UN, 2000). In Section 1.3.2, the author will further introduce the MDGs in detail and the execution of MDGs in Ghana to better understand the existing problems and then define the objectives of this thesis.

1.3.2. MDGs in Ghana

In 2000, Ghana, along with 189 United Nations (UN) member countries adopted the Millennium Declaration are committed to achieving the MDGs by 2015 (UNDP, 2010).

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[14] According to the World Bank, Gross National Income (GNI) is the sum of value added by all resident producers plus any product taxes (fewer subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. GNI per capita is gross national income divided by mid-year population. The World Bank uses GNI per capita for classifying economics. Online access (retrieved on July 20th, 2012) at: http://www.unicef.org/infobycountry/stats_popup1.html

[15] Mission Statement from the Ministry of Education, online retrieved on July 30th, 2012: http://www.ghana.gov.gh/index.php/governance/ministries/331-ministry-of-education

[16] Information retrieved from the Ministry of Education on July 30th, 2012: http://www.ghana.gov.gh/index.php/governance/ministries/331-ministry-of-education

1.3.2.1 On Track Success

According to the Ghana Millennium Development Goals Report published in 2010, Ghana is on track of achieving the following MDGs and targets (UNDP, 2010):

- Reducing by half the proportion of the population living in extreme poverty (Goal 1 target 1.A);
- Achieving Universal primary education (Goal 2);
- Achieving gender parity (Goal 3);
- Halving the proportion without access to safe water (Goal 7 target 7.C).

It is likely that Ghana is going to achieve Goal 2 (education) and partially achieve Goal 1 (economics) and Goal 7 (the environment). This thesis also focuses on goals and targets in Ghana by 2015.

1.3.2.2 Challenges with MDGs in Ghana

1.3.2.2.1 Economics Challenges

Economically, Ghana is facing regional disparity due to the economic inequality between the north and the south (Al-Hassan and Diao, 2007; UNDP, 2010). The economic difference results from the growth of export agriculture, which southern regions (Western, Central, Eastern and Ashanti) contribute much more to GDP than the Northern Sector (Northern, Upper East and Upper West) (Al-Hassan and Diao, 2007). While entrepreneurs are one of the major factors of economic growth, and they do exist in Ghana, their businesses are facing many limitations, one of the most pronounced of which is the education of entrepreneurs (Robson and Obeng, 2008).

1.3.2.2.2 Education Challenges

Without doubt, Ghana has made tremendous progress in basic school enrollment (UNDP, 2010). However, the education issues in developing countries are not solved after primary education enrollment increases. Such issues include survival rate[17] of Junior High (UNDP, 2010). According to various authors, education issues can potentially become an obstacle to achieving other MDGs (Waage et al., 2010; Dzidonu, 2010; Fleshman, 2003). For example, the World Cocoa Foundation suggests that to improve sustainable crop production and enhance biodiversity, education on specific skills and training is necessary for farmers (World Cocoa Foundation, 2011). The United Nations Development Program also found that malnutrition was associated with the mother's education in Ghana (UNDP, 2010).

[17] Survival rate is the number of students completing school over the total number of enrolled students.

1.3.2.2.3 Environmental Challenges

The MDG of ensuring environmental sustainability in Ghana is not yet fully achieved. One of the most severe problems includes the depletion of forest cover in the past decades (UNDP, 2010). Such a phenomenon is driven by the demand for agricultural land and population growth in Ghana (Attuquayefio and Fobil, 2005). Additionally, loss of biodiversity has been linked to illegal logging, destruction of natural habitats and poaching (WWF, 2012). Although it is very likely that Ghana will achieve its target of *halving the proportion of persons without sustainable access to safe drinking water* by 2015, some communities such as Tia-Noba, Wabukugiri, etc., lack any facilities for improved drinking water (UNDP, 2010). Another survey done in Northern Region also shows that a large portion of the population in rural areas still use unprotected surface water as their primary drinking water source in both wet and dry season (Figure 1-7) (Lu, 2012). Furthermore, bacterial contamination in drinking water sources, such as boreholes and dugout are found in Ghana (Parker, 2011; Miller, 2012); broken and leaky of public pipes in urban and sub-urban areas have also resulted in contamination of drinking water (Dongdem et al., 2009).

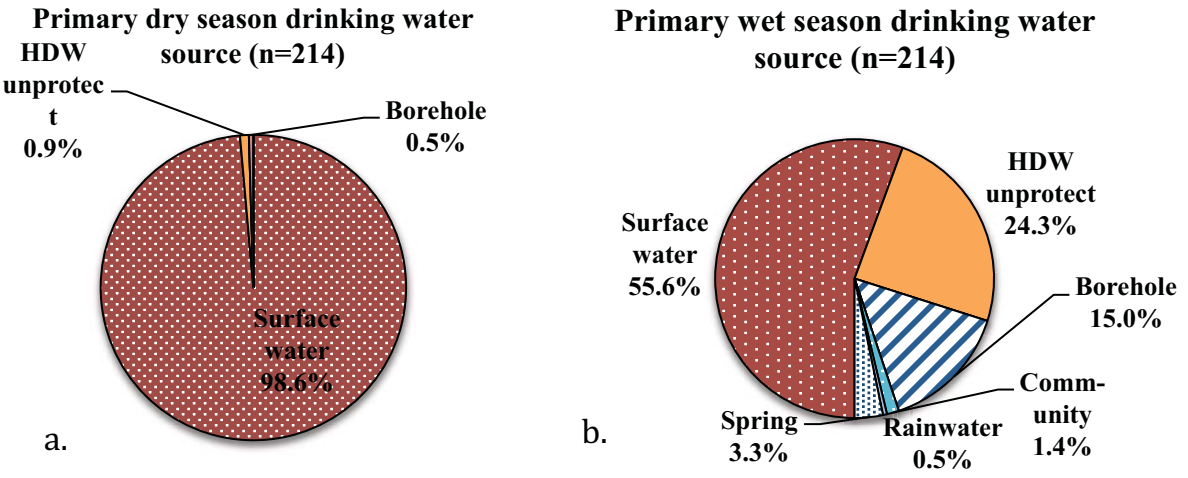

Figure 1-7. Primary dry (a) and wet (b) season drinking water sources in rural communities surveyed in Northern Region

1.4. Defining the Objectives and Why the Thesis is Important

1.4.1 Why Correlations between Economics, Education and the Environment

We have learned from the *Introduction* Section 1.2 that three MDGs Goals 1, 2 and 7 are still facing challenges. Despite progress in Ghana and some other countries, in sub-Saharan Africa generally, these goals are not yet achieved and might not be able to be achieved by 2015. At the same time, guidelines for the frameworks generated by international

organizations are mostly for national development and the MDGs are primarily focusing on the average of the whole nation. The achievement of the MDGs on regional scales and guidance for sub-national scale, are yet to be discussed. Additionally, regional disparity is another obstacle.

There are three more years left before 2015, which is the MDGs set deadline. Time is running out. Therefore, the author is interested in knowing the relationship between economics and the environment as well as education on a regional scale, in order to find out:

a. If it is possible to utilize such relationships (if they exist) to shorten the time to reach two or more MDGs targets or indicators at the time;
b. Based on possible correlations to give recommendations to bridge the gap of regional development.

Figure 1-8 shows the potential relationship among economics, education and the environment based on discussion in this section.

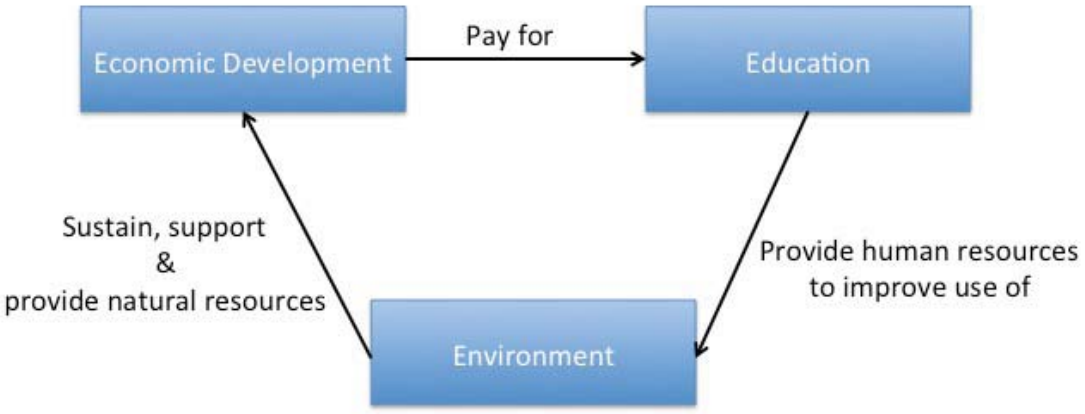

Figure 1-8. Potential relationships between economics, education and the environment.

1.4.2 Why Ghana

There are a few reasons why the thesis is targeting Ghana:

1. Ghana is among the few countries that has had a significant economic increase in recent years, reclassified from a low to a low-middle income country;
2. Ghana is in sub-Saharan Africa and in general, the MDGs Goal 1, 2 and 7 are not on track in sub-Saharan Africa;
3. Ghana is considered as a natural resources rich country;
4. Ghana has 10 regions, in which natural resources endowments are significantly different;
5. The author conducted household water product market research in Ghana in January of 2012, which links to Target 7.C and is a case study that is the focus of the second half of this thesis.

2. OBJECTIVES

This thesis has two major sections, one is a marco-scale correlation study in Ghana, and the other is micro-scale case study in urban Tamale. Part I of the thesis proposes two objectives and part II of the thesis is to achieve the third objective:

1. To collect, review and analyze the most updated data for Ghana at both a national level and in Ghana's ten regions (Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong Ahafo, Northern, Upper East, Upper West of Ghana) in terms of economy, education and natural resources[18], the three components of the MDGs Goal 1, 2 and 7 and important indicators of the development frameworks mentioned;

2. To suggest broad regional planning priority recommendations based on correlations found between economics, education and natural resources;

3. To conduct market survey on Household Water Treatment and Safe Storage (HWTS) products and customers' preferences in Tamale, a city in the Northern Region of Ghana. We expect that the market research case study help us better understand the existing problems in MDGs Target 7.C and potential problem in the post-2015 MDGs. Additionally, we hope that, if the market for HWTS exist, HWTS products can create economic development opportunities in Northern Sector of Ghana to reduce the economic disparities with other regions in Ghana.

[18] Due to the closer relationship between economics, basic needs of human being such as food and water, natural resources will be used for analysis of the thesis instead of the large environmental pictures.

3. METHODOLOGY AND DATA GATHERING

3.1 Methodology for the Macro Study in Ghana

3.1.1 Methodology

Although all the MDGs are inter-related with other goals, *ending poverty* is the No.1 MDG. Without the growth of the economy, the government can hardly have funds to provide public goods such as clean water, health benefits and educational opportunities to the country's residents. Yet, access to water, sanitation, universal education and maternal and child health are also goals and targets of the MDGs. Natural resources are essential for human survival as well as a strong indicator for how well a country's economy can do. One of the *three pillars* environmental sustainability would require natural resources to be used for fulfillment of the current needs but also needs of the future generation (WCED, 1987). Sustainable development and effective use of natural resources require education including basic literacy, but also science, technology, engineering, business and more.

The *three pillars* of Sustainable Development, the Human Development Index, Sustainable Livelihoods Framework and the Inclusive Wealth Index have been used to help the author identify four targets of the three MDGs (Goal 1, Goal 2 & Goal 7). National data is used as a background reference for the analysis of the regional data. To fulfill the objectives of the thesis as well as needs for sustainably achieving the MDGs, the author also considered important indicators beyond the three components of the MDGs, economics, education and the environment. Reasons of indicators selections will be explained below in Section 3.2. Based on the availability of regional data in economics, education and the environment, the author utilizes correlation, ranking, combined analysis and advantage analysis to find relationships among the three selected MDGs as well as indicators within the targets of the MDGs. Analysis will be further explained in Section 4.2. *Data Analysis and Discussion*. Logistics in selecting indicators for regional analysis are shown in schematics (Figure 3-1).

Logistics and steps of the methodology:

1. Understand MDGs and, based on literature review, find out problems of achieving the MDGs;
2. Using frameworks introduced as a guide, identify four targets of the three goals in MDGs for analysis;
3. Indicators in economics, education and natural resources are chosen for correlation analysis;
4. Based on correlation analysis result, provide recommendations for better achieving the MDGs.

The author has introduced problems of achieving the MDGs, Ghana's current situation as well as requirements for five different frameworks in the Section 1 *Introduction*, to fulfill Step 1. Then three goals are chosen based on the literature reviews and frameworks (facts, achievement, critiques and achievement). Further explanation of indicators selections will

be discussed in Section 3.2, which fulfilled Step 3. Finally Section 4 will present data, perform correlation analysis, and provide regional recommendation to accomplish Step 4.

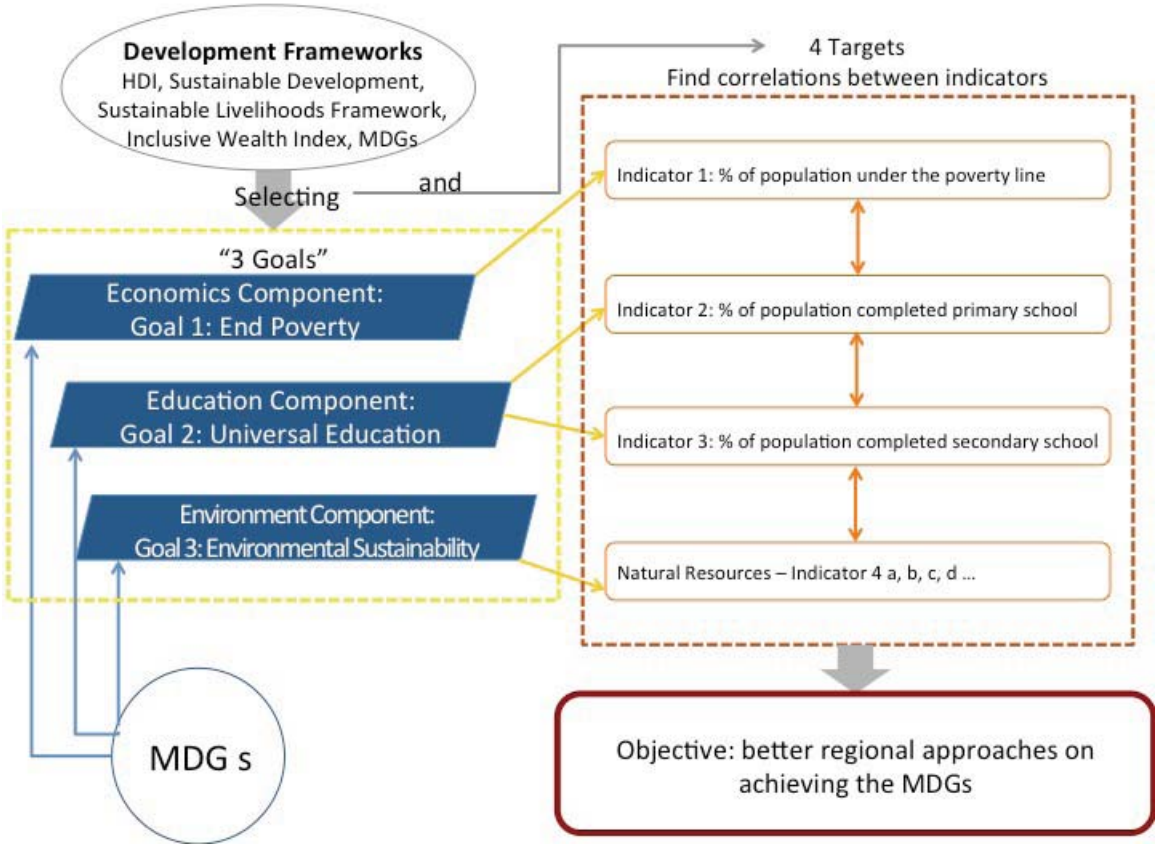

Figure 3-1. Methodology of the thesis. Selection of indicators of natural resources will be discussed in Section 3.2.3.1.

3.1.2. Explanation and Limitation of the Data

Data used for this thesis comes from international organizations as well as local government agencies. Surveys are conducted by various organizations for gathering information on education and natural resources. Calculations on economics indicators (GDP, GNI, etc.) are done by other parties that the author of the thesis has no control of. One can find related data reports references in the next Section 4.2. Due to reports generated from various organizations, the year that the data was collected is not always the same. However, to keep the analysis as accurate as possible, the differences are less than four years. Most of the regional data has been collected during 2006-2008 with exception of oil palm, as the only data externally available for oil palm is in 2010. For annual precipitation, the most updated data available is 1990 to 2000.

Additionally, correlations between economic, education and natural resources reflect Ghana's regional difference and might not apply to other countries' regions. Such correlations are used for the purpose of the regional recommendations. If a relationship

between the proportion of population under the poverty line and the percentage of population that has completed primary school exists, increasing investment in primary education **might** help reduce the population under the poverty line, **or** helping people get out of extreme poverty might increase the completion rate of primary education. However, **correlation does not equal causations whether it is of economics, education or natural resources**.

3.2 Data Gathering

For each MDG, there are thousands of data available. For the purpose of this thesis and based on the author's interest, we selected three broad components: Economics, Education and Natural Resources. Within these broad components, there are various indicators that can represent the development levels of each area. For the purpose of the thesis, the author has set these limits on the data collected.

3.2.1 Economics Data Gathering and Rationale

Data indicators for economics are available for both national and regional level in Ghana; in addition, such indicators have to be widely used to predict the growth or decline of the economy.

- **Background national data**: Gross Domestic Product (GDP), GNI and HDI;
- **Regional indicator**: percentage of population under the poverty line in each region.

Rationale: percentage of population under the poverty line is a direct measurement for Goal 1 to *end poverty* and to reduce the number of population whose income is less than $1.25 a day (the poverty line). The indicator will show how well each region is doing currently in terms of economics development.

Data sources:
1. World Development Indicators for national GDP and GNI information;
2. United Nations Development Programme for HDI information;
3. Ghana Info 6.0[19], for percentage of population under the poverty line.

3.2.2 Education Data Gathering and Rationale

For education, data for nationwide scale can be general yet important for future development of the country and, data for regional scale has to be more specific and in detail

[19] Website for Ghana info 6.0 can be accessed at: http://www.ghanainfo.gov.gh/, retrieved on July 1st, 2012

in order to predict if the current education level is able to provide enough different level to provide for employment needs.

- **Background national data**: number of enrolled children dropping out of primary school, percentage of education attainment in different age groups, percentage of female and male attendance;
- **Regional indicators**: percentage of population that has completed primary and secondary schools; percentage of population that has more than secondary school, medium years of school completed in different regions.

Rationale: ensuring completion of primary education is in Target 2.A and it is necessary to present data on the percentage of population that has completed primary school in order to keep track on the progress of universal education in different regions. However, as mentioned in the *Introduction*, it takes more than primary education to satisfy needs for sustainable development. Therefore, the author is going to analyze regional data on completion of secondary education, to take a step further for analyzing potential correlation between secondary education and economics as well as natural resources, which affects the achievement of sustainable development on a regional scale.

Data sources:
1. World Bank Database for students who have dropped out of primary school on a national level[20];
2. Ghana Demographic and Health Survey report 2008 for any other education data.

3.2.3 Natural resources Data Gathering and Rationale

For natural resources, the data has to be essential for human needs and/or have great potential and development benefits in Ghana currently and in the future.

- **Background national data**: Types of water withdrawal
- **Regional indicators:** water resources (surface water, groundwater and precipitation), cash crops, agriculture, etc.

Rationale: Since the environment (in the case of the thesis: natural resources), includes tremendous amounts of data, the author only choose resources that are essential for universal needs, important for the economy of Ghana and for which productivity might be affected by education and technology. This seemed to make more sense since these natural resources would apparently be correlated with education and economics as well as health.

Data sources:
1. National Renewable Energy Lab (NREL)[21] for land use information;

[20] Website access: http://databank.worldbank.org/ddp/home.do?Step=1&id=4, retrieved on July 1st, 2012

2. United Nations Statistics Division – Commodity Trade Statistics Database (UN COMTRADE)[22] for major cash crops information such as export countries;
3. Ghana Cocoa Board newsletters for cocoa regional production;
4. GhanaSTAT[23] for various agricultural data;
5. MASDAR Consulting Team[24] for oil palm regional production;
6. Meteorological Service Agency for precipitation data;
7. *AQUASTAT*, Food and Agriculture Organization[25] for types of water withdrawal.

3.2.3.1 Natural Resources Selection Criteria

Due to the fact that natural resources include large amounts of information and therefore the analysis would take longer than time allows, only key major natural resources were included in mapping and data analysis. General information regarding natural resources present in different regions has been collected, using ArcGIS and Excel.

Based on the MDGs targets as well as basic needs required and economic benefit brought into the country, the author has restricted requirements for selection of natural resources analyzed:

1. Such resources exist in Ghana and are available online for external use;
   AND
2. Closely related to other MDGs such as health, education, etc.
3. Have been proven and/or are potential key contributions to Ghana's GDP or government revenue; or
4. Require technical employees and/or are labor-intensive and have potential to boost employment rate.

The types of natural resources selected to map and analyze will be discussed in Sections 3.2.3.2 to 3.2.3.6.

3.2.3.2 Water Resources

Water is the basic need for human beings and for the growth of plants and the survival of animals. In the United Nations Millennium Development Goals, Goal 7 Target 7.C: *Halve, by 2015, the proportion of the population without sustainable access to safe drinking water*, has emphasized the importance of water to contribute to the development. Currently, Ghana is facing severe water challenges including broken pipes, disparities of water resources in

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[21] Data available at: http://www.nrel.gov/international/geospatial_toolkits.html, retrieved on: July 8th, 2012 and can be downloaded to QGIS for data extraction in ArcGIS
[22] Database under management of the United Nations and data can be downloaded upon request at: comtrade.un.org/db/, retrieved on July 1st, 2012;
[23] Data is available at: http://countrystat.org/gha/cont/, accessed on July 1st, 2012
[24] Data is available at: http://mofa.gov.gh/site/?page_id=10244, accessed on July 1st, 2012
[25] Data is available at: http://www.fao.org/nr/water/aquastat/data/query/results.html, accessed on July 1st, 2012

rural and urban regions etc. (Shirimori, 2012; Pearce, 2012), which we will continue to discuss in Section 6. With the rapid growth of the country and increasing population, and lacking of financial support to build comprehensive water related infrastructure such as drinking water and/or wastewater treatment plant, pipelines, etc., water resources and its accessibility at regional scale should be considered to analyze if available water resources can be supportive to tremendous recently discovered economic opportunities (e.g., oil and gas) and, determine if water related infrastructure should be built in certain areas as priorities to support relatively rapid growth in specific regions.

3.2.3.3 Oil Palm

Oil palm is a cash crop that is considered as a leading foreign earner for Ghana (MASDAR, 2011). It has been used domestically and been exported to 26 countries (Woodhill, 2010; UN Comtrade, 2011). Palm oil produced from oil palm has been widely used in Ghana for cooking oil (GSS, 2009). In Ghana particularly, oil palm is a commercial crops that take up 9% of the total croplands with coverage of over 300,000 square kilometers of land (SRID, 2010). Additionally, oil Palm has great potential to provide energy after it is processed into oil, since oil palm has high potential to produce high yield biodiesel (Yong, 2009). According to the United Nations Development Program, one hectare of oil palm can produce 2,400 liters of oil, which is higher than other biodiesel crops such as soya bean, sunflower, etc (UNDP, 2011). In principal, biodiesel made from palm oil could be environmentally friendly (Gilbert, 2012). However, plantation of oil palm has been accused of having negative environmental impact due to increasing land use and its cause of deforestation (Kongsager and Reenberg, 2012; UNEP, 2011).

3.2.3.4 Cocoa

Cocoa is the major source of foreign exchange in Ghana (CIA, 2012). Hence, Ghana has become the world's second largest cocoa producer following Ivory Coast (Ghana News Agency, 2011). According to the International Food Policy Research Institute, cocoa production in Ghana has played a large role in poverty reduction and economic development. Additionally, the share of cocoa in GDP rose to 8.1 percent in 2005/2006 and the industry is the largest contributor to agricultural GDP (Breisinger et al., 2007; Centre for the Study of African Economies, 2009). However, cocoa production relies heavily on farmers and land availability. Farmers' education as well as residents in areas where cocoa is planted has become issues and barriers for sustainable development and for further poverty reduction (World Cocoa Foundation, 2012).

Following Figure 3-2 is an example of natural resources data collected for cocoa and presented in ArcGIS.

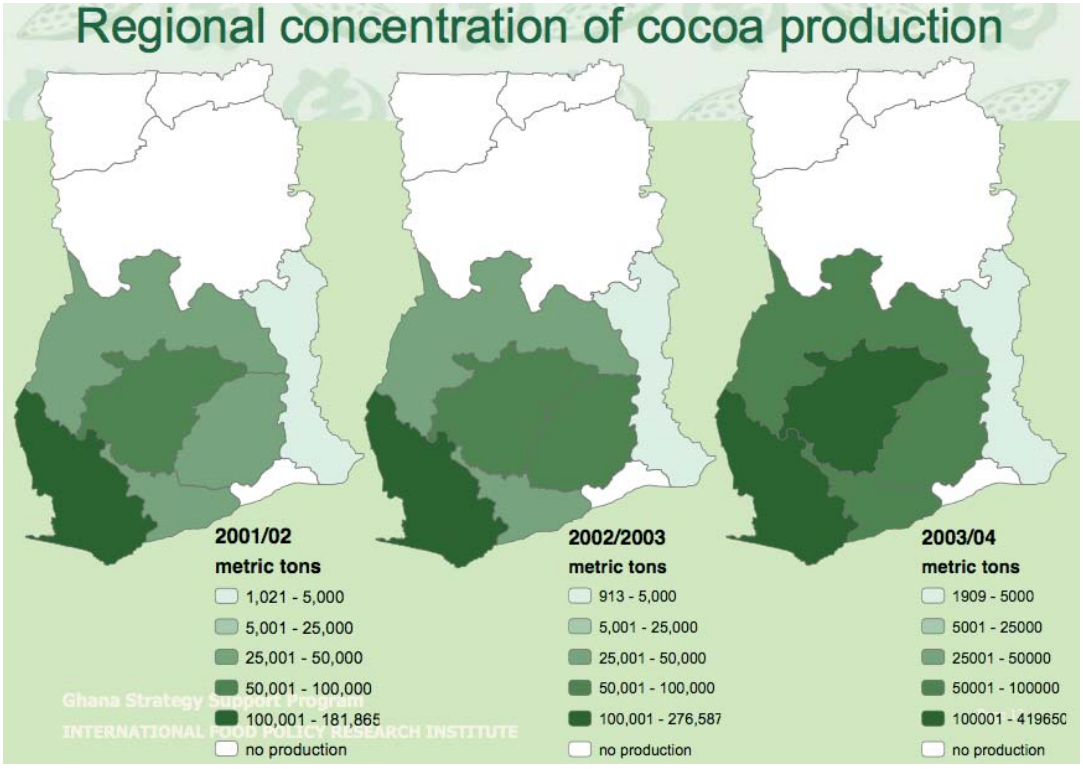


Figure 3-2. Example of regional concentration of cocoa production from year 2001 to 2004 (Breisinger et al., 2007)

4. DATA PRESENTATION AND ANALYSIS

4.1 Data Presentation and Results

4.1.1 Economics

4.1.1.1 National Economics Data

There is no fixed line for developed and developing countries. A developed country, as defined by Kofi Annan, former Secretary General of the United Nations, is "one that allows all its citizens to enjoy a free and healthy life in a safe environment" (Annan, 2000).

The World Bank has divided country economies into four income groups based on 2011 GNI per capita (World Bank, 2011a):

Low income: $1,025 or less;
Lower middle income: $1,026-$4,035;
Upper middle income: $4,036-$12,475;
High income: $12,476 or more.

Ghana is not yet a developed country due to its low living standards (lower middle income country) as well as low HDI (Ranked 153, where the highest HDI ranked No.1 is Norway and lowest is Democratic Republic of Congo ranked No. 187) (Figure 4-1).

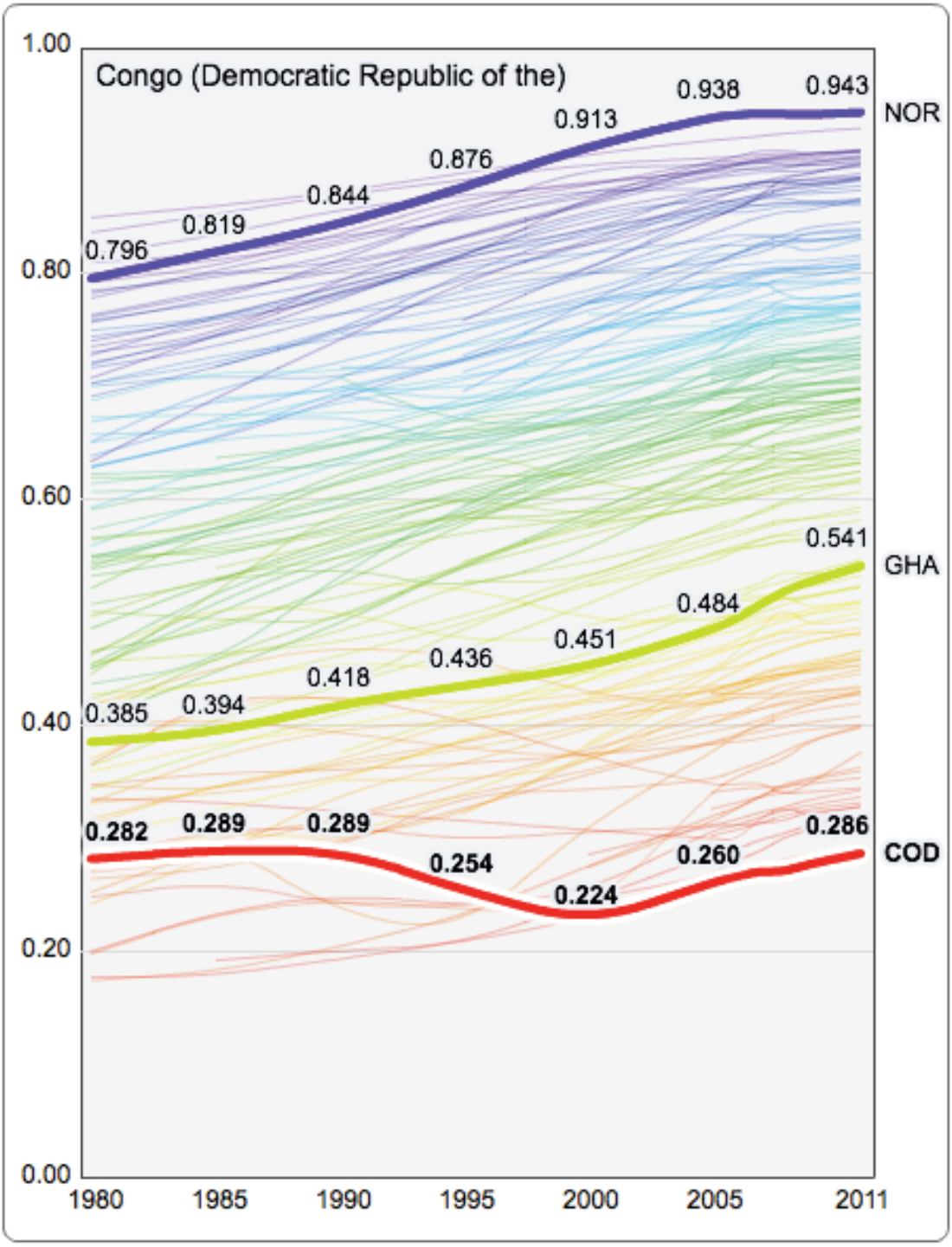


Figure 4-1. Comparison of the Human Development Index (HDI) between Norway (Rank No.1), Ghana (Rank No.153) and Congo (Rank No.187). (Source: UNDP, 2012[26])

[26] Data comes from: http://hdr.undp.org/en/data/trends/, where one can choose countries for comparison.

According to the World Bank, Ghana is one of the few countries that became a lower-middle income country in 2010 (World Bank, 2011c). However, Ghana is still considered as a developing country. It has over 30% of the population earning less than $1.25 per day, of which is an international poverty threshold or poverty line, the minimum level of income needed to secure the necessities of life (World Development Indicators, 2011).

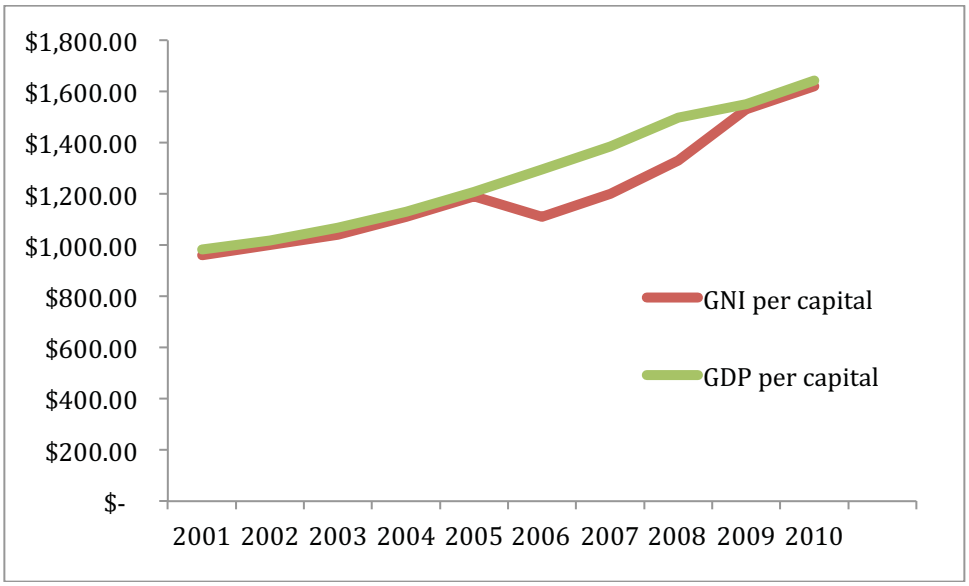


Figure 4-2. Ghana's GDP and GNI on a countrywide scale from 2001 to 2010 (data from WDI, 2011).

In the past 10 years (2001-2010), both Ghana's GDP and GNI are increasing (Figure 4-2). With such a growth trend, it is expected that both GDP and GNI will reach to US$2,394 per capita by 2015[27]. The Ghana Shared Growth and Development Agenda (GSGDA) seeks to achieve an even higher income per capita of US$3,000. That requires a minimum average real GDP growth kept at 8% or above (GSGDA, 2010). In fact, the first quarter of 2012, Ghana's real GDP has grown by 8.7% compared to the same period in the previous year (GSS, 2012). Other GDP contributors, the industry sector including mining, gold, manufacturing, etc. and service sector including education, finance, etc., have all increased; however, the general agriculture sector declined by 2.9 percent (GSS, 2012).

4.1.1.2 Regional Economics Data

The concern of the MDGs Goal 1 is whether countries can eradicate extreme poverty by 2015. Although both GNI and GDP per capita in Ghana have increased in the past years, poverty at the regional scale is an obstacle to achieving the MDGs in various countries, including Ghana (Harsch, 2008). Therefore, Figure 4-3 looks at economics in Ghana, especially those living under the poverty line of $1.25 a day on a regional scale.

[27] Calculation based on trend line (not shown) generated from Excel for Figure 4-2.

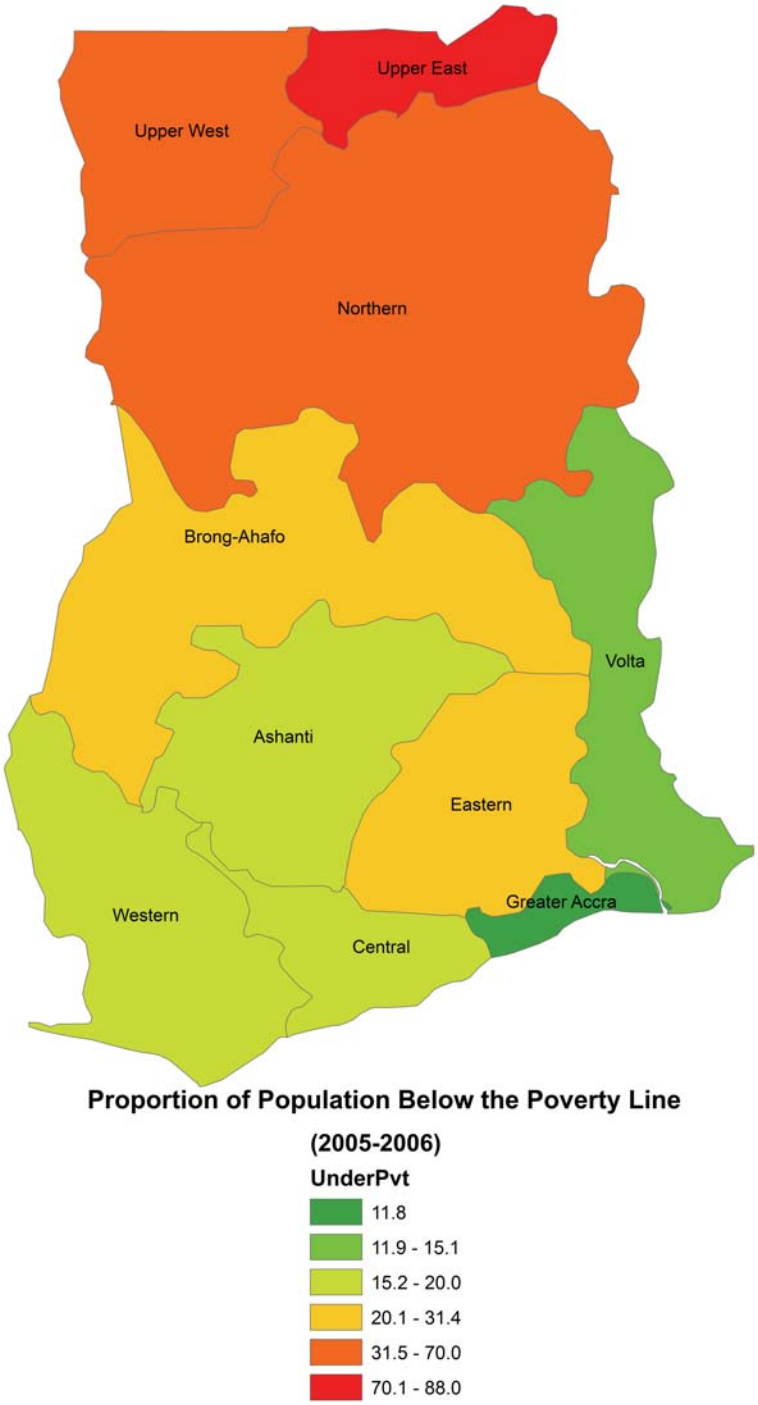


Figure 4-3. Proportion of population below the poverty line in 10 different regions of Ghana in 2005/06 (most updated available data obtained from GhanaInfo 6.0, owned by the Government of Ghana[28]).

[28] Data can be assessed by typing in "Under Poverty" on database website: http://www.ghanainfo.gov.gh/

According to Figure 4-3 the three Northern Sector: Northern, Upper East and Upper West Regions are the poorest among all regions. In addition, the proportion of population under the poverty line is surprisingly high, i.e., Upper East has 88% of its population under poverty line. In these three regions, over 2.5 million people earn less than $1.25 per day[29].

4.1.2 Education

4.1.2.1 National Education Data

Education affects whether or not regions have enough human resources to support economic growth and development with different types of skills and enterprises. By looking at educational attainment among different age groups, one can determine, if regions are lacking workers in the next 5 to 10 years that require secondary or tertiary education to fulfill development of various natural resources enterprises that match the profile of certain regions.

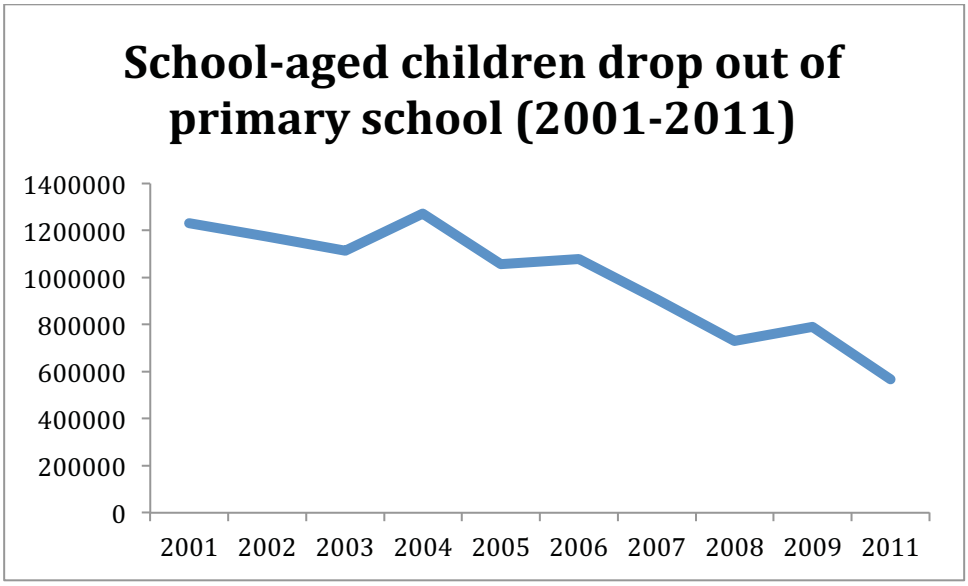


Figure 4-4. Children dropped out of primary school on a nationwide scale in Ghana from 2001 to 2011. Data comes from World dataBank[30].

According to Figure 4-4, school-aged children[31] dropping out of primary school has decreased from 2001 to 2011. The total number that dropped out of school has decreased

[29] This number is estimated based on 2000 Population and Housing Census conducted by Ghana Statistical Service, last updated in November of 2011 (online access: http://countrystat.org/gha/cont/pxwebquery/ma/081spo010/en)

[30] Data can be assessed at: http://databank.worldbank.org/ddp/home.do?Step=1&id=4, retrieved July 1st, 2012

by half. However, until 2011, there are 600,000 school-aged children who dropped out of school and data regarding the distribution of these children in the various regions is unknown.

The education information below is collected by the Ghana Statistical Service in 2008 when conducting the Health and Demographic Survey, Ghana Statistical Service, Ghana Health Service, Ghana AIDS Commission, UNICEF and UNFPA (GSS, 2009). To predict if Ghana is able to provide enough highly educated workers (secondary and tertiary school) currently as well as in the next 5 to 10 years, we are looking at three age groups:

a. Age 20-64 (the main labor age for now)
b. Age 15-59 (will become the main laborers in the next 5 years)
c. Age 10-54 (will become the main laborers in the next 10 years)

Such categories allow us to compare the education changes in 5-year increments on a national level. Considering the fact that the education level for the population age 6 to 9 is likely to change in the near future[32], therefore, data given by Ghana Statistic Service is less reliable to predict educational change in the next 5 to 10 years. Similarly, the age group that is over 65 is less likely to become the key employees in the future, especially for labor-intensive sectors. Data presented includes percentage of "no education", "completed primary school", "some secondary school", "completed secondary school" and "more than secondary school".

[31] Primary school aged children is defined as children at age 6-11 by UNICEF. Online available at: http://www.unicef.org/wcaro/wcaro_GHA_MTSP2.pdf. Online assessed on August 8th, 2012

[32] According to the Ghana Demographic and Health Survey, the Ghana's current education system includes six years of primary school, followed by three years of junior secondary school (JSS) and further three years of senior secondary school (SSS). Therefore, children from age 6-9 are less likely to finish primary school.

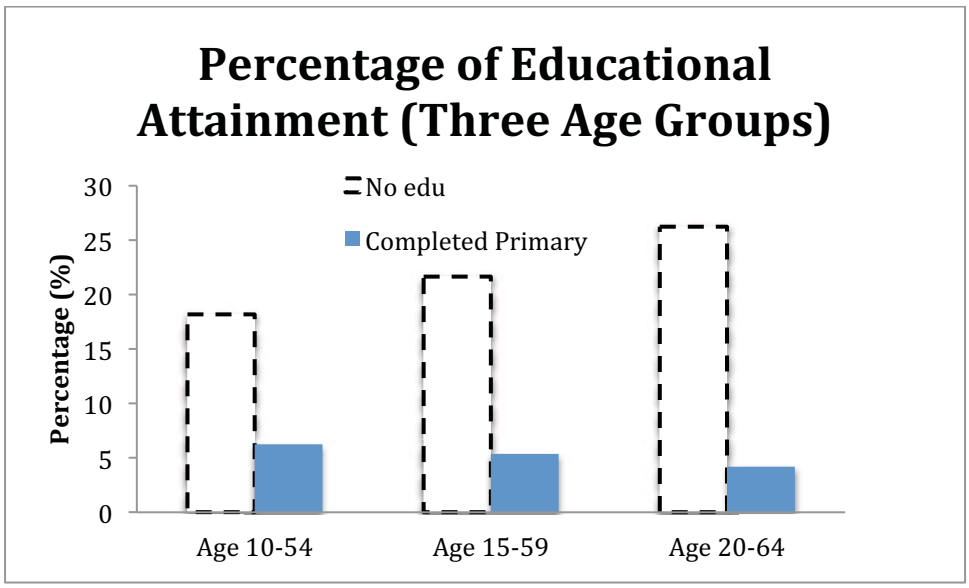


Figure 4-5. Comparison of the percentage of education attainment (no education and completed primary school) for both male and female with three age groups on a national scale

*Note: The percentage of completed primary school presented has excluded those have either some secondary education or who have completed secondary school

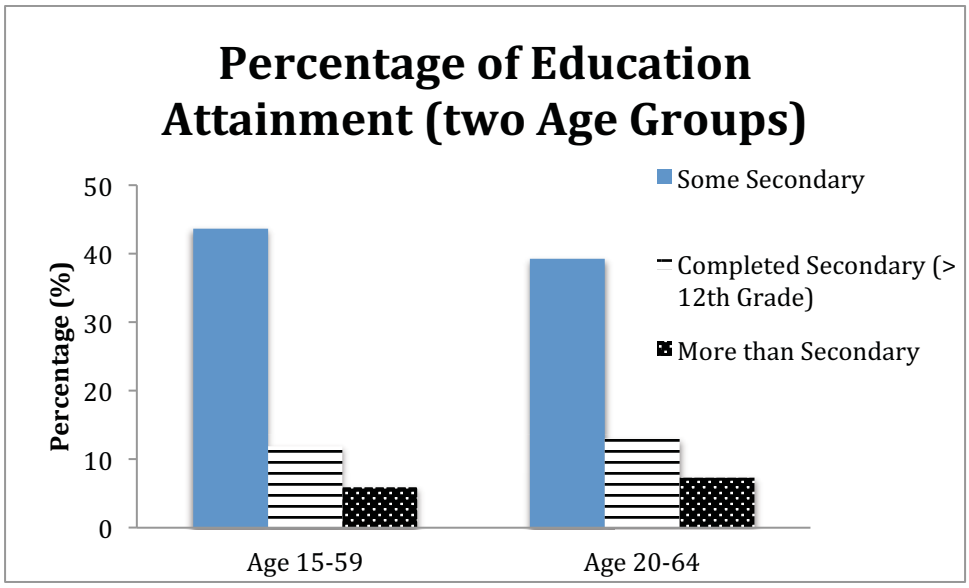


Figure 4-6. Comparison of the percentage of education attainment (some secondary school, completed secondary school and more than secondary school education) for both male and female showing two age groups

*Note: Percentage of *some secondary school* and *more than secondary school* excluding those who have *completed secondary school*

** Data at Figures 4-5 & 4-6 both come from Ghana Statistics Survey in 2008 (GSS, 2009)

For Figure 4-5 the dash columns show that, as the average age of each of the three compared age groups is 5 years older than each previous group (from left to right), the

number of school-age children with no education is increasing. Similarly, in Figure 4-5, the solid columns show that the percentage of people who have completed primary school is higher for the younger group, where group of Age 10-54 has a higher percentage of the population that has completed primary school compared to the group of Age 15-59 and Age 20-64. Group Age 15-59 also has a higher percentage of population completing primary school compared to group Age 20-64. In addition, more children from age 10-15 will complete primary school in the next 5 years, which will help increase the percentage of population completing primary school in Age 15-59 group. That is to say, Ghana is approaching the MDGs for universal primary education but data obtained does not indicate that whether the MDG Goal 2 will be achieved by 2015. In the next 5 – 10 years, the number of people without education will continue to decrease, as more children from the Age 6-9 group (not shown in Figure 4-5) will be attending primary school. However, the percentage of people with no education and who have not completed primary school is still high. With a current population of 24,932,000 in Ghana (World Bank, 2010), it is estimated that over 4.5 million people in the Age 10-54 group, (18%) which is the age group considered as the pillar of employment in the next 10 years, has not obtained any education.

According to Ghana Statistical Service (GSS) and Ghana Health Service (GHS), the current education system has six years of primary school, three years of Junior Secondary School and three years of Senior Secondary School (GSS and GHS, 2009). With the interviews the author held with local students, children go to school at the age of eight or later. That is to say, children aged from 10-15 are still in the process of completing their *secondary education*. Therefore, the author compared only two age groups, Age 15-59 and Age 20-64 in Figure 4-6. We found that the older age group (20-64) has higher *Completed Secondary School* and *More than Secondary School* rates. Since it is possible that the younger portion (e.g. from Age 15-20) of the group of Age 15-59 are still in school and not yet graduating from secondary school (which will be counted as *completed secondary school*), there is a trend that there have been more students going to secondary school in the past 5 years. In Figure 4-5, one can see that the Age 15-59 group has more percentage obtaining *Some Secondary School* compared to the Age 20-64 group. Therefore, in the next 5 years, it is very likely that there will be more students (who now belong to the group of Age 15-59) completing secondary school and going for higher education.

4.1.2.2 Regional Education Data

In order to understand the education differences in the various regions, median years of education completed are presented based on gender and regions[33]. Presenting the median years data for both men and women helps us understand the educational level in 10 regions and potential problems of education due to gender inequality.

[33] The median is a good tool to separate the higher and lower value of the sample (Gogg and Craig, 1995). The median is the "middle" value in the list of numbers.

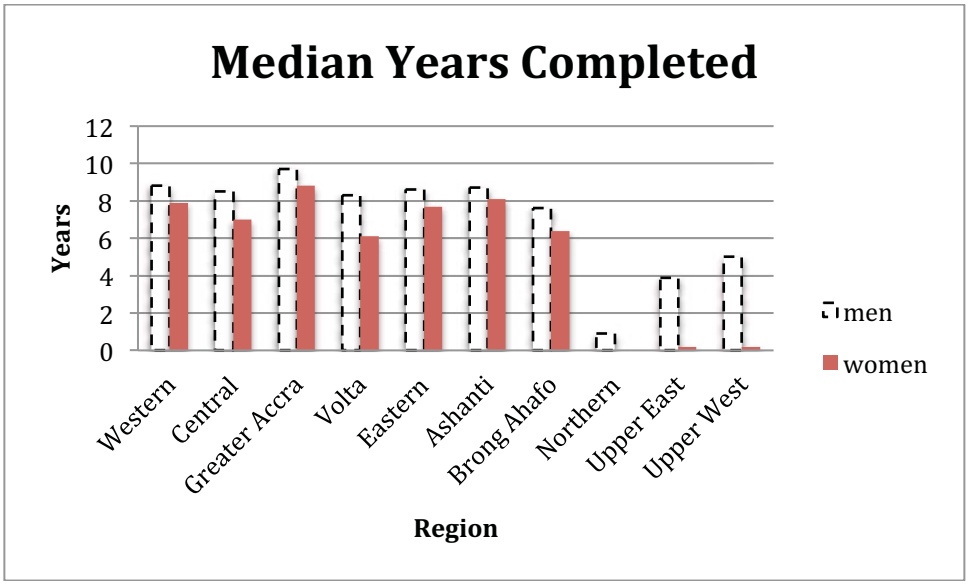


Figure 4-7. Comparisons on *median years of education completed* in both male and female (age 15-49) in Ghana between 10 different regions

Figure 4-7 shows several important trends. Female attended less years of schools compared to male in all regions. In the Northern Sector of Ghana, regions including Northern, Upper East and Upper West the majority of women interviewed by the GSS received almost no education. For example, in the Northern Region, the median years of education for female aged from 15-49 is 0 (see Figure 5-7 Northern region column); which means over half of the females have never received any education in the Northern Region. Greater Accra and Ashanti Regions, where the capital and the second largest city Kumasi is located, have the highest median years of completed education and the least difference in years of female and male education. However, even in Greater Accra, there is still a difference between male and females in education.

Percentages of men and women who have completed primary school (6 years), secondary school (12 years in total) and have more than secondary school are also presented based on different regions.

Maps for percentage of men completed primary school, secondary school and have more than secondary school[34] are generated from ArcGIS to compare the proportion of the population completed primary school, secondary school and tertiary school across 10 regions in Figure 4-8:

[34] More than secondary school here can be assumed as tertiary education, as the tertiary education in Ghana is defined in the Report of the President's Committee on Review of Education Reforms in Ghana (2002:xxxvi) as the education offered AFTER SECONDARY level at university, polytechnic, specialized institutions, open university and any other institutions to provide training that lead to the award of diploma and degree qualifications

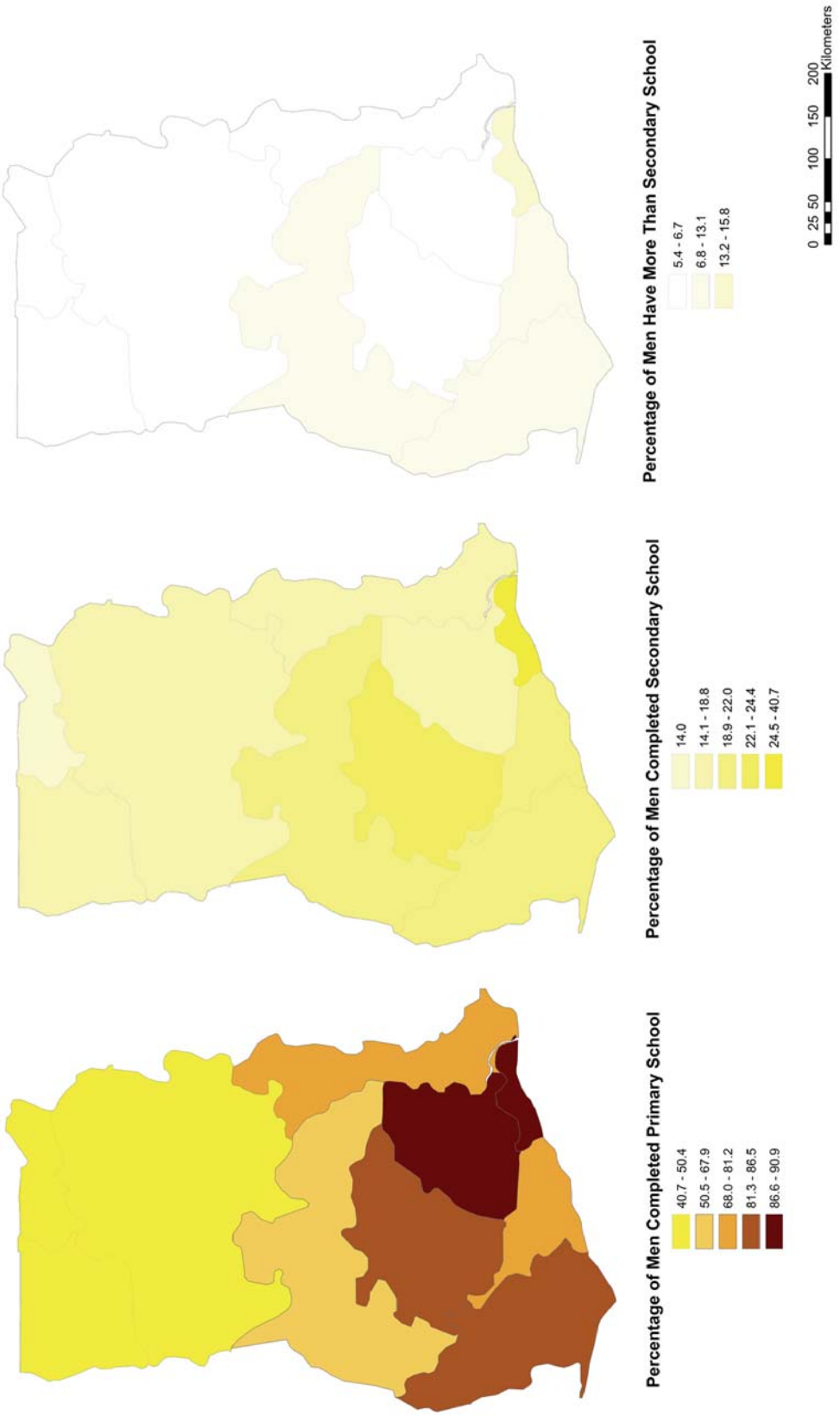


Figure 4-8. Percentage of men (aged 15-49) completed primary, secondary school and more than secondary school education in Ghana (Data from GSS demographic and health survey, 2009)

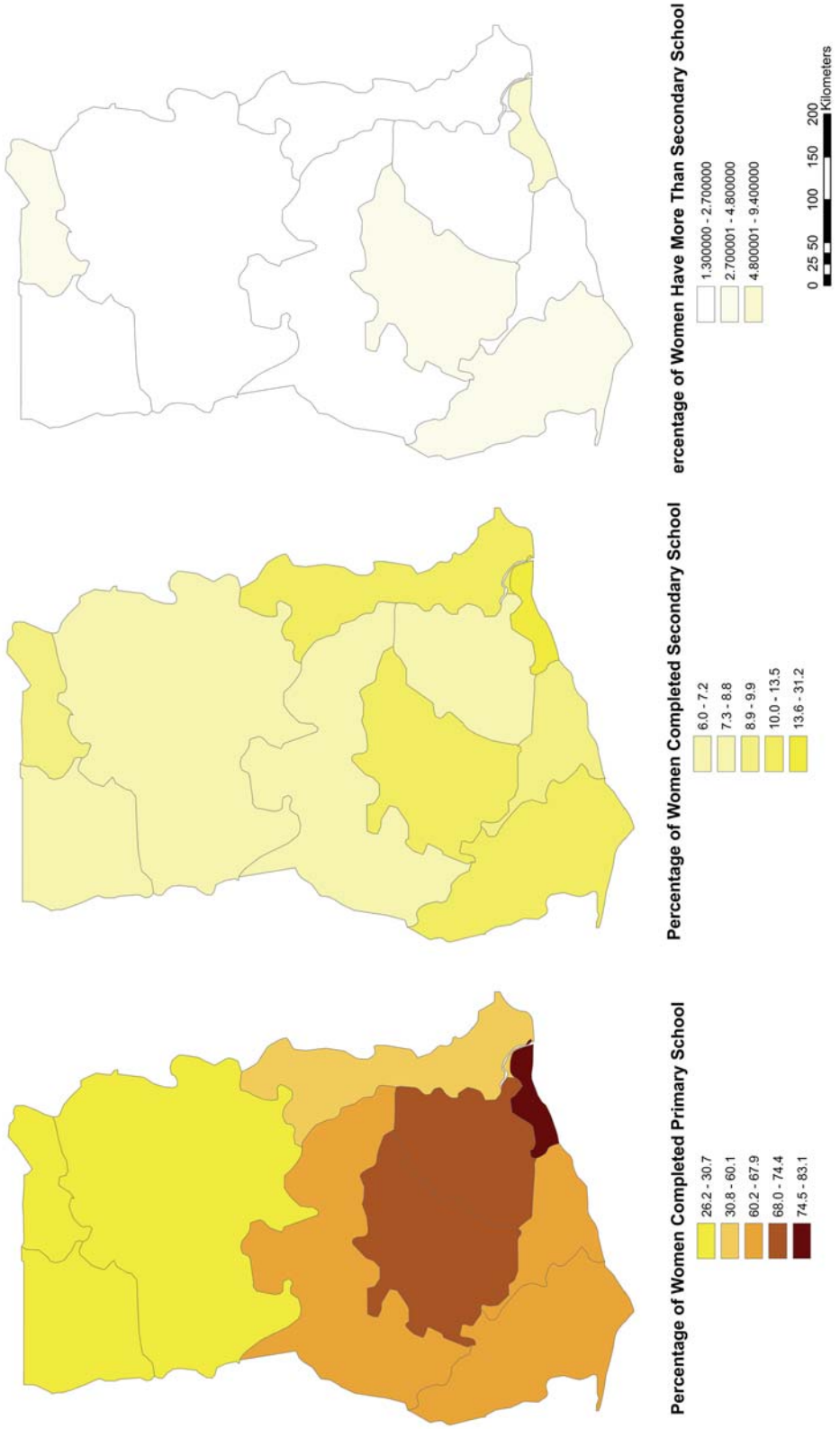


Figure 4-9 Percentage of women (aged 15-49) completed primary, secondary school and more than secondary school education in Ghana (Data from GSS demographic and health survey, 2009)

Both Figure 4-8 and 4-9 show that education, regardless of primary, secondary or tertiary education is more widespread in Greater Accra and Ashanti Regions (areas where the colors are darker); while northern regions are always lighter than the southern regions in all education levels.

When compared with primary school education, there are far fewer people who have completed secondary school, and less than 16% and 8% of men and women respectively who have attained education greater than secondary school. And the highest completion of secondary education rate for both men and women come from Greater Accra Region.

Gender disparity in education is severe in all regions as the scale of Figure 4-8 (male education) is always higher than that in Figure 4-9 (female education). However, since the MDG Goal 3 *Gender Parity* is not one of the scopes of this thesis, the analysis of difference in female and male education is not included in the analysis.

Although Ghana is rapidly approaching the goal to provide primary education universally and both men and women in Ghana completed primary school, the scale of the Figure 4-8 and 4-9 indicate that Northern, Upper East and Upper West Regions have almost half of the population from age 15-49, including over 2/3 of the women not being able to finish primary school or never been to primary school at all.

4.1.3 Natural Resources

4.1.3.1. Water Resources

4.1.3.1.1 National Water Resources Data

According to *AQUASTAT,* the Food and Agricultural Organisation of the United Nations (FAO), Ghana has 51.9 billion cubic meters per year of surface water and 26.3 billion cubic meters per year of groundwater in 2010 (*AQUASTAT*[35]*,* 2010). With the population of Ghana in 2010, it is estimated that total renewable water resources per capita is 3206 cubic meter per inhabitant per year. Water withdrawal is used for three types of activities: agriculture, municipal and industry. The source of water withdrawal is mainly surface water (0.37 billion cubic meters per year) and approximately 22% as groundwater (0.107 billion cubic meters per year)[36].

[35] Data collected in 2010. Internal Estimate by *AQUATAT and it is* obtained from *AQUATAT,* the Food and Agricultural Organisation of the United Nations (FAO), online access on: http://www.fao.org/nr/water/aquastat/data/query/results.html

[36] Data collected in 2000. Aggregate value, either an aggregate of more than one source, or a calculated value depending on values with mixed symbols obtained from *AQUATAT*, FAO, online access on: http://www.fao.org/nr/water/aquastat/data/query/results.html

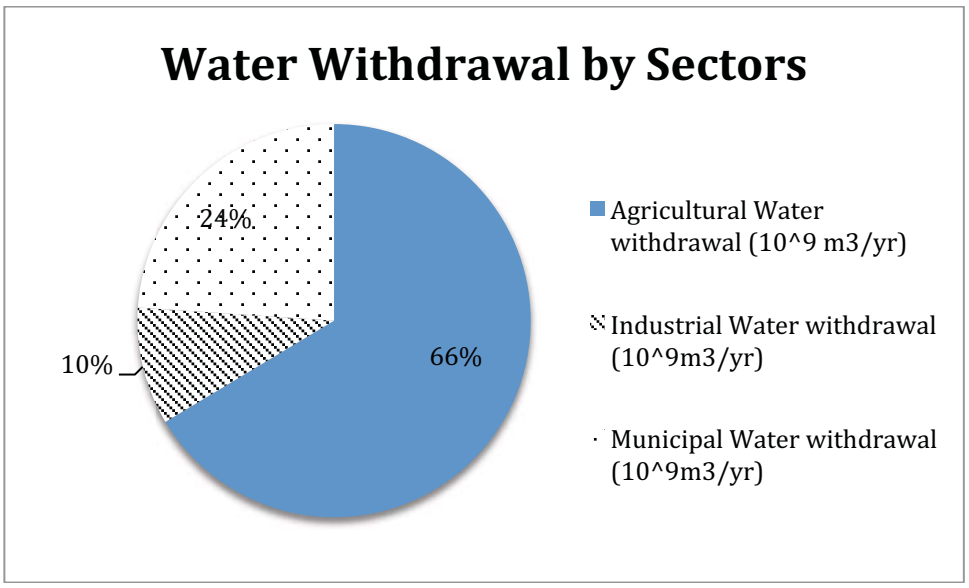


Figure 4-10. Water withdrawal in Ghana by sector (2010), data obtained from *AQUASTAT*, FAO, data from 2000[37]

As shown in Figure 4-10, the agriculture sector is the main water withdrawal, representing over 66% (0.652 billion cubic meters per year) of the total water withdrawal. Next is municipal water withdrawal, which represents 24% (0.235 billion cubic meters per year) of the total water withdraw. Industry withdraws the lowest amount (less than 10% of the total withdrawal).

4.1.3.1.2 Regional Water Resources Data

We have also collected two types of regional data related to/on water resources and its accessibility.

1. Average minutes to get to drinking water source. This set of data indicates the accessibility of public water facilities in different regions.
2. Precipitation and surface water at 10 different regions. This data helps us understand natural water available for these regions.

[37] Data obtained from FAO on July 6th, 2012 and figure is generated from Excel®. Online access on: http://www.fao.org/nr/water/aquastat/data/query/results.html

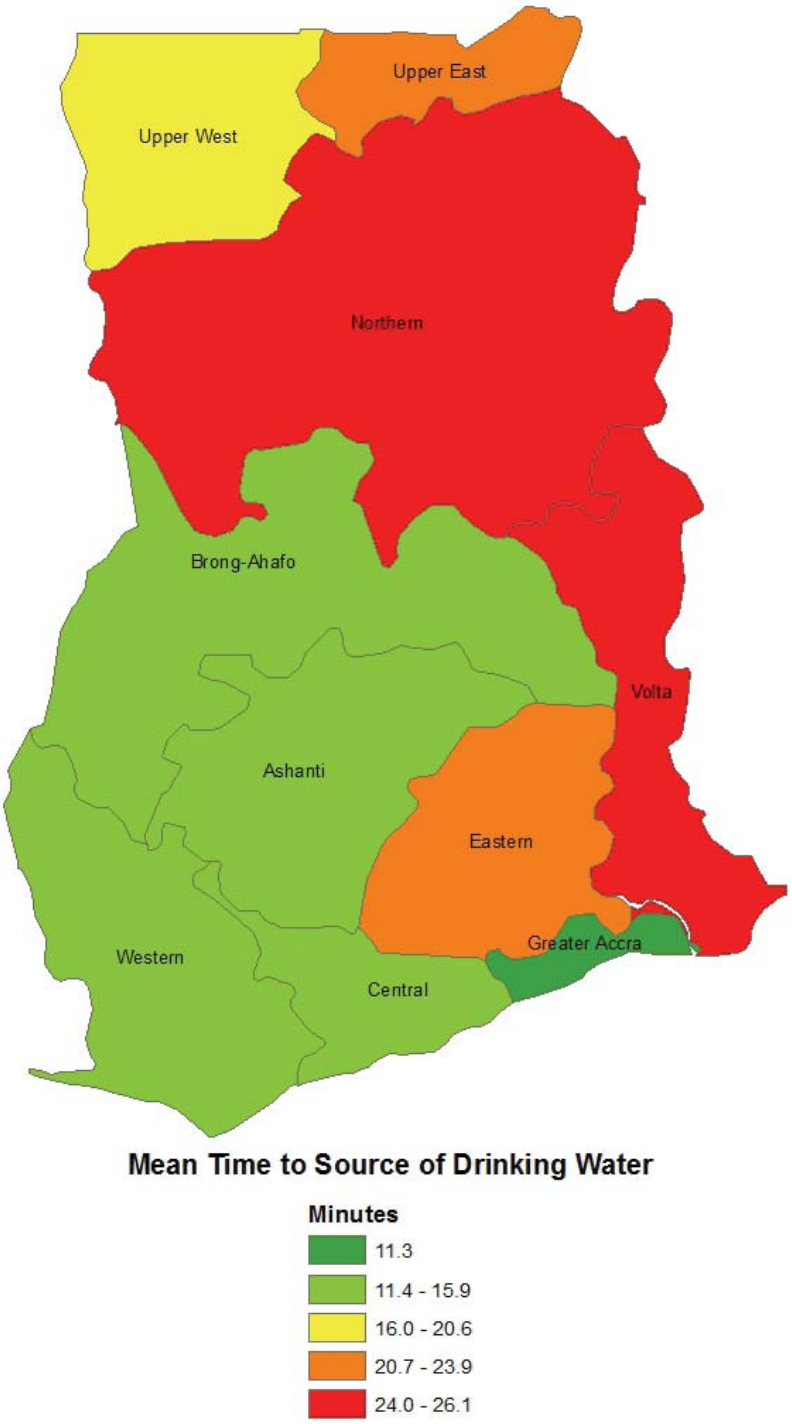


Figure 4-11. Average time in minutes to get to the source of drinking water in 10 different regions in Ghana in 2006 (data obtained from GhanaInfo[38])

[38] Data obtained from GhanaInfo, typed in indicator: drinking water, choose "Mean Time to Source of Drinking Water". Online available at: http://www.ghanainfo.gov.gh/. Assessed on July 10th, 2012

Figure 4-11 shows that people in Greater Accra Region use the least mean time (11.3 minutes) to access drinking water compared to other regions. People in the Northern and Volta Regions take the longest time to the drinking water source (24-26 minutes respectively). Regions such as Western, Central, Ashanti and Brong Ahafo Regions, although close to the coast or Volta Lake, also take 12-15 minutes to access drinking water.

According to WHO report by Howard and Bartram, household's water service level can be measured by the time it takes to get access to drinking water (Howard and Bartram, 2003).

Table 4-1. Summary of access measure (Howard and Bartram, 2003)

Service level	**Access measure**	*Needs met*	**Level of health concern**
No access (quantity collected often below 5 l/c/d)	More than 1000m or 30 minutes total collection time	Consumption – cannot be assured Hygiene – not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 l/c/d)	Between 100 and 1000m or 5 to 30 minutes total collection time	Consumption – should be assured Hygiene – handwashing and basic food hygiene possible; laundry/ bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 l/c/d)	Water delivered through one tap on-plot (or within 100m or 5 minutes total collection time	Consumption – assured Hygiene – all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity 100 l/c/d and above)	Water supplied through multiple taps continuously	Consumption – all needs met Hygiene – all needs should be met	Very low

Table 4-1 suggests that one is considered not to have access to drinking water if it takes more than 30 minutes to collect water. Taking 5-30 minutes to collect water is under the category of *basic access* to drinking water. With the data shown in Figure 4-11, although mean time to get to the source of drinking water varies, ALL regions, on average,, only reached the *basic access* service level based on these Table 4-1.

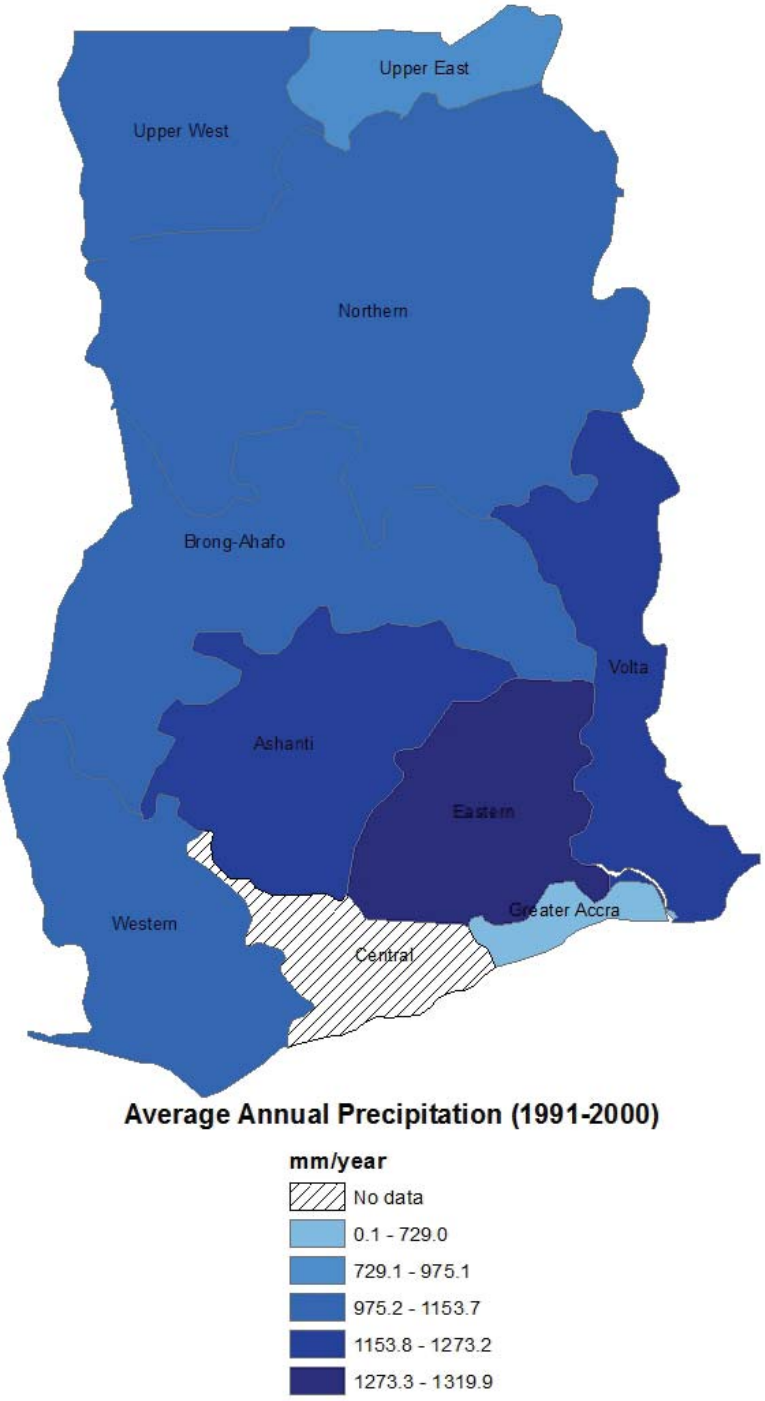


Figure 4-12. Annual precipitation in millimeter in 10 regions in Ghana during 1991 to 2000 period (Note: Central Region data is not available). Data source from Meteorological Service Agency[39]

[39] Data collected from GhanaSTAT. Online available at: http://countrystat.org/gha/cont/pxwebquery/ma/081swa011/en. Assessed on July 5th, 2012

In Figure 4-12, annual average precipitation is fairly balanced in its distribution. The least annual precipitation is in Greater Accra and the most is in Eastern Region, which borders of Greater Accra. Other regions Western, Brong Ahafo, Norterhn and Upper West regions all have relatively similar annual precipitation levels.

According to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation 2012 report, piped drinking water covered 33% and 3% of the population in urban and rural areas respectively in 2010 (JMP, 2012a). Table 4-1 suggests that *water supplied through multiple taps continuously* is considered as *optimal access* to drinking water. Figure 4-11 suggests that it is likely that, in both urban and rural areas, public water facilities, such as piped water, has not benefited the majority of the population, since the mean time to get access to source of drinking water range from 11.3 to 26.1 minutes, even in relatively prosperous area such as Greater Accra. When compared with different regions (Figure 4-12), Volta Region, for example, has relatively abundant precipitation; yet, people take the longest average time to get to the drinking water source. This suggests that water abundance does not necessarily translate into having a water service level.

4.1.3.2 Oil Palm

4.1.3.2.1 National Oil Palm Data

According to the Master Plan of Oil Palm Industry Ghana Final Report, the total area under oil palm is about 336,000 hectares (ha) in 2010 (MASDAR, 2011). The report says that average production of fresh oil palm fruit bunches is 15 metric tonnes (mt)/ha in Ghana, of which yields total 5,040,000 metric tonnes of fresh oil palm fruit. The oil palm produces palm oil that is mostly used as cooking oil in Ghana, and it can also be used as soap and margarine (MASDAR, 2011).

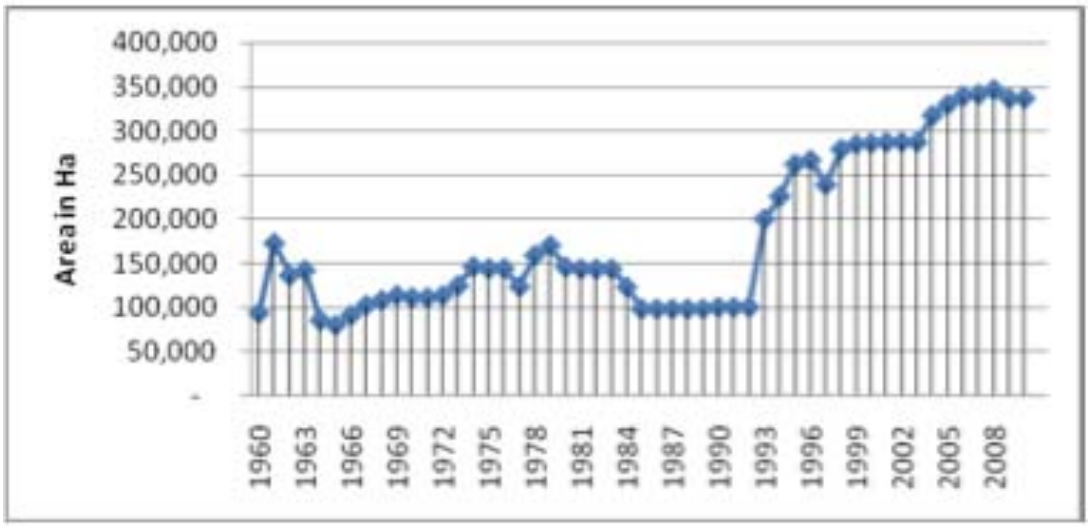


Figure 4-13. Total oil palm cultivation area in Ghana from 1960 to 2010 (MASDAR, 2011)

Figure 4-13 shows that areas for oil palm cultivation increased dramatically from 1992 to 1996. This was also during a period when the President's Special Initiative on Oil Palm was

launched (MASDAR, 2011). Since then, the area for oil palm has slowly and steadily increasing.

4.1.3.2.2 Regional Oil Palm Data

Data on percentage of areas under oil palm cultivation by region is collected to estimate the production of palm oil in different regions.

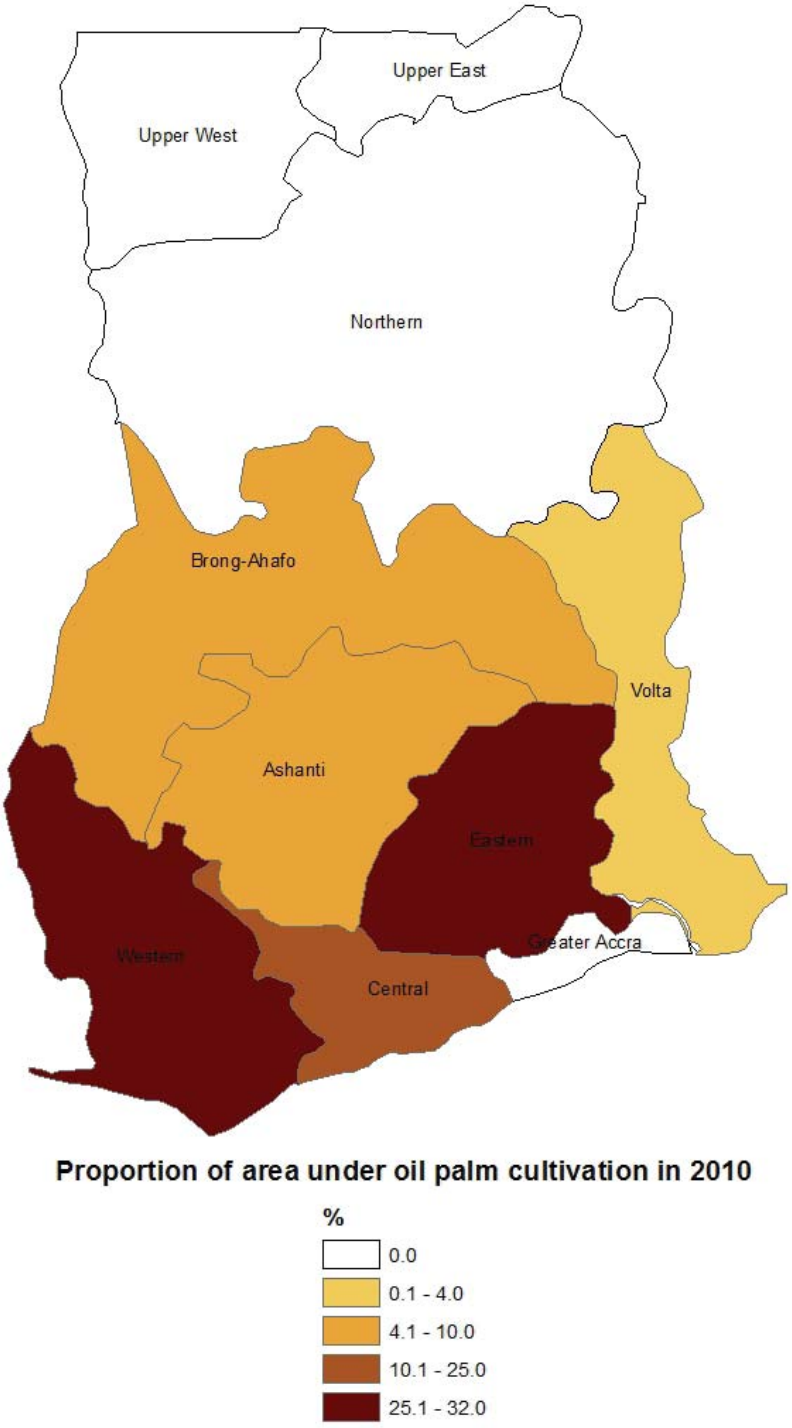


Figure 4-14. Proportion of area under oil palm cultivation by region in 2010. Data from MASDAR, 2011 Final report[40].

[40] Data collected from the final report of master plan study on the oil palm industry in Ghana, MASDAR Consulting Team 2011. Online available at: http://mofa.gov.gh/site/?page_id=10244. Accessed on July 1st, 2012

Figure 4-14 shows that the Western and Eastern Regions are the sites of the major oil palm cultivation plants. The total areas for oil palm cultivation in these two regions accounts for over ½ of the total area in Ghana, which is 168,000 ha and can potentially produce over 2.5 million metric tonnes of fresh palm oil brunches. The Central Region is the location of one-third of oil palm area by percentage. Greater Accra and the Northern Sector (Northern, Upper West and Upper East) do not have oil palm cultivation areas.

4.1.3.3 Cocoa

4.1.3.3.1 National Cocoa Data

The production of cocoa in Ghana goes through its ups and downs in the past decades (Kolavalli and Vigneri, 2010). On a national scale, Kolavalli and Vigneri report that two organizations Gill & Duffus Group and the Ghana Cocoa Marketing Board have monitored the production of cocoa from 1900 to 2008 (Gill & Duffus Group, 1976; Ghana Cocoa Marketing Board, 2008). That data is used as the background to help understand the cocoa market in Ghana.

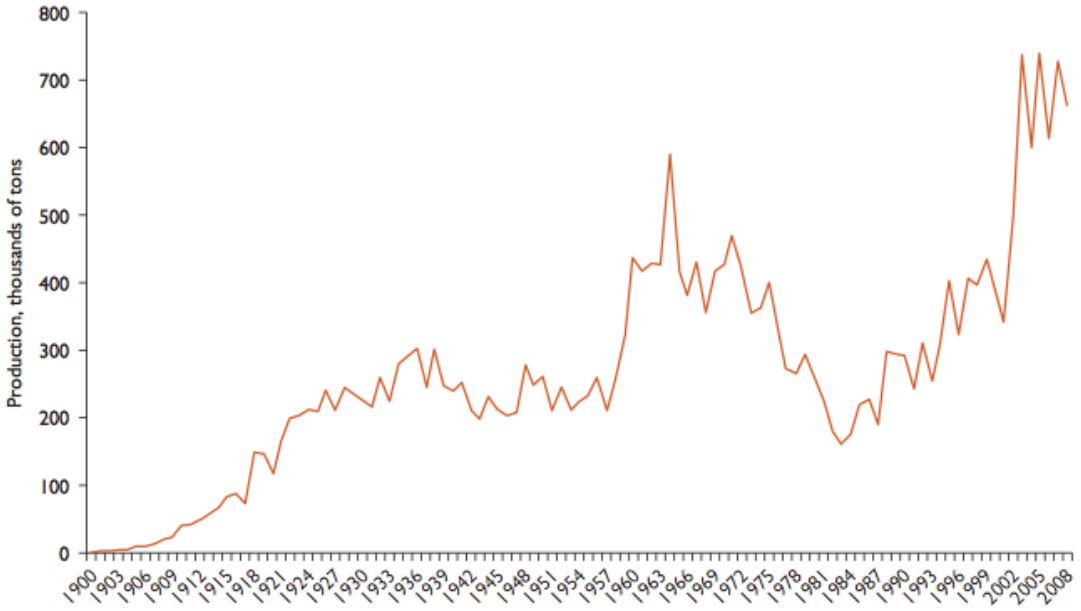


Figure 4-15. Production of cocoa in Ghana from 1990 to 2008, source from Gill & Duffus Group and Ghana Cocoa Marketing Board, generated by Kolavalli and Vigneri in 2010.

4.1.3.3.2 Regional Cocoa Data

Production and number of cocoa yield from 2005 to 2006 in 10 regions are presented.

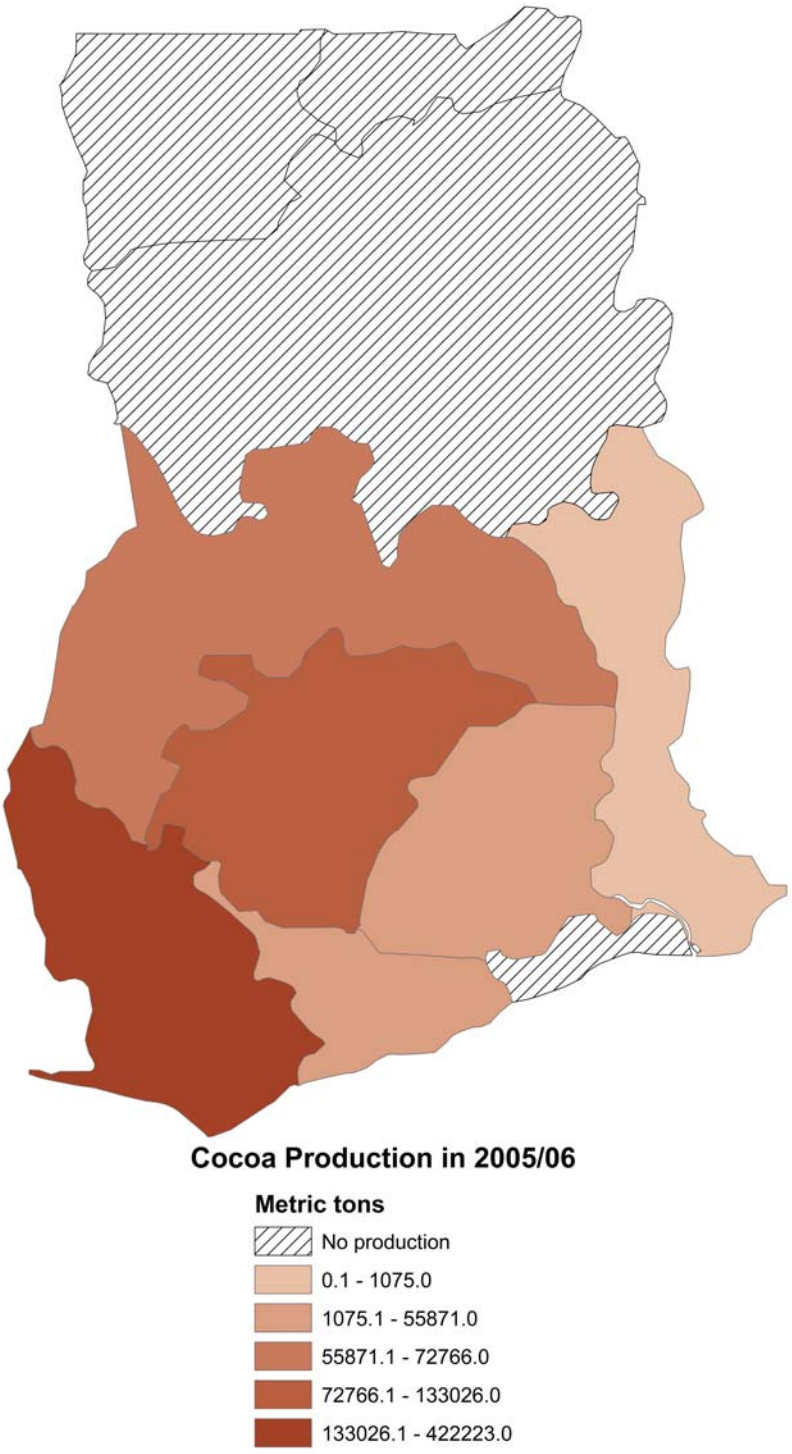


Figure 4-16. Cocoa production and yields from 2005 to 2006 in six regions in Ghana. Data from the Ghana Cocoa Board: Economic Activities

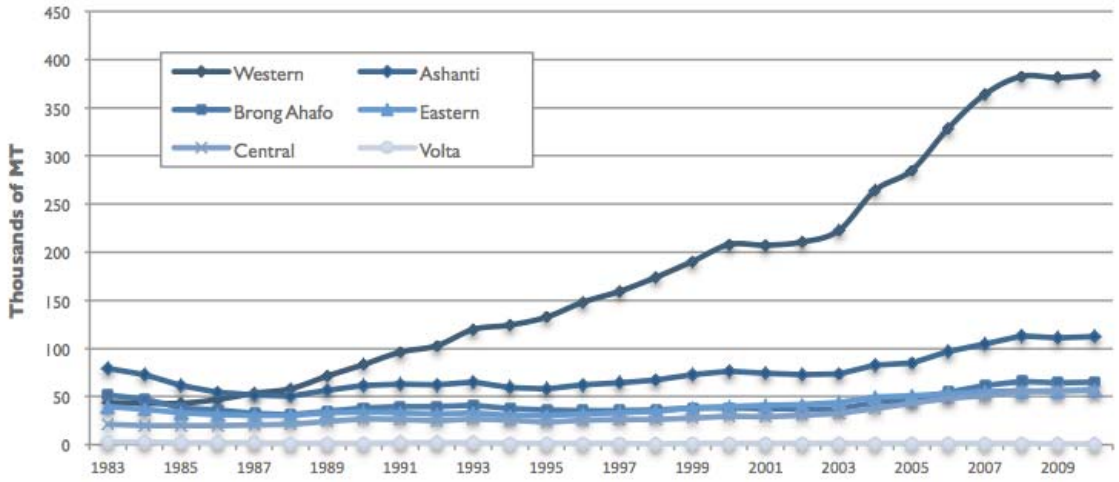


Figure 4-17. Cocoa production from 1983 to 2009 from six regions that produced cocoa (World Bank, 2010)

Figure 4-16 shows that only Greater Accra and the Northern Sector (Northern, Upper West and Upper East) do not have any production of cocoa. The Western Region has the highest cocoa production in 2005-2006. Both Figure 4-16 and Figure 4-17 show that the Western Region has the highest cocoa yield from 1983 to 2010 (World Bank, 2010). In recent years starting from 2003 (Figure 4-17), the amount of cocoa produced in the Western Region increased dramatically and became steady and highly productive since 2008. Other regions Ashanti, Brong Ahafo and Central all have had a slight increase in cocoa production since 2004. The production of Volta Region is small compared to other regions and therefore, increase in production is not obvious (Figure 4-17).

The disparity of cocoa production might be due to the variety of geographic locations, where the growth of cocoa requires suitable climate that includes a certain combination of hours of sun, rainfall, soil conditions and temperature (Anim-Kwapong and Frimpong, 2004). Such advantages have made the Western Region become the main cocoa producers with over 50% of the products coming from that region.

4.2 Data Analysis and Discussion

4.2.1 Data Analysis Methodology

4.2.1.1 Correlation Analysis

The primary foci of first part of this thesis are economics, education and natural resources indicators. Before comparing 10 regions and providing national and regional development strategy recommendation based on these foci and the current situation of these regions, correlation between economics, education and natural resources will first be analyzed by measures using statistical dependence

Pearson correlation coefficient analysis will be used to determine the linear dependence of two variables. The Pearson correlation coefficient can also be generated in Excel® using linear regression function.

4.2.1.2 Ranking Analysis

To enhance the correlation analysis (Pearson correlation), the ranking analysis is used as well. The method is similar to the first part (the ranking step) of the Spearman's rank correlation,, a non-parametric measure of statistical dependence between two variables within nominal variables, which assesses the relationship between two ranked variables (Leard Statistics, 2012). The ranking is based on the best performance. The ten regions in Ghana will be ranked from the best performance to the worst in the themes of interest. For example, best performance can mean: the least proportion of population under poverty line, the highest percentage of school-age children completed primary school, etc. All indicators' ranking will be compared in order to investigate whether there are patterns of such rankings. For example, when economic indicator is ranked No.1, whether natural resources are also ranked No.1 etc.

4.2.1.3 Combination Analysis

The purpose of this analysis is to help better understand the correlations and prioritize planning on a regional and national scale in Ghana. The combination analysis is only used for natural resources indicators when finding the correlations with economics and education, since natural resources have more indicators.

The method is to consider economics (X), education (Y) and natural resources (Z) as three sets of data. Each set of data has its own indicator(s).

- Economics has one indicator: Proportion of population under poverty line (X1);
- Education has two indicators:
    - Percentage of population completed primary school (Y1),
    - Percentage of population completed secondary school (Y2);
- Natural resources (Z) has four indicators:

- mean time to source of drinking water (Z1),
- average annual precipitation (Z2),
- percentage of area for oil palm plantation over the total area of oil palm in Ghana (Z3) and,
- production of cocoa (Z4).

Each set of (X, Y, Z)'s indicators will be compared with all other indicators to find the Pearson correlation coefficient (R) of every paired indicator set. At the same time, each indicator will be scored (Score 1-10 [the author defined this score as performance score (iScore)], 10 is the highest score) based on their ranking compared to other regions, highest ranking receive 10 and the score descends as the ranking goes down. The iScore then multiplies by the corresponding correlation coefficient square R^2 and this is the final score [the author defines this score as fScore] of two related indicators.

For example, we are interested in sets X & Y. X has one indicator X1 and Y has two indicators Y1, Y2 among four regions. To estimate the correlation between X1 and Y (include both Y1 and Y2), the correlation can be obtained by three steps:

1. Calculate the linear regression coefficients between X1 and Y1 ($R1^2$), X1 and Y2 ($R2^2$);
2. Now regions ranking are as followed:
    a. Region 1 – Y1: 2 Y2: 1;
    b. Region 2 – Y1: 3 Y2: 2;
    c. Region 3 – Y1: 1 Y2: 3;
    d. Region 4 – Y1: 4 Y2: 4;

    So iScore will become:
    e. Region 1 – Y1: 9 Y2: 10;
    f. Region 2 – Y1: 8 Y2: 9;
    g. Region 3 – Y1: 10 Y2: 8;
    h. Region 4 – Y1: 7 Y2: 7;
3. Then calculate fScore:
    a. fScore for Region 1: $9^* R1^2 + 10^* R2^2$
    b. fScore for Region 2 : $8^* R1^2 + 9^* R2^2$;
    c. fScore for Region 3 : $10^* R1^2 + 8^* R2^2$;
    d. fScore for Region 4 : $7^* R1^2 + 7^* R2^2$.
4. Finally all four regions in set Y will have a new set of total indicator scores to correlate with set X.

The benefit of such an analysis is to eliminate or lessen the impact of less important indicators to the set of interest, while strengthening the key indicators' contribution towards the correlation between two or more sets. The combination analysis will be used for calculating a better relationship between the selected natural resources and education and economics.

4.2.1.4 Correlation Scale

To better define the how closely each set of indicators are correlated, the author has defined scales for Pearson's correlation coefficient (R) and *combination analysis*:

- No correlation: $R^2 = 0$;
- Weak correlation: the correlation square $R^2 \in (0,0.25]$
- Moderate correlation: $R^2 \in (0.25,0.55]$
- Strong correlation: $R^2 \in (0.55, 1]$

4.2.1.5 Scenario Analysis

Scenario analysis is used to further explore the correlation between proportion of population under the poverty line and proportion of population that has completed secondary education. It is used to calculate, under the different assumptions whether the percentage of the people who have completed secondary school come from above the poverty line or whether the percentages of population completed secondary education come from two tiers (namely, the population coming from above the poverty line and below the poverty line).

For example, for a region that have X% of the population under the poverty line and Y % of population completed secondary school, assume Q % of the secondary education come from the population above the poverty line,

a. The percentage of population above the poverty line that have a secondary degree = Y*Q/(1-X);
b. The percentage of population under the poverty line that have a secondary degree = Y*(1-Q)/X

4.2.1.6 Advantage Analysis

Advantages analysis is a method that the author developed to see whether certain regions have similar patterns compared to the national average. It is particularly used for correlation between the three designated areas this thesis is focusing on. The idea is to compare the differences in each region with the national average for economics, education and natural resources in order to identify advantages in development for each region and find out if there is any similar pattern for advantages in the indicators selected. Advantage calculation score (A) for an indicator of one Region (Xi) can be performed as: $A_i = X_i$ – Average of $X_{i, j, k,...}$, and plot all $A_{i, j, k, ...}$ into a radar chart in Excel to compare the shapes and patterns for all indicators.

4.2.2 Economics and Education

4.2.2.1 Analysis on Economics and Education

This section is focusing on the relationships between economics and education indicators: Proportion of population under the poverty line (economic indicator) and percentage of population completed primary school and secondary school (education indicators).

The coefficient R between the proportion of population under the poverty line and the percentage of population completing primary school is -0.88, which means that the economic indicator and education indicator (completion of primary school) is highly negatively correlated (i.e., strong correlation as for Section 4.2.1.4). However, when compared with the second education indicator (completion of secondary school), economic indicator has weaker correlation with education, though the coefficient R-value is still relatively high (-0.55). A linear regression is also calculated using Excel Spreadsheet (Figure 4-18 a-d).

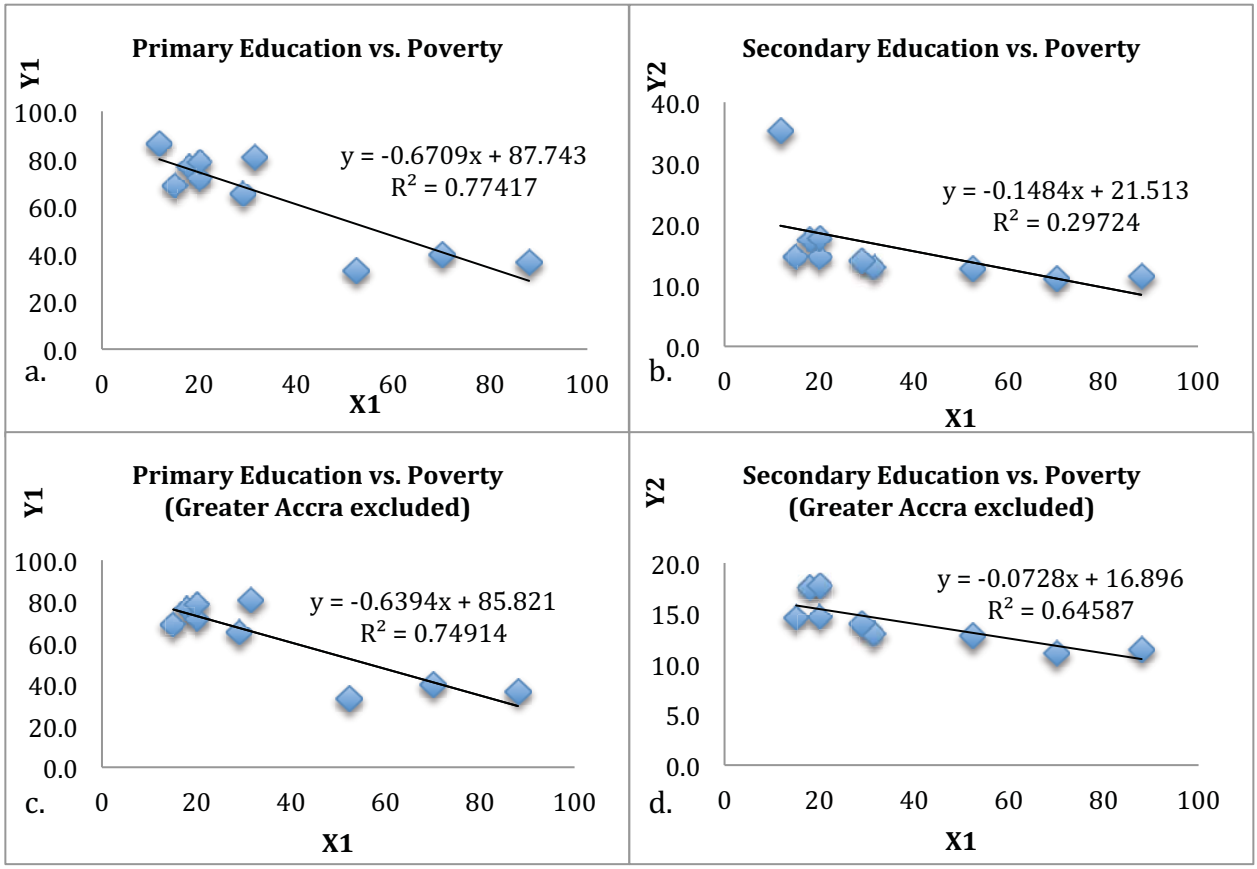


Figure 4-18 a-d. Linear regression for proportion of population completed primary school and secondary school with population under the poverty line. Y1 = Proportion of population completed primary school; Y2 = Proportion of population completed secondary school; X1 = Proportion of population under the poverty line.

In Figure 4-18 b., an outlier, a point that does not fit the general trend has appeared. This outlier belongs to the Greater Accra, where secondary education is much higher than other regions. When this point is eliminated, Figure 4-18 c and d are generated to compare the correlations between both education indicators with the economic indicator.

From Figure 4-18 a-d, it is obvious that both education indicators (completion of primary school and secondary school) are negatively correlated with economic indicator (proportion under poverty line), although secondary education has weaker correlation with the proportion under the poverty line. However, after eliminating the outlier, secondary education has a much stronger negative correlation with proportion of education under poverty line. Both Figure 4-18 a and c confirm that primary education, has a stronger correlation with proportion of population under the poverty line, with and without the outlier Greater Accra, which has the best performance in all three indicators.

Rankings and proportion of population under poverty line, completed primary school and secondary school for 10 regions in Ghana are presented in Table 4-2.

Table 4-2. Proportion and ranking of population under poverty line (X), percentage and ranking of population completed primary school (Y1) and completed secondary school (Y2) among 10 regions

Under Poverty (X) vs. Completed Secondary (Y2) and Completed Primary (Y1)						
	(X) Under Poverty (%)	(Y1) Completed Primary (%)	(Y2) Completed Secondary (%)	Rank X	Rank Y1	Rank Y2
Western	18	76.7	17.5	3	4	3
Central	20	72.0	14.7	4	5	4.5
Greater Accra	11.8	86.3	35.3	1	1	1
Volta	15.1	69.1	14.7	2	6	4.5
Eastern	31.4	80.9	13.0	7	2	7
Ashanti	20	78.6	17.8	5	3	2
Brong Ahafo	29	65.5	14.0	6	7	6
Northern	52.3	33.2	12.8	8	10	8
Upper East	88	36.8	11.5	10	9	10
Upper West	70	39.9	11.1	9	8	9

Table 4-2 along with Figure 4-18 a and c, indicates that it is very likely that economics indicator has a strong correlation with primary school education. Greater Accra has the highest primary education level and the lowest poverty proportion. Similarly, regions with lowest percentage of completion of primary and secondary school, i.e., Northern Region, Upper East and Upper West, have the highest proportion of population under poverty line. In fact, each of these regions's proportion under the poverty line is (roughly) doubled or more compared to the next ranked region (Eastern region 31.4%), and completion of primary school is almost half of the next ranked region (Brong-Ahafo 65.5%). With more than half of the population below the poverty line and less than 2/5 of the population completed primary school in these three northern regions of Ghana (Northern Regions, Upper East and Upper West), both MDGs for *Eradicate Extreme Poverty* and *Achieve Universal Primary Education* are very likely to fail by 2015 in these areas.

Meanwhile, all regions only have 11%-18% of completion of secondary school, except the Greater Ghana Region (35.3%), of which the completion of secondary school is almost doubled of that the second ranked region (Ashanti:17.8%). While proportions of population below poverty line of Volta and Western Regions are similar to that of Greater Accra, the percentage of population completing secondary education is not quite the same. It indicates that the population under poverty line has weaker correlation with the population completed of secondary school compared to that with the population completed primary school.

When compared with the secondary education and primary education (proportion of completing secondary school divided by proportion of completed primary school) (Table 4-3), it shows that the Northern Sectors of Ghana, though the completion of secondary school is the lowest among all, the percentage of students continue to finish secondary school after completion of primary schools is the highest compared to other regions except Greater Accra. It indicates that people in Northern Sector of Ghana and Greater Accra who complete primary school are more likely to go for further secondary education than people in other regions.

Table 4-3. Ratio of population completed secondary school to population completing primary school and their rankings of 10 regions

Regions	(W) Y1/Y2	Rank Y1/Y2
Western	23%	5.5
Central	20%	9
Greater Accra	41%	1
Volta	21%	7.5
Eastern	16%	10
Ashanti	23%	5.5
Brong Ahafo	21%	7.5
Northern	39%	2
Upper East	31%	3
Upper West	28%	4

Again, the author compared such a ratio (proportion of population completed secondary school over primary school) with proportion of population under the poverty line. A linear regression line is plotted (Figure 4-19). The analysis shows that the economics indicator (proportion under the poverty line) of the area has less to do with the population who continue to finish higher education (completion of secondary school) after completion of primary school.

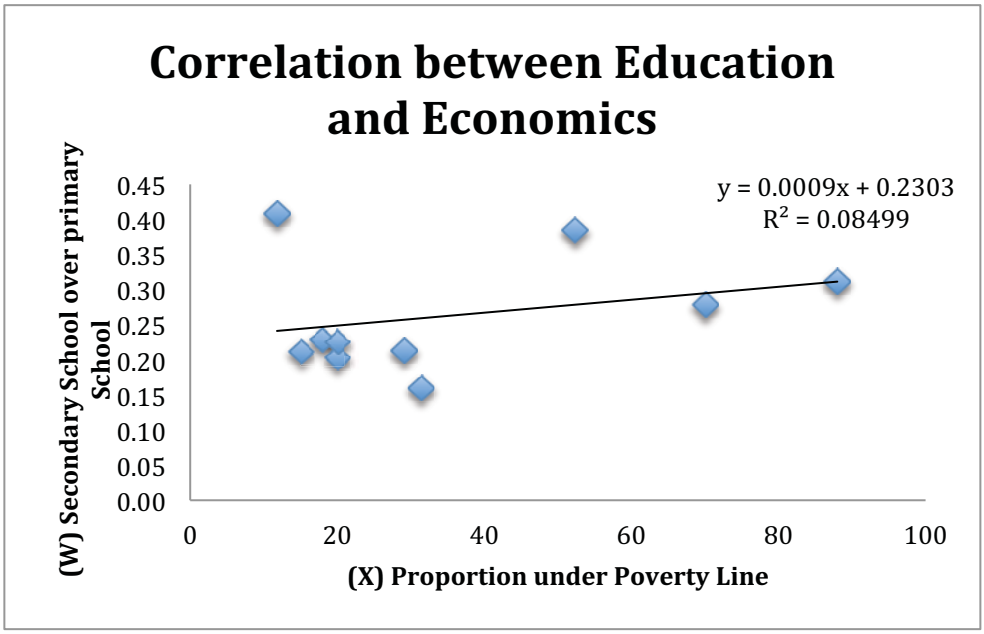


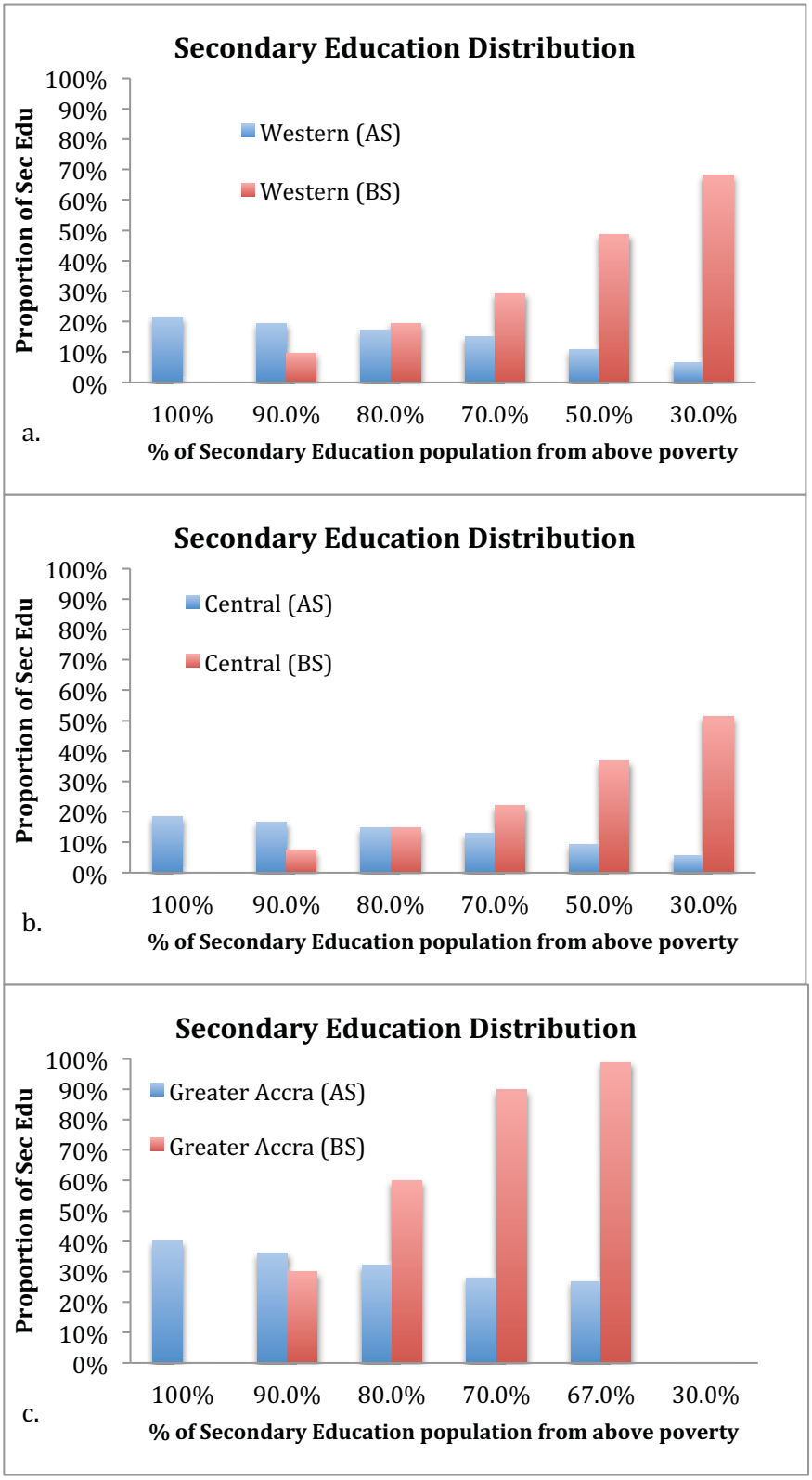
Figure 4-19. Correlation between ratios of the proportion of secondary school to primary school with proportion of population under the poverty line

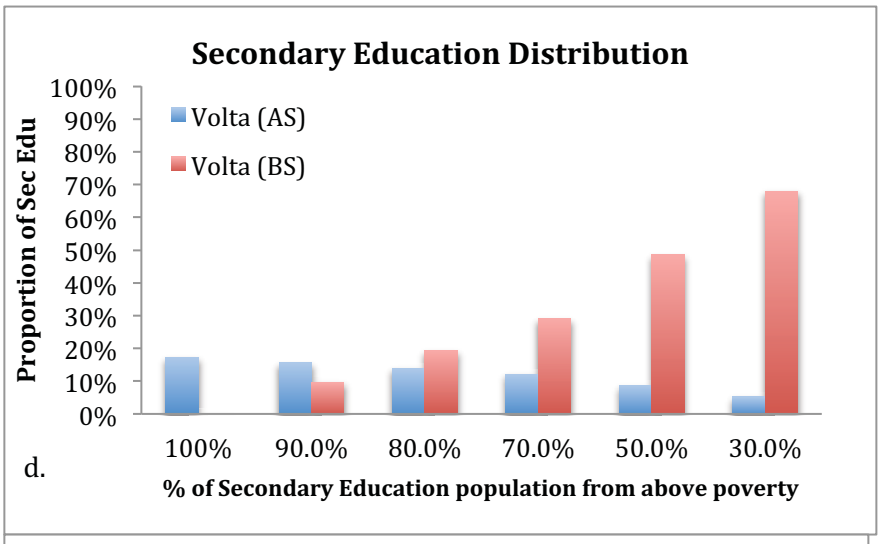
According to the Ghana MDGs report, Ghana is on track for achieving *Universal primary education* MDG 2 target 2.A by 2015 (UN, 2010). From the data shown in the previous section and analysis in this section, school-age children are likely to complete primary school even in economically disadvantaged regions, such as Northern Region, Upper East and Upper West.

While the correlation shows that secondary education has a weak correlation with the proportion of the population under the poverty line than primary education, further analysis on the correlation between extreme poverty and secondary education is necessary to help understand the complex issue and potential inter-relationship between economics and education.

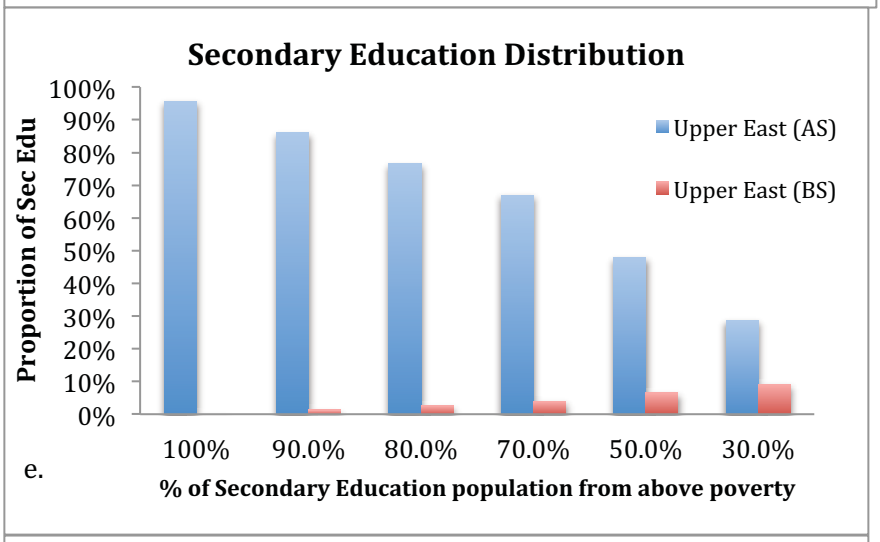
Therefore, the author also hypothesized several scenarios (scenario analysis described in Section 4.2.1.5) to calculate the percentage of secondary education among the population below and above the poverty line, in order to foresee the difficulties of achieving secondary education in two economic groups (below and above the poverty line) in 10 different regions. The idea is to compare the proportion of population who has completed secondary school among people living under the poverty line and those above. The hypothesis

assumes there are 100, 90, 80, 70, 50 and 30% of the population who completed secondary education coming from the population above the poverty line.

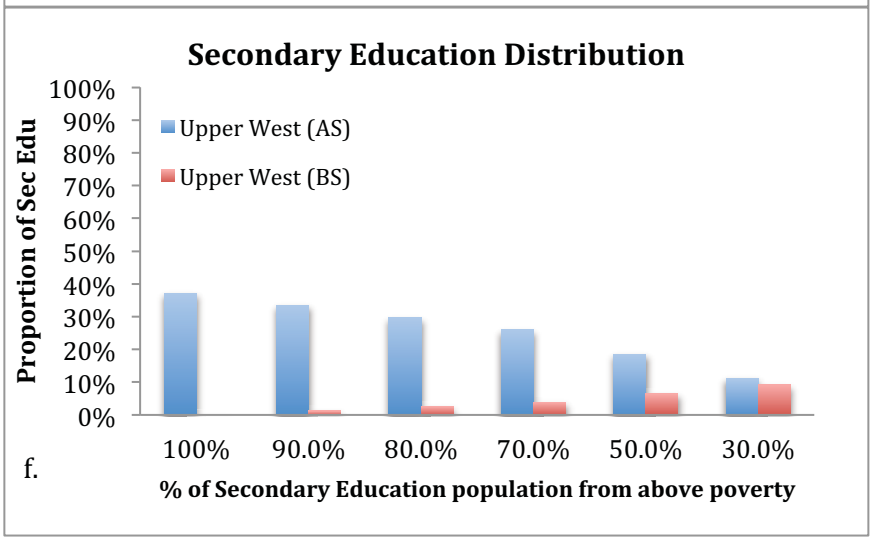



Secondary Education Distribution
Proportion of Sec Edu
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Volta (AS)
Volta (BS)
100%
90.0%
80.0%
70.0%
50.0%
30.0%
% of Secondary Education population from above poverty

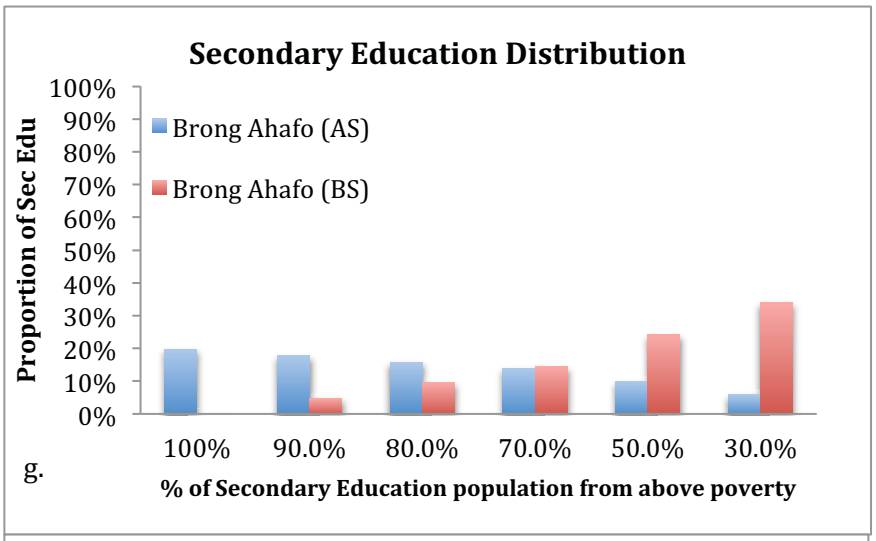
d.


Secondary Education Distribution
Proportion of Sec Edu
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Upper East (AS)
Upper East (BS)
100%
90.0%
80.0%
70.0%
50.0%
30.0%
% of Secondary Education population from above poverty

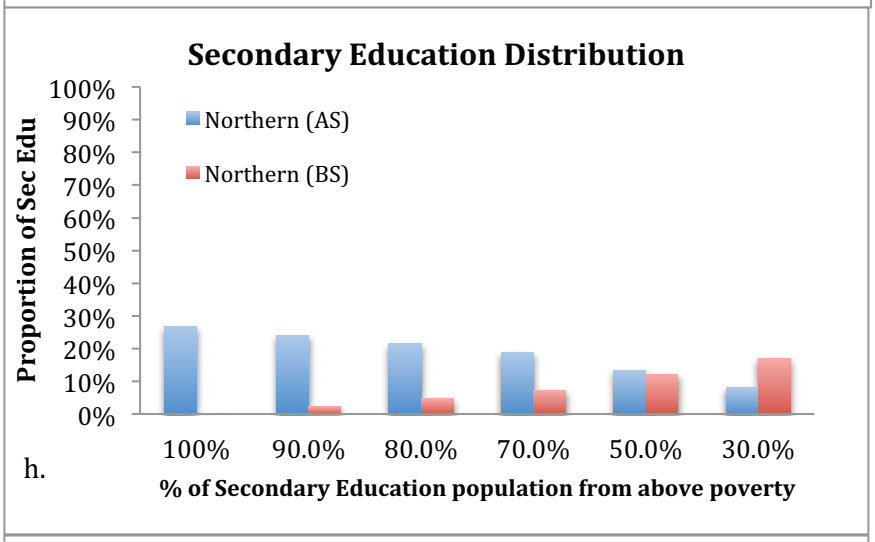
e.


Secondary Education Distribution
Proportion of Sec Edu
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Upper West (AS)
Upper West (BS)
100%
90.0%
80.0%
70.0%
50.0%
30.0%
% of Secondary Education population from above poverty

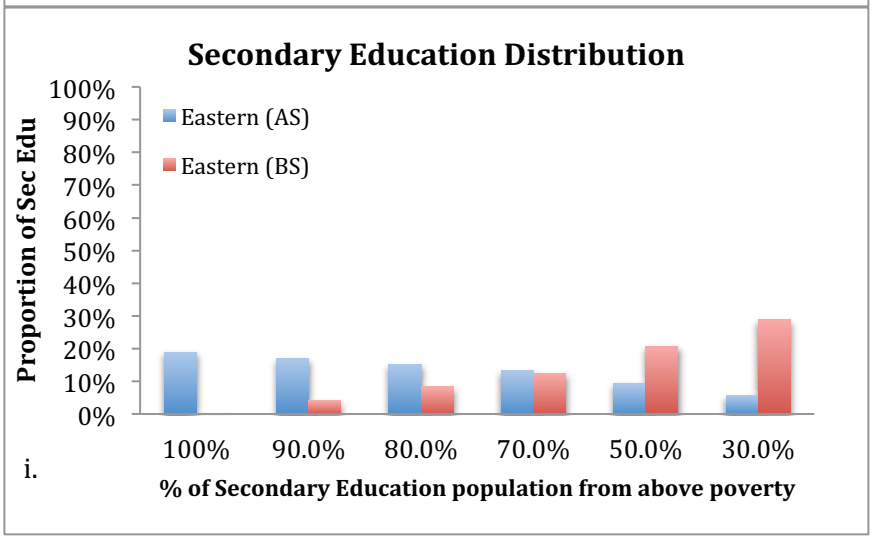
f.


Secondary Education Distribution
Proportion of Sec Edu
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Brong Ahafo (AS)
Brong Ahafo (BS)
100%
90.0%
80.0%
70.0%
50.0%
30.0%
% of Secondary Education population from above poverty

g.


Secondary Education Distribution
Proportion of Sec Edu
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Northern (AS)
Northern (BS)
100%
90.0%
80.0%
70.0%
50.0%
30.0%
% of Secondary Education population from above poverty

h.


Secondary Education Distribution
Proportion of Sec Edu
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eastern (AS)
Eastern (BS)
100%
90.0%
80.0%
70.0%
50.0%
30.0%
% of Secondary Education population from above poverty

i.

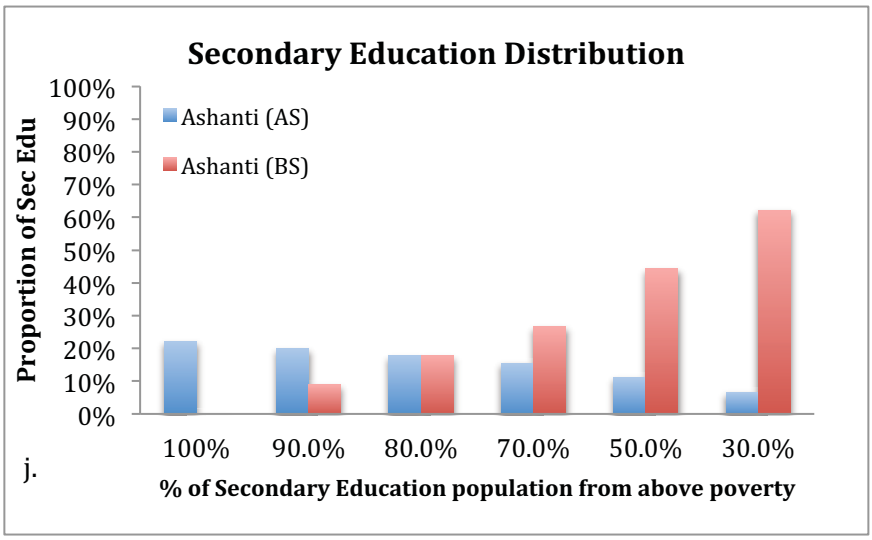


Figure 4-20 a-j. Prediction for proportion of population completed secondary school in two groups (under and above poverty line) in different scenario for 10 regions.
*AS = above the poverty line AND completed secondary school;
BS = below the poverty line AND completed secondary school.

In Figures 4-20 a-j, the proportions of population completed secondary school from both below and above poverty line are shown. These Figures show that secondary education distributions are imbalanced between population under poverty and above poverty. For Upper East (Figure 4-20 e), Upper West (Figure 4-20 f), Brong Ahafo (Figure 4-20 g.), Northern (Figure 4-20 h.), Eastern (Figure 4-20 i). Regions, less than half of the population have completed secondary school among people live under extreme poverty in all scenarios assumed. It indicates that if ones (government, NGOs, etc.) provide less than 70% of secondary education opportunities for the population under the poverty line (the other 30% for population above the poverty line), it is still very unlikely that the half population under poverty line will complete secondary education in these regions. If investment and efforts are put equally into both people who live under and above the poverty line, people above the poverty line will benefit first as a whole, since there is a larger amount of the population that lives under the poverty line. Therefore, a small growth in numbers of students completing secondary education will not largely affect the proportion on a large scale. For example, if the same effort is put towards ensuring that 4,800 students from population below and above the poverty line each complete secondary school in Upper East Region (Figure 4-20 e), under the scenario that 100% of the original people complete secondary school come from the population above the poverty line, only 1% of the population from below the poverty line are benefited, while nearly 100% of the population come from above the poverty line will complete secondary education.

One more important finding comes from Greater Accra (Figure 4-20 c.). The calculation shows that 33% of the populations who complete secondary school in Greater Accra come from a population under the poverty line, yet those people, though with secondary education, still live under extreme poverty in Greater Accra, where the capital Accra is

located. This tells us that completion of secondary education by itself does not guarantee economic well-being.

4.2.2.2 Interpretation and Conclusion

The proportion of the population under the poverty line has a strong correlation with primary education and moderate correlation with secondary education in Ghana, respectively. However, whether economics determines the education level or vice versa, is not fully indicated by the data and analysis presented. What is certain is that it will require much more efforts to balance and achieve greater equity in the differences between population under and above the poverty line in education, as it relates to completion of primary or secondary education.

Greater Accra, where the capital Accra is located, has historical advantages compared to other regions due to its early agriculture exports, prime climate, piped water and roadway infrastructure and Centralized Business District (Njeru, 2006; Skidmore and Lanegran, 2003). Therefore, it is reasonable to assume that the Greater Accra region is much more prosperous than other regions in Ghana. Additionally, the World Bank argues that greater investment into secondary education will accelerate Africa's economic growth (World Bank, 2007). The Ghana government was also convinced that higher education research focused on local development problems could bring economic progress, and therefore, this led to a series of reforms in secondary and higher education (Akyeampong, 2007). The National Democratic Congress (NDC), the major political party that won elections since 1992 also states that *access to education is an individual right for the development and fulfillment of the potential of each Ghanaians* in its MANIFESTO[41] in 1996 (NDC, 1996). Such an economic advantage and change in political attitude towards education might have affected the investment in education and therefore, more families in Greater Accra, who have more income than average households in Ghana, can afford their school-age children to go for secondary education. In figure 4-20 c supports this finding by showing that with more investment in secondary education, more population under the poverty line will benefit.

However, although without economic advantage, the Northern Sector, which has the largest proportion of the population living under the poverty line, it nonetheless has a higher percentage of school-age children completing secondary school after primary school than other more prosperous regions in the Central, Western and Eastern Regions. Although it is possible that the populations who have completed secondary school in Northern Sector are mostly coming from families whose income is higher than $1.25 per day or more, the data still suggests that people in Northern Sector will require less effort to achieve a higher completion of secondary education among people above the poverty line. However, with the current secondary education situation, it will require more than 70% of population who live below the poverty line to complete secondary school in order to reach a target of over half of the population under the poverty line receiving full secondary education.

[41] Script of the MANIFESTO can be found at:
http://www.ghanareview.com/NDC_Manifesto.html

The obstacle to achieve the MDG for education is that in areas where more population lives under extreme poverty, it takes much more effort to increase the percentage of the population completing secondary school. In more prosperous regions such as Greater Accra, although there is at least 33% of the population living below the poverty line have completed secondary education, their financial condition does not seem to improve (i.e., still live less than $1.25 per day) (Figure 4-20 c).

Key Findings:

- **R^2 correlations between primary education and poverty are: 0.77 and 0.75 (strong) with and without Greater Accra, secondary education and poverty correlations are 0.30 and 0.65 (moderate to strong) with and without Greater Accra;**
- **The economics indicator (proportion under the poverty line) of the area has less to do with the population who continue to finish higher education (completion of secondary school) after completion of primary school;**
- **In areas where more population lives under extreme poverty, it takes much more effort to increase the percentage of the population completing secondary school**
- **Greater Accra has at least 33% of the population, although completed secondary education, still living below the poverty line.**

4.2.3 Education and Natural Resources

Before getting into analysis of education and selected natural resources, correlationsNext we present analysis between selected natural resources is first presented to suggest possible correlations within among the natural resources indicators are considered. Selected natural resources should not be correlated since each selected resources should be an independent variables, so that when considering correlations between selected natural resources (combined) and other indicatorsand , analysis will not be interferedwill not interfere further analysis.

4.2.3.1 Selected Natural Resources Analysis

According to the annual precipitation map shown in the previous section (Figure 4-12), precipitation from 1971 to 2000 is most abundant in Eastern Region (1315 mm), Ashanti (1295 mm), Volta Region (1262 mm), Brong Ahafo (1154 mm) and Western Region (1117 mm)[42] Regions. The Oil Palm Research Institute (OPRI) suggests that oil palm production should have annual water precipitation of 1,300 mm for high production and biomass production (OPRI and NaanDanJain, 2011). The cash crop product of cocoa requires annual

[42] Data is for average rainfall from 1991-2000. Data collected from GhanaSTAT. Online access at: http://countrystat.org/index.asp?ctry=GHA&t=1&lang=1

rainfall from 1250 to 3000 mm per annum (BAR, 2007). Precipitation requirements for these two types of crops indicate that locations where oil palm and cocoa can be produced should be similar. Although not all regions in Ghana have precipitation greater than 1,300 mm and average annual precipitation of the most abundant regions (Eastern, Ashanti, Volta, Brong Ahafo and Western Regions) only reach slightly above 1,200 mm, the data we have collected for oil palm (Figure 4-14) and cocoa (Figure 4-16) show that the estimate rainfall requirements per annum are correct. Productions of these two crops occurred in the six regions[43] where precipitation is the most ample in Ghana.

To further analyze the correlation between the selected natural resources, correlation and ranking are both used for the analysis.

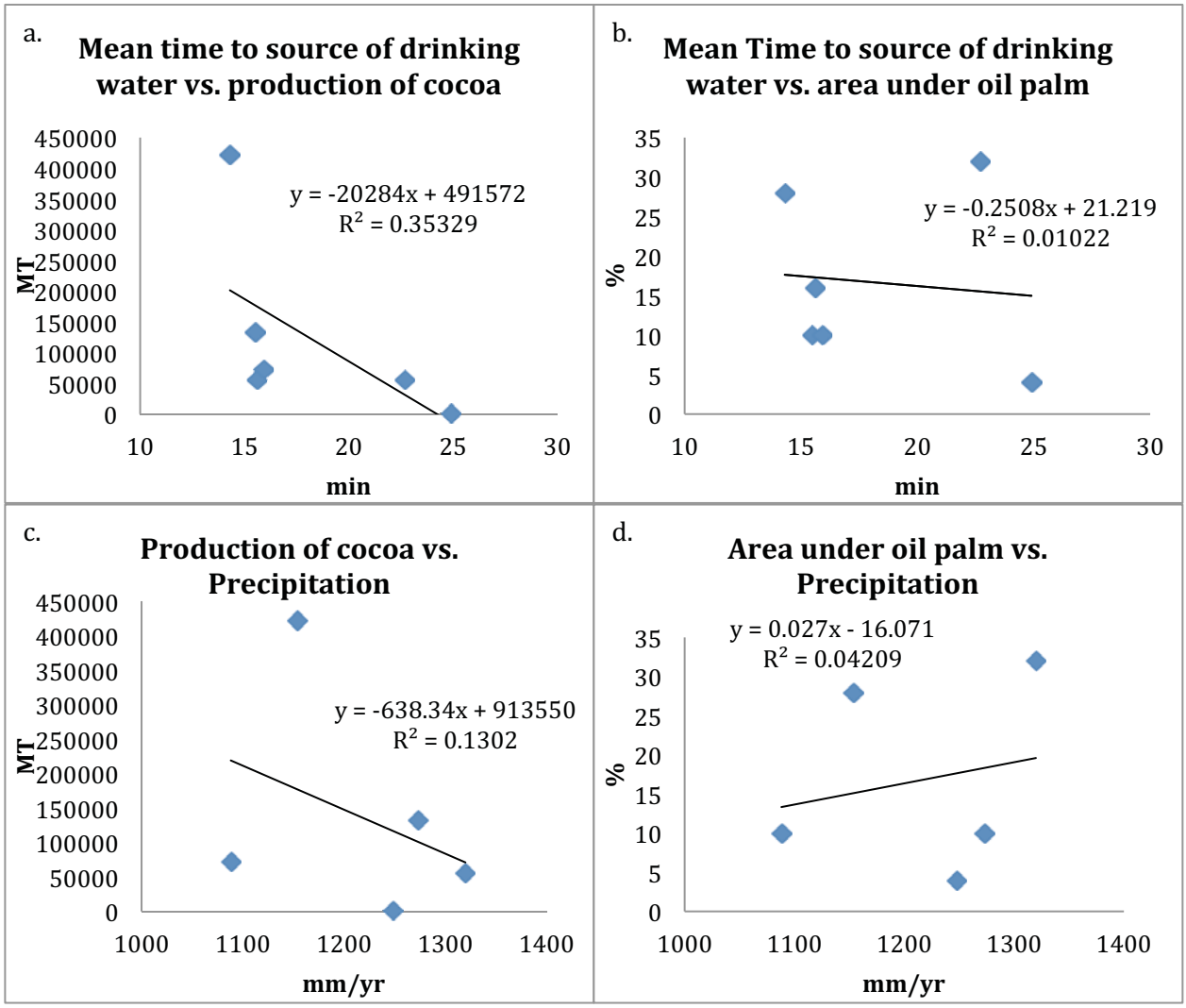
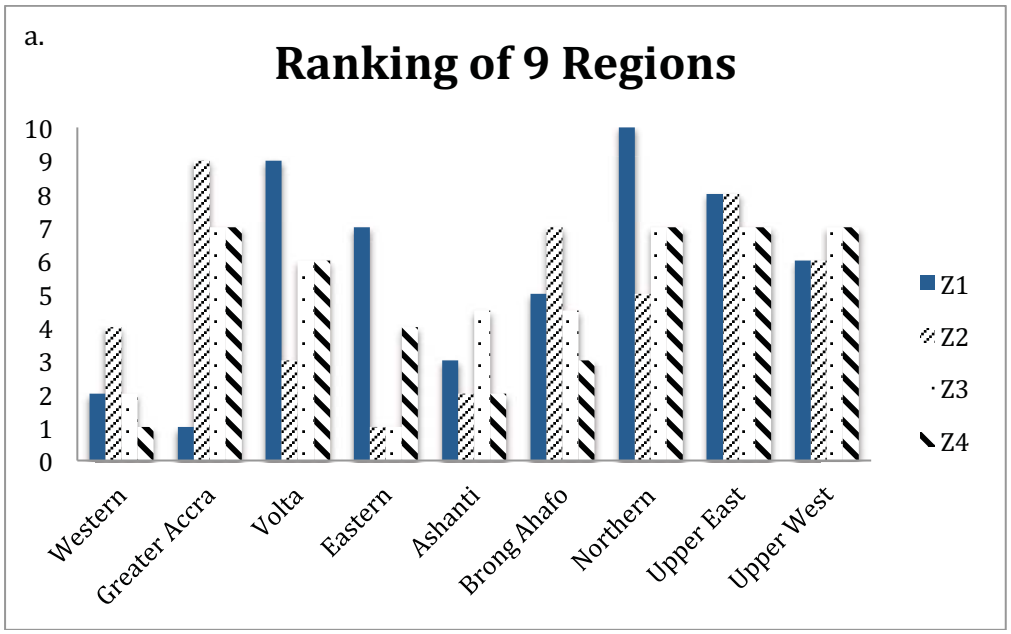


Figure 4-21 a-d. Linear correlation between production of cocoa, percentage of oil palm plantation each region owns and water resources

[43] Note: Data for Central Region is missing

Figure 4-21 a-d show that water resources precipitation and minutes taken to drinking water source, have weak linear correlation with production of cocoa and area of oil palm plantation in six regions. Although the Oil Palm Research Institute (OPRI) suggests that heavy rainfall (greater than 1,300 mm/yr) yields high oil palm products and/or biomass, Figure 4-21 d., indicates that this is not likely the case in Ghana (assuming that every unit of area in different regions produce the same amount of oil palm biomass/product) (R^2 = 0.042). Similarly, Figure 4-21 c shows that high precipitation does not guarantee high cocoa production (R^2 = 0.13), and in fact, production of cocoa and precipitation, although they have little correlation, is inversely correlated. Figure 4-21 b shows that there is little correlation between percentage of area of oil palm cultivation that each region owns and mean time to source of drinking water; production of cocoa has moderate correlation with mean time to source of drinking water (Figure 4-21 a).

Ranking is also used to obtain a better understanding within selected natural resources. All regions with oil palm and cocoa production are ranked and compared with natural resources separately[44]. (Figure 4-22 a & b)



[44] Regions without certain natural resources, such as Northern Sector and Greater Accra are ranked last. In the case of oil palm and cocoa, since there are six regions that produce these crops, the Northern Sector (Northern, Upper East and Upper West) and Greater Accra will be ranked seven, indicating that there are no production of oil palm and cocoa. Central region is excluded in both rankings, due to unavailability of the data, which is different from "no production". See Appendix III, IV and V for references.

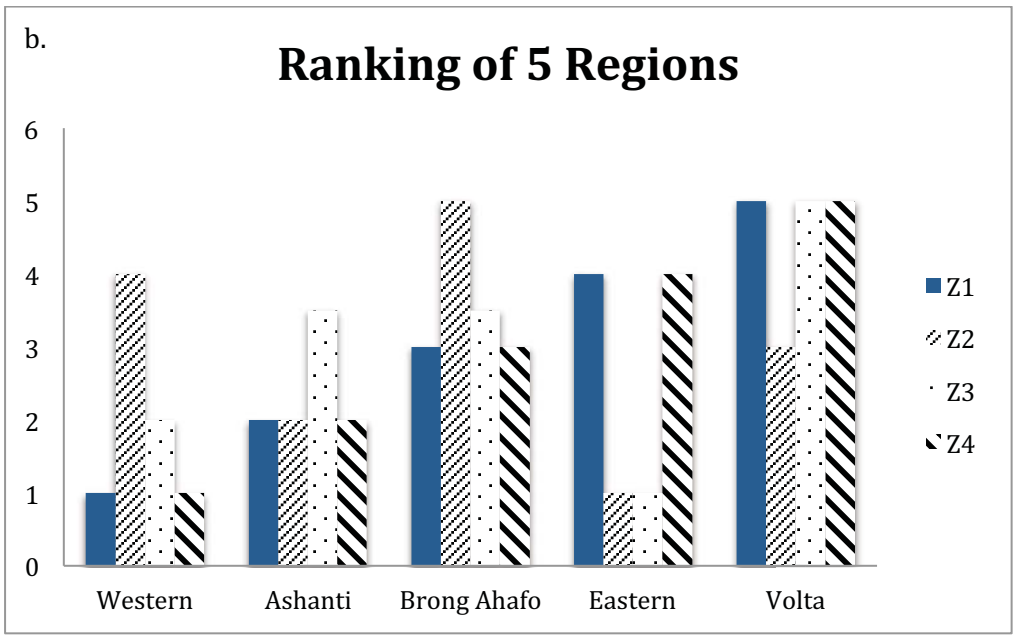


Figure 4-22 a-b. Ranking and comparisons of water resources and cash crops in different regions
*Z1 = Mean time to drinking water; Z2 = Average annual precipitation (1991-2000);
Z3 = Oil Palm; Z4 = Cocoa.

Figure 4-22 a and b show that an ascending order of the accessibility of water resources or amount in regions does not apply to ascending order of the amount of cocoa production or area of oil palm plant. There is an exception, however, in Figure 4-22 b, the ranking of mean time to drinking water source (Z1) is the same as ranking for the production of cocoa (Z4). It indicates that regions that produce more cocoa are also where its residents take less time to get access to drinking water, and such an indication only applies to regions that have cocoa production.
Both correlation (Figure 4-21 a-d) and ranking (Figure 4-22 a-b) analysis confirm with bigger certainty that the two water resources and accessibility indicators do not have obvious linkage with the two selected cash crops oil palm and cocoa.

4.2.3.2 Analysis of Education and Water Resources

The correlation between education levels and water resources will use four indicators for analysis: percentages of population completing primary school and secondary school and, two water resources datasets mean time to drinking water source and annual precipitation.

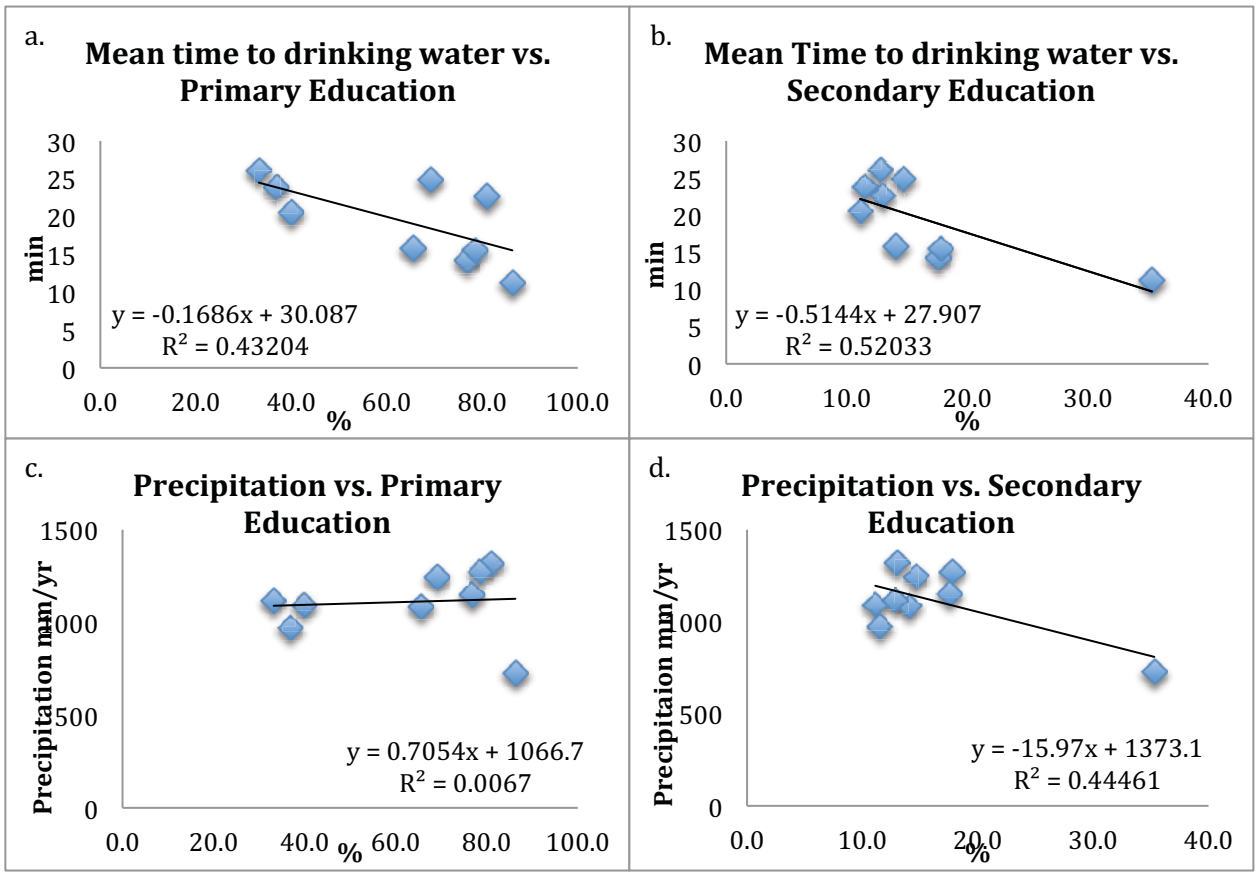


Figure 4-23 a-d. Linear regression correlation between water resources indicators and education levels (Note: Central Region's precipitation data is not available).

Figure 4-23 a, b and d. show that water resources is somewhat correlated with education levels. The author found that *mean time to drinking water* has moderate negative correlation with both education levels, with $r^2 = 0.43$ for primary education and with $r^2 = 0.52$ for secondary education, respectively (shown in Figure 4-23 a and b). Precipitation rarely correlates with primary education ($R^2 = 0.0067$) (Figure 4-23 c) but has moderately correlation with secondary education ($R^2 = 0.44$) (Figure 4-23 d). An outlier is detected from Figure 4-23 b-d, with Greater Accra, where precipitation is the lowest (Central region is excluded due to data unavailability) and percentage of population completing primary and secondary schools are the highest. Therefore, correlations between water resources and education levels WITHOUT the Greater Accra outlier are plotted (Figure 4-24 a-d).

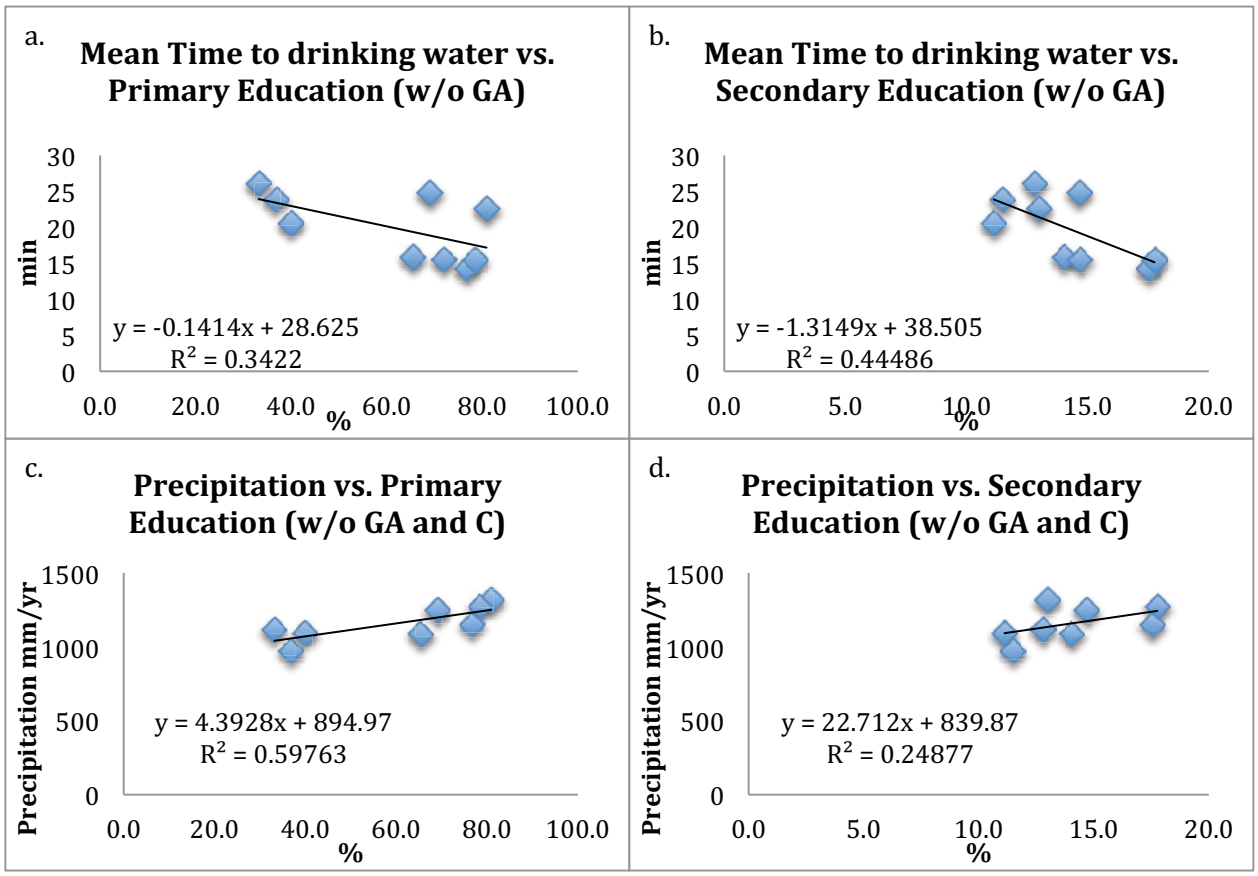


Figure 4-24 a-d. Linear regression correlation between water resources indicators and education levels WITHOUT Greater Accra (outlier) and Central Region (where precipitation data is missing)

Mean time to drinking water are inversely correlated to completion of primary education and secondary education without Greater Accra (Figure 4-24 a & b). In Figure 4-24 a, b and d, without the Greater Accra region outlier, water resources correlation with education levels decrease, except the one between precipitation and percentage of population completing of primary education (Figure 4-24 c). In fact, by eliminating the Greater Accra, annual precipitation is strongly positively correlated with percentage of population completing primary education (R^2 = 0.60). Secondary education seems to have less to do with annual precipitation when Greater Accra is included in the analysis compared to Figure 4-23 d.

4.2.3.3 Analysis of Education and Oil Palm

Correlation between education levels and oil palm production will use three indicators in total for analysis: percentages of population completing primary school and secondary

school and, proportion of area under oil palm cultivation by region over the total areas under oil palm cultivation in Ghana[45].

According to the MASDAR and Ministry of Food & Agriculture Republic of Ghana (MOFA)[1,46], only six regions: Western, Central, Volta, Eastern, Ashanti, Brong-Ahafo are suitable for oil palm plantation. Additionally, data for oil palm are only available in these six regions. Therefore, the analysis will exclude the Northern Sector and Greater Accra.

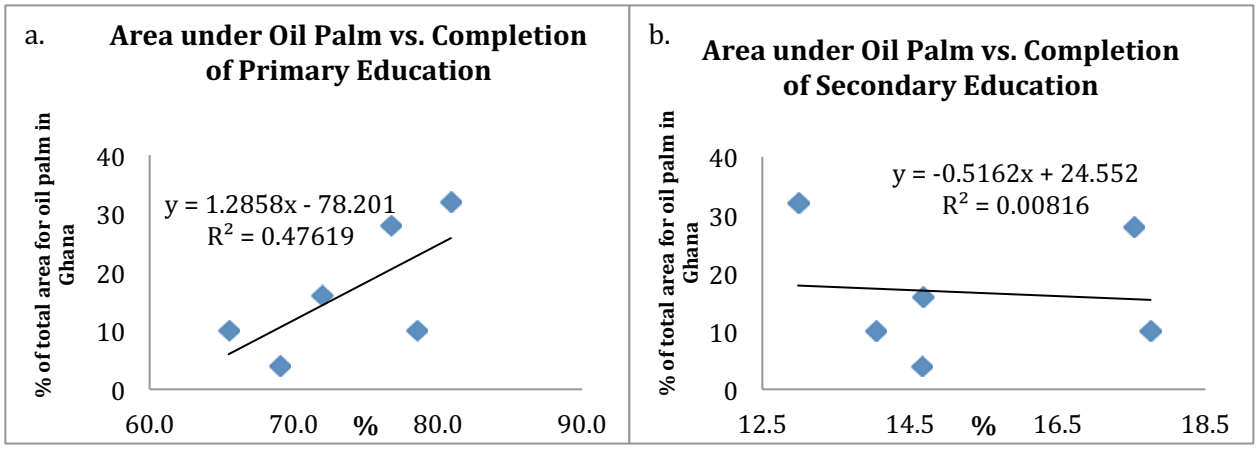


Figure 4-25 a-b. Linear regression correlation between oil palm cultivation area and percentage of population completed primary and secondary school (excluding Northern Sector and Greater Accra)

Figure 4-25 a. suggests that the proportion of oil palm cultivated is moderately positively correlated with the region's percentage of population that has completed primary school (R^2 = 0.48). The higher percentage of population that has completed primary school, the larger the oil palm area one region is likely to have, compared to the total national area for oil palm in the six regions.

However, oil palm cultivation area of a region has almost nothing to do with secondary education in these six regions, since there is nearly no correlation between oil palm cultivation area and completion of secondary school (R^2=0.0082) in Figure 4-25 b.

4.2.3.4 Analysis of Education and Cocoa

Similar to oil palm, correlation between education levels and cocoa production will use three indicators for analysis: percentages of population that has completed primary school and secondary school and, production of cocoa in six regions.

[45] Currently there is no data available for the number of oil palm trees in different regions. However, the production of fresh palm oil brunches (produced by oil palm plant) in regions can be estimated by areas owned by the regions following guidance provided by MASDAR final report (MASDAR, 2011).

[46] Information can be found on Ministry of Food & Agriculture Republic of Ghana: http://mofa.gov.gh/site/?page_id=8819

According to Ghana Cocoa Board[47], the regions that produce cocoa in Ghana include: Western, Central, Volta, Eastern, Ashanti and Brong-Ahafo. Additionally, data that the author found for cocoa is only for these six regions. Therefore, analysis will exclude the Northern Sectors and the Greater Accra.

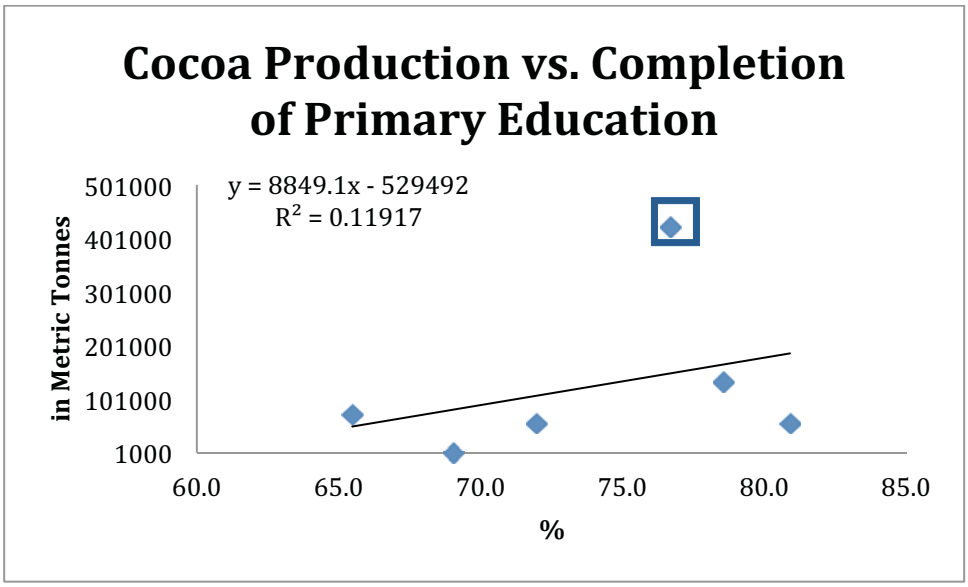


Figure 4-26 a. Linear regression correlation between cocoa production and percentage of population completed primary school in six regions. Point in square represents Western Region.

It shows in Figure 4-26 a shows that there is a slight positive correlation between cocoa production and percentage of population that has completed primary school in these six regions (R^2 = 0.12). An outlier is found due to the high production of cocoa in Western Region.

[47] Information can be found on: http://cocobod.gh/history.php

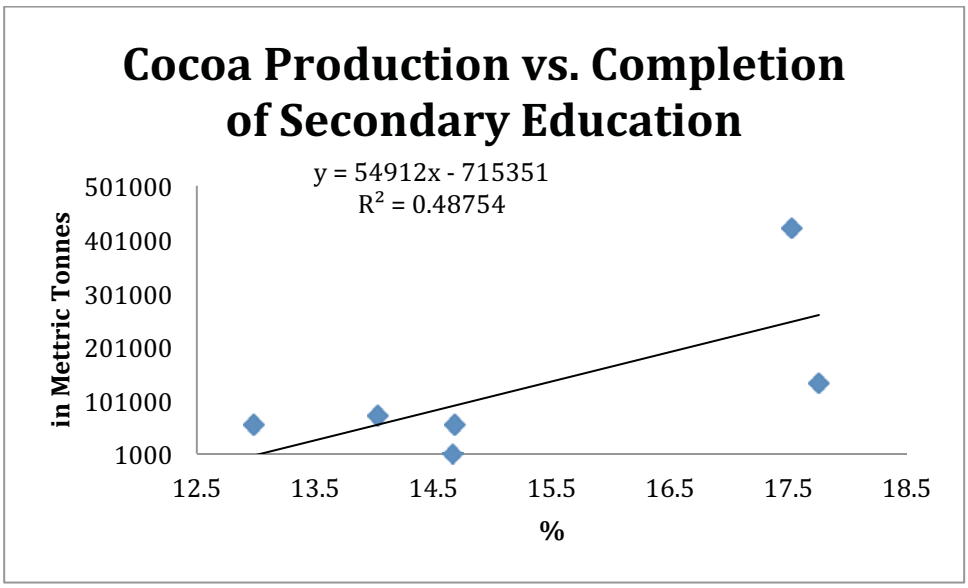


Figure 4-26 b. Linear regression correlation between cocoa production and percentage of population completed secondary school in six regions

Figure 4-26 b. shows that there is a moderate positive correlation between cocoa production and percentage of population completed secondary school in six regions (R^2=0.49). Cocoa production might have some linkage with percentage of population completing secondary school.

4.2.3.5 Analysis of Education and Selected Natural Resources

This thesis focuses on three natural resources. The idea is to get a better understanding of how natural resources in general correlates education. Since there are so many types of natural resources, this thesis has selected three major ones, water resources, which is essential for human survival; oil palm, a potentially renewable energy source and important cash crop and food oil; cocoa, Ghana's major export contributor and cash crop. The author then uses four natural resources indicators as an example to develop a model for Ghana to demonstrate the correlation between natural resources and education. Such a model, hopefully in the future can be used to estimate better correlation between natural resource and education when other natural resources data of different regions become available.

Using the combination analysis described in the Section 4.2.1. *Data Analysis Methodology*, the author calculated fScore for ten regions when comparing the contributions of water resources, oil palm and cocoa (Appendix VI). From the previous section, we found that Greater Accra has been an outlier in several correlation analyses and therefore, the fScore for scenarios without Greater Accra are also calculated (Appendix VII).

Table 4-4 a. Correlation coefficient summary table with Greater Accra

Correlation	Primary school	Secondary School
Mean to H2O	0.43[48]	0.52[49]
Precipitation	0.067[50]	0.44[51]
Oil Palm	0.48[52]	0.008[53]
Cocoa	0.12[54]	0.49[55]

Table 4-4 b. Correlation coefficient summary table without Greater Accra

Correlation	Primay school	Secondary School
Mean to H2O	0.34[56]	0.44[57]
Precipitation	0.6[58]	0.25[59]
Oil Palm	0.48[10]	0.008[11]
Cocoa	0.12[12]	0.49[13]

[48] Coefficient comes from Figure 4-23 a.
[49] Coefficient comes from Figure 4-23 b.
[50] Coefficient comes from Figure 4-23 c.
[51] Coefficient comes from Figure 4-23 d.
[52] Coefficient comes from Figure 4-25 a.
[53] Coefficient comes from Figure 4-25 b.
[54] Coefficient comes from Figure 4-26 a.
[55] Coefficient comes from Figure 4-26 b.
[56] Coefficient comes from Figure 4-24 a.
[57] Coefficient comes from Figure 4-24 b.
[58] Coefficient comes from Figure 4-24 c.
[59] Coefficient comes from Figure 4-24 d.

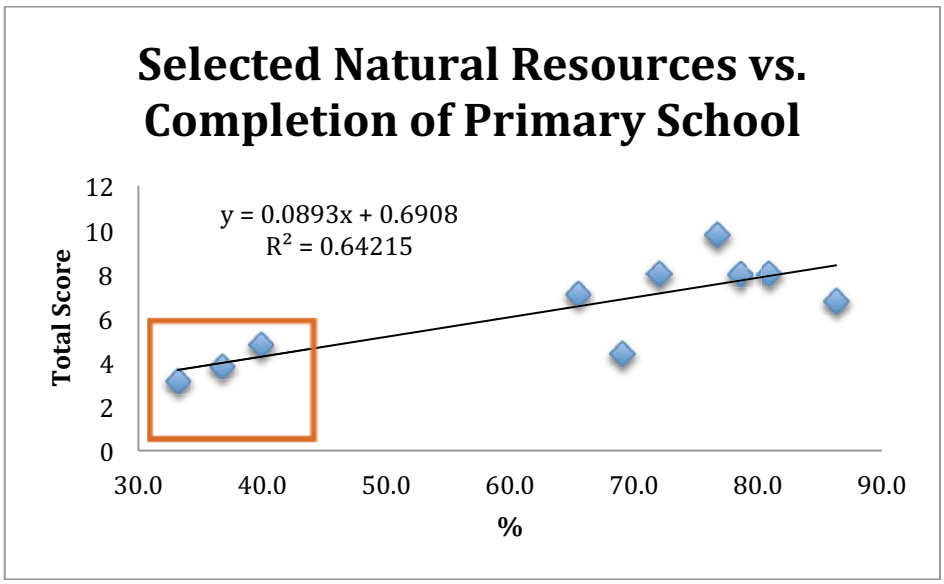


Figure 4-27 a. Linear correlation between all selected natural resources and primary education[6061] in 10 regions

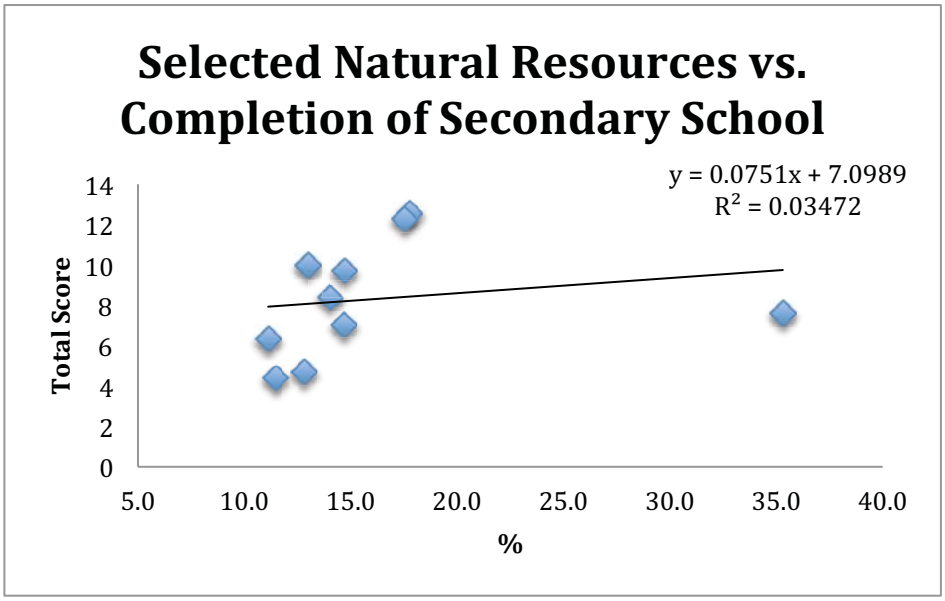


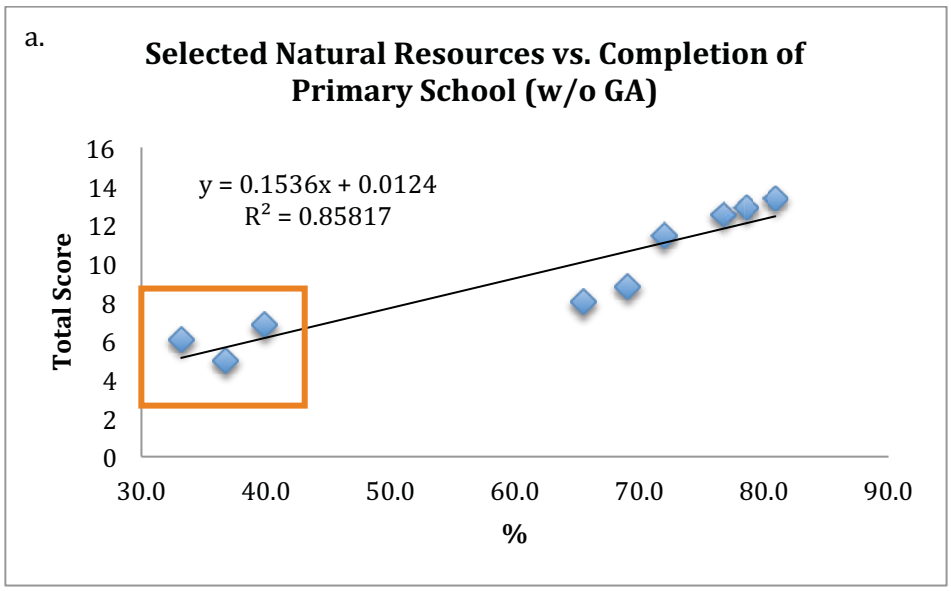
Figure 4-27 b. Linear correlation between all selected natural resources and secondary education[6061] in 10 regions

Figure 4-27 a shows that the percentage of population completing primary school has a moderate correlation with selected natural resources combined (R^2 = 0.62). Meanwhile, Figure 4-27 b indicates that the percentage of completion of secondary school almost has

[60] Central Region precipitation data is missing and for the convenience of calculating correlations, average precipitation of 5 regions that produce oil palm and cocoa (1991-2000 data) are used to estimate the precipitation of Central Region.

[61] For regions that do not have certain resources, it will be ranked last. For example, Northern Sector and Greater Accra are ranked 7 and the iScore received is 4.

no correlation with selected resources combined. However, outlier is also detected in Figure 4-27 b. Additionally, there are three points at the left bottom in Figure 4-27 a that separated from the major body (other seven points are close to each other).



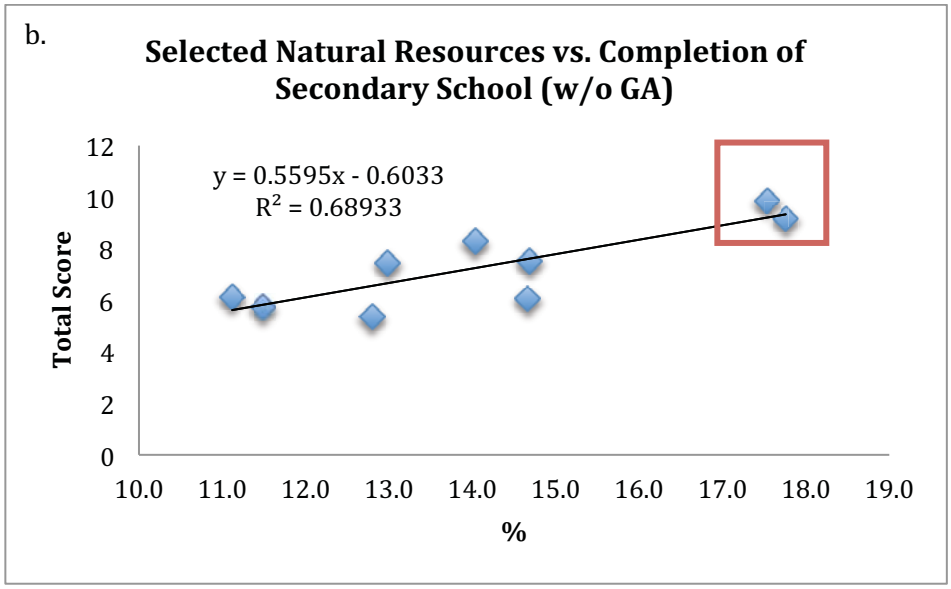


Figure 4-28 a and b. Linear correlation between all selected natural resources and two educational levels[62][63] in 9 regions (without Greater Accra)

[62] Central region precipitation data is missing and therefore, average precipitation of 5 regions that produce oil palm and cocoa (1991-2000 data) are use to estimate the precipitation of Central region.

[63] For regions that do not have certain resources, it will be ranked last. For example, northern sectors and Greater Accra are ranked 7 and the iScore received is 4.

Figure 4-28 a and b shows that after eliminating Greater Accra, the linear correlation between selected natural resources combined and percentage of population completed primary (R^2 = 0.86) and secondary school (R^2 = 0.67) have increased dramatically, compared to Figure 4-27 a and b. In Figure 4-28 a. the total score for three points at the left bottom are separated from the six other points. Similarly, two points in Figure 4-28 b are also separated from the other points.

4.2.3.6 Education and Natural Resources Interpretation and Conclusion

In Figure 4-23 a, b and Figure 4-24 a, b, mean time to drinking water seems to have correlation with both education levels, with or without consideration of Greater Accra region, where percentage of population completed primary and secondary schools are higher than any other regions. These four figures indicate that the areas with larger populations that have completed primary and secondary education are also areas where people take less time to reach sources of drinking water on average.

However, Figure 4-23 c, d and Figure 4-24 c, d show that the precipitation has little to do with education levels achieved. Although Figure 4-23 d and Figure 4-24 c show that precipitation has a moderate correlation with both primary education and secondary education, the results are though to be accurate since precipitation varies by months and years. Although using precipitation data from 1991 – 2000 could potentially predict general rainfall pattern among ten regions in Ghana since the pattern has been consistent over three decades (Figure 4-29), when looking at precipitation differences in 1971-1980, 1981-1990 periods compared to the average over 30 years (1971-2000), the author found that precipitation has varied (Figure 4-30).

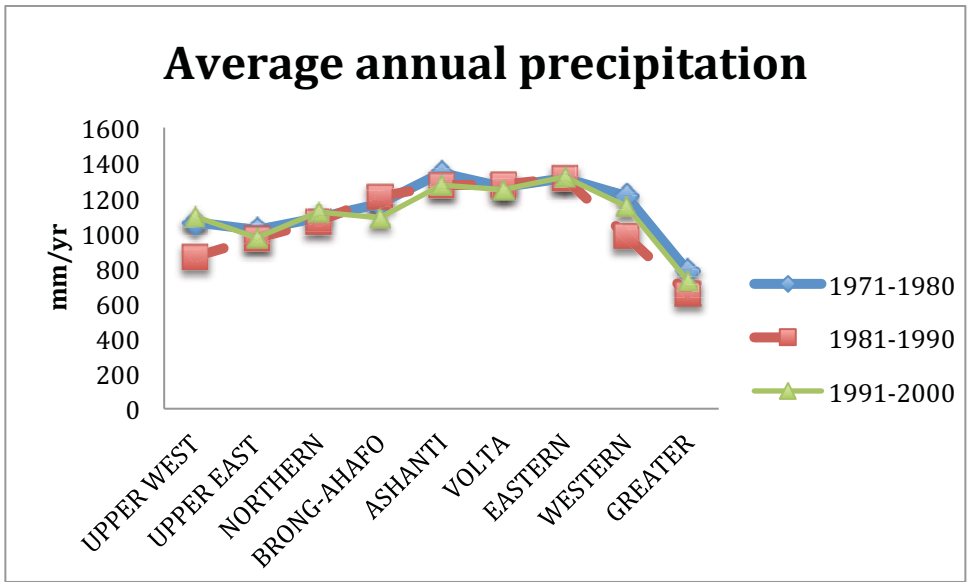


Figure 4-29. Comparison between average annual precipitation over three periods in 10 regions (Data generated from GhanaSTAT)

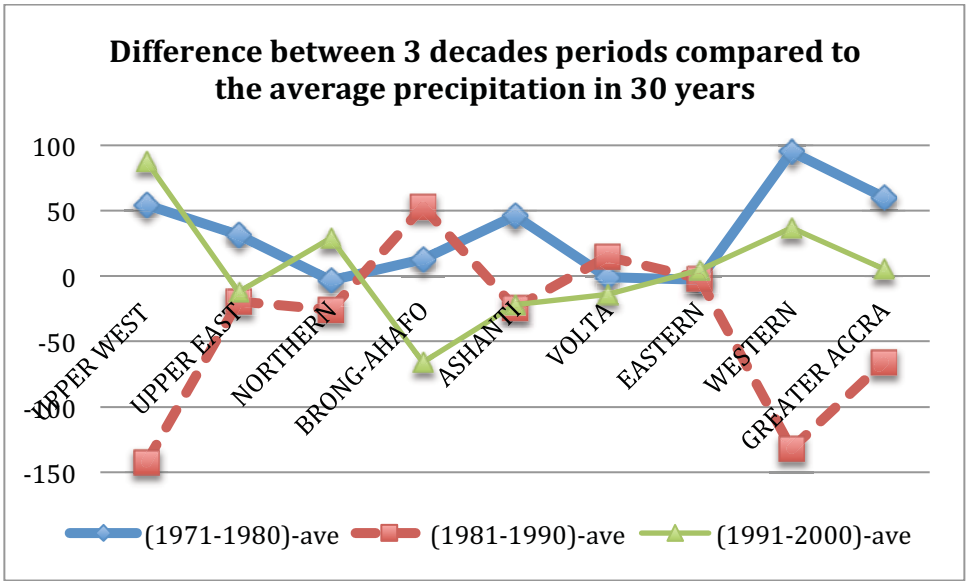


Figure 4-30. Annual average precipitation difference in 1971-1980, 1981-1990 and 1991-2000 periods compared to the overall average precipitation over 30 years (1971-2000)

The variation in precipitation shown in Figure 4-30 has changed the ranking of precipitation in 10 regions since Upper West and Western Regions show a larger oscillation (with a gap as large as 200 mm) than other regions and the difference between the nearby ranks is as small as 6 mm/year (Figure 4-29).

Figure 4-25 a and b indicate that oil palm plantation might have some positive correlation with primary school but not secondary school; in contrast, cocoa production might have more to do with secondary school. It is possible that oil palm and cocoa require more workers with primary education and secondary education respectively, and therefore, this suggests that primary education and secondary education are important in regions where oil palm plantation and cocoa grow. It is also possible that due to the growth of oil palm and cocoa, people are likely to earn more money to send their children to primary and secondary school. The Master Plan for Oil Palm in Ghana 2011 report supports this finding the thesis in its survey of the Western and Central regions, where have the largest proportion of oil palm area over the total in Ghana, also has the highest number of family members having acquired education from primary to tertiary levels (MASDAR, 2011).

The Oil Palm Research Institutes in Ghana and Bureau of Agricultural Research in the Philippines consider high precipitation is necessary for oil palm cultivation and cocoa production (OPRI, 2011; BAR, 2007). However, in Figure 4-21 c-d, we found that in Ghana's case, precipitation has only moderate correlation with the production of oil palm and cocoa. However, the advantage of the six regions having oil palm and cocoa are related not only to precipitation but also to its climate, soil type, etc. (MASDAR, 2011). Therefore, the slight changes in precipitation (0-250 mm/yr) (Figure 4-30.) should not affect the other favorable advantages of the regions compared to others. Using the *mean time to drinking water* to measure the water infrastructure capacity in the six regions, we found that although these six regions have large contribution to the cash crops in Ghana, people's

drinking water and its condition are not necessarily improved by the agriculture contribution to the society. In other words, the economic benefit has not been translated into a water infrastructure benefit for the people. As for dependence on water resources, oil palm and cocoa operate as independent variables which means high average annual precipitation does not mean high oil palm and cocoa production (Figure 4-21 a and b shown). That is to say, precipitation is only one variable,

When comparing Figure 4-27 to Figure 4-28, Greater Accra is a key area to determine the correlation between education levels and natural resources. However, due to Greater Accra's high completion of secondary education among its population (Figure 4-27 b), it has become a crucial outlier when it comes to this analysis. It is necessary to eliminate Greater Accra when doing further natural resources and education correlation analysis, as it can be considered as an exception for various reasons such as historical advantages, being the capital, etc.

Figure 4-27 a and Figure 4-28 a both suggest that primary education has a high positive correlation with the four selected natural resources indicators. People from areas with abundant natural resources (water resources, cocoa and oil palm and combined) on average are very much more likely to receive more primary education than areas without. With such a high correlation between natural resources and primary education in both figures with and without the Greater Accra Region, it also suggests that execution of achieving the MGD of primary education in MDGs has something to do with availability (such as precipitation, ability to plant cash crop, etc.) and accessibility (mean time to drinking water) of water. In the Master Plan for Oil Palm in Ghana final report, the research group also found that Central Region, where farmers have the highest number of family members attending schools, is also the area that has the most educational facilities (MASDAR, 2011). It might also imply that educational facilities are more likely to be built in natural resources abundant regions and therefore, primary and secondary educations are higher in the six regions where oil palm and cocoa are cultivated.

In Figure 4-27 a and 4-28 a, there are three points (in orange box from left to right: are Northern, Upper East and Upper West Regions) score the lowest yet have the lowest percentage of population that have completed primary school. From the total scores that these three regions gain, these regions might have potentially faced larger challenges in improving primary education when natural resources are not available. In contrast, from Figure 4-28 b, the two leading points (in red box) represent Western and Ashanti regions. With a relatively higher percentage of the population that has completed primary school, the total scores for selected natural resources are only slightly increased for these two regions when compared to other regions.

While none of the correlations between education levels and each individual resource (precipitation, time to drinking water, areas for oil palm cultivation and production of cocoa) in Figure 4-23 to 4-26 are as strong as ones shown in Figure 4-28, it indicates that this model and calculation can be a potential tool for evaluating the relationship between education levels and various natural resources combined.

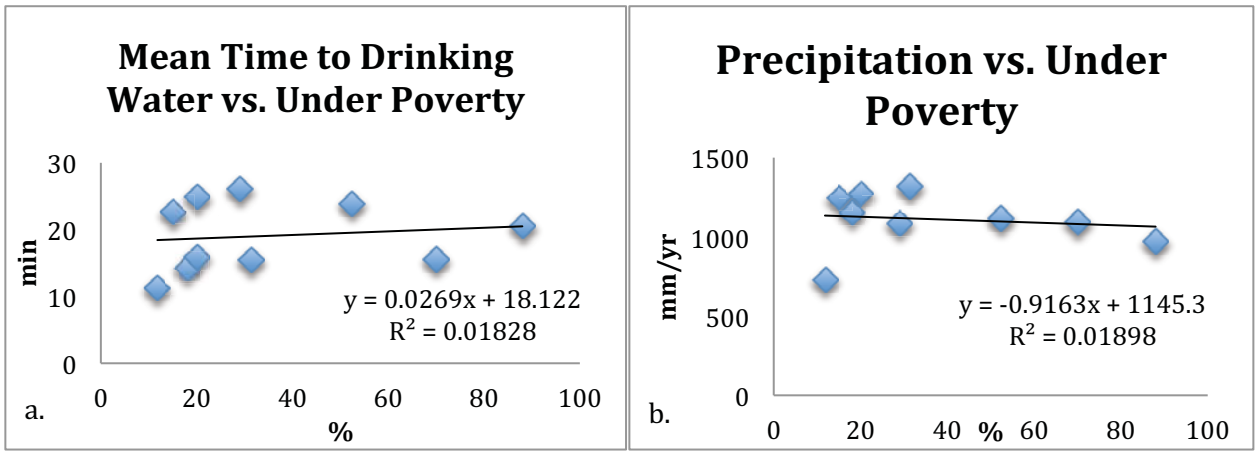
Key Findings:

- **Each selected natural resource acts as a independent variable – two water resources (mean time to drinking water and precipitation) do not have obvious linkages with oil palm and cocoa;**
- **R^2 correlations between mean time to drinking water and education range from 0.34 – 0.52 (moderate) with and without Greater Accra;**
- **R^2 correlations between precipitation and education range from: 0.0067 – 0.6 (weak to strong) with and without Greater Accra;**
- **R^2 correlations between area under oil palm and education range from 0.0082 – 0.48 (weak to moderate);**
- **R^2 correlations between cocoa production and education range from 0.12 to 0.49 (weak to moderate);**
- **Correlations between all selected natural resources and education range from 0.0035 to 0.86 (weak to strong) with and without Greater Accra.**

4.2.4 Economics and Natural Resources

4.2.4.1 Analysis of Economics and Water Resources

The correlation between economics and water resources will use three indicators for analysis: proportion of the population living below the poverty line for the economic indicator, mean time to drinking water source and average annual precipitation for water resources indicators.



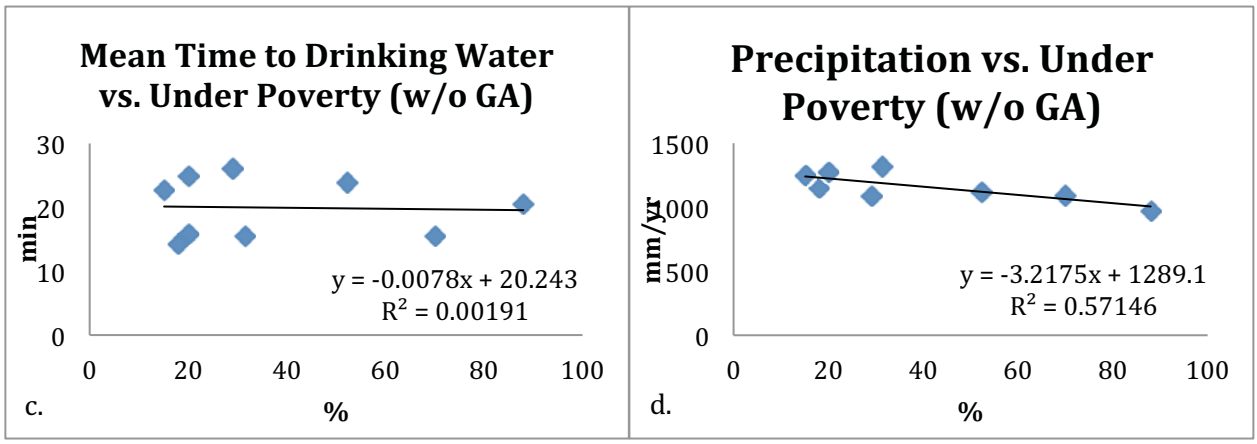
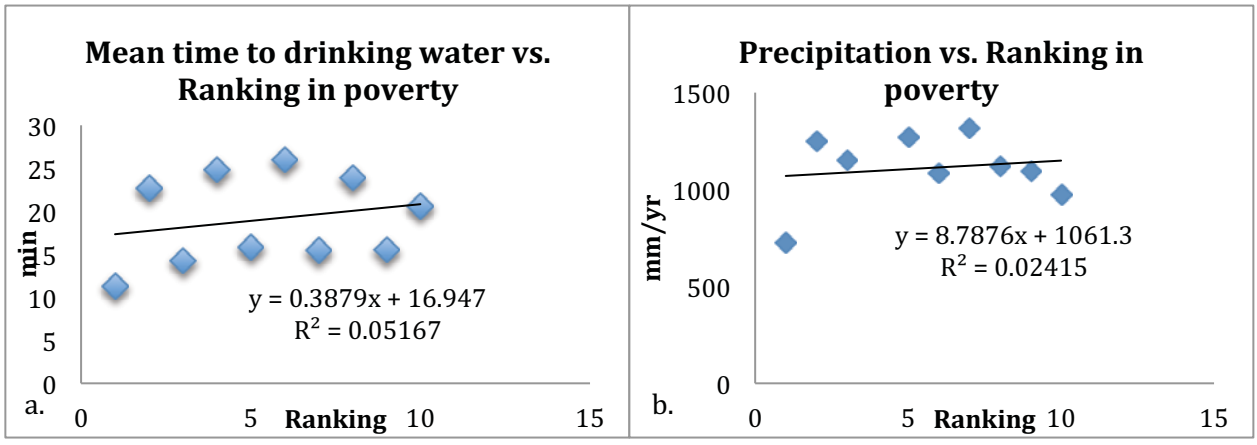


Figure 4-31 a-d Linear regression correlation between water resources indicators and economics indicator with (a & b) and without Greater Accra regions (c & d)

Figure 4-31 a – b show that for the two water resources indicators, both mean time to drinking water and precipitation have little linear correlation with the proportion of the population living under the poverty line. Greater Accra as an outlier is again detected in Figure 4-31 b. However, Figure 4-31 c shows that even without Greater Accra, analysis suggests that mean time to drinking water still has little linear correlation with proportion of population under the poverty line. While in Figure 4-31 d precipitation is moderately and negatively correlated with proportion of population under poverty without outlier.

As described in previous section, according to the World Health Organization (WHO), all 10 regions's natural resources indicator Z1 (mean time to drinking water source) in fact are under the category of *basic access* for drinking water service. Figure 4-31 a & b also show that the slope of the linear regression lines are gentle, which means the difference between mean time to drinking water in regions are small; yet the differences between proportion of population under the poverty line in regions are large. Therefore, ranking will be used to better understand, under the *basic access* to drinking water category, if mean time to drinking water has correlation with the economic indicators.



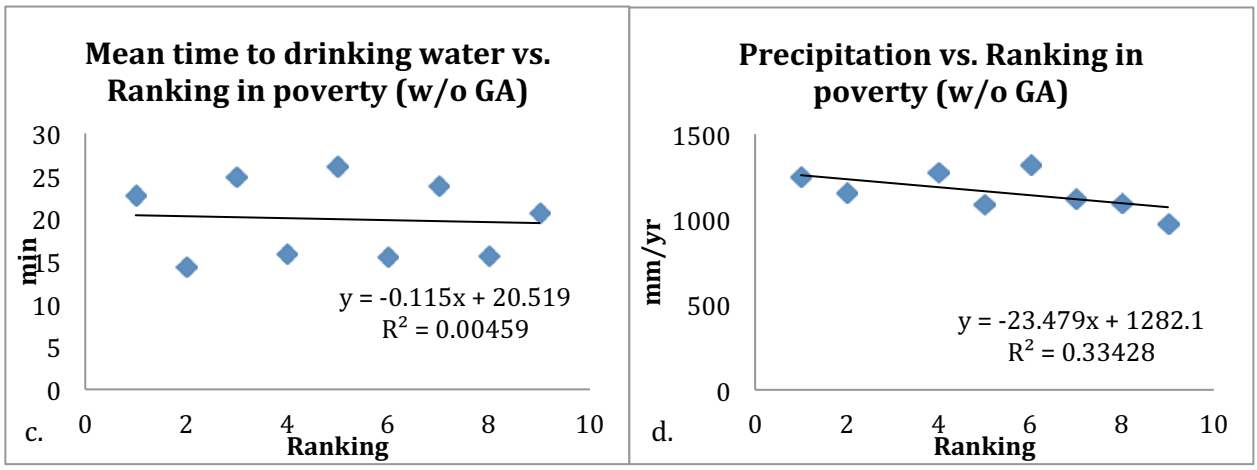


Figure 4-32 a-d. Linear regression correlation between water resources indicators and RANKING of economic indicator with (a & b) and without Greater Accra region (c & d)

Figure 4-32 a-d show that the correlation coefficients increase slightly compared to the Figures in 4-32 a-c except d, it does not give strong evidence that the two water resources indicators have a lot to do with the economic indicator, even after the Greater Accra is eliminated. Figure 4-32 a-d confirm with greater certainty that the water resources are not related to economic indicator. That is to say, regions with more water resources and less time in accessing water on average are not necessary regions with lower proportion of population under the poverty line.

4.2.4.2 Analysis of Economics and Oil Palm

Correlation between economics and oil palm production will use two indicators for analysis: proportion of population under the poverty line and area under oil palm cultivation in different regions over the total area under oil palm cultivation in Ghana.

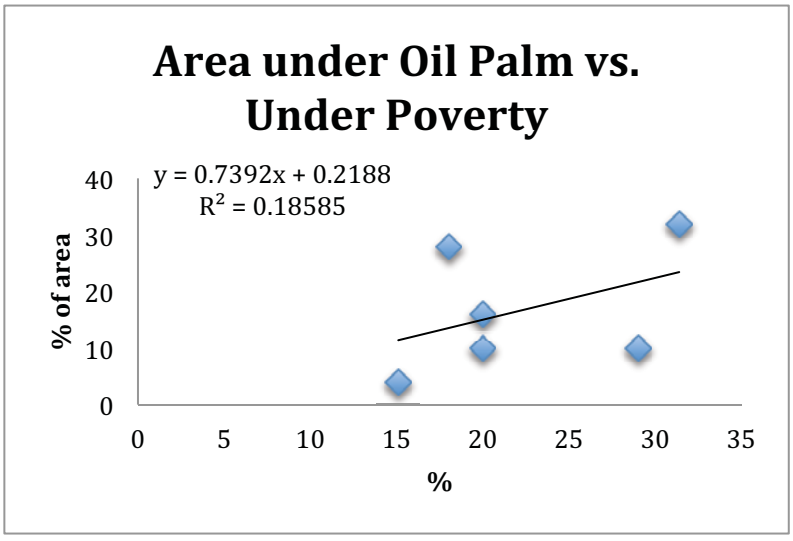


Figure 4-33. Linear regression correlation between area under oil palm cultivation in different regions and proportion of population under the poverty line

Figure 4-33 shows that there is slight positive correlation between area under oil palm cultivation in regions and proportion of population under poverty (R^2=0.19). Although such a correlation is positive, the points in the figure are scattered and a correlation is not clear.

4.2.4.3 Analysis of Economics and Cocoa

Correlation between economics and cocoa will also use two indicators for analysis: proportion of population under the poverty line and production of cocoa in six regions that produce cocoa.

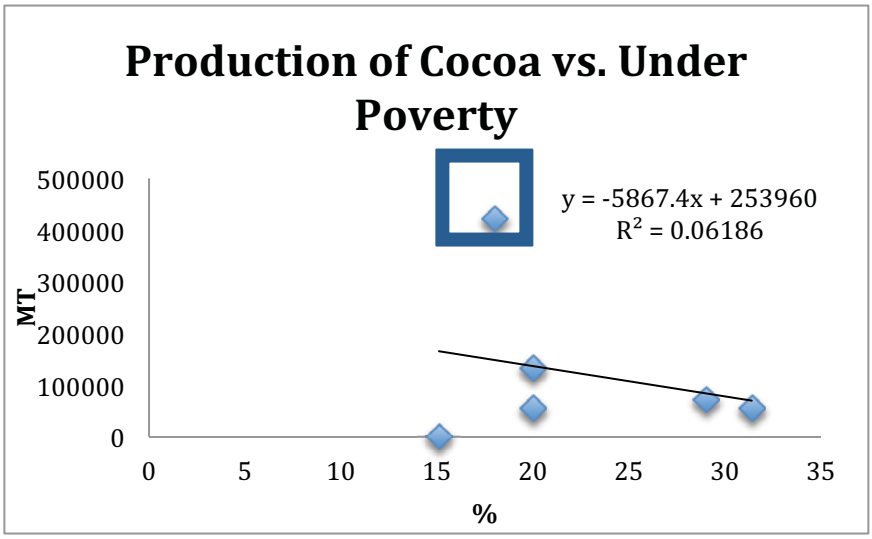


Figure 4-34. Linear regression correlation between production of cocoa and proportion of population under the poverty line. Note: The square represents Western Region

Similarly to oil palm, Figure 4-34 shows that there is almost no correlation between production of cocoa and proportion of population under poverty line (R^2 =0.06). Western Region has the highest cocoa production, however, since the proportion of population under the poverty line is within the range of six regions', such a point is not considered as an outlier.

4.2.4.4 Analysis of Economics and Selected Natural Resources

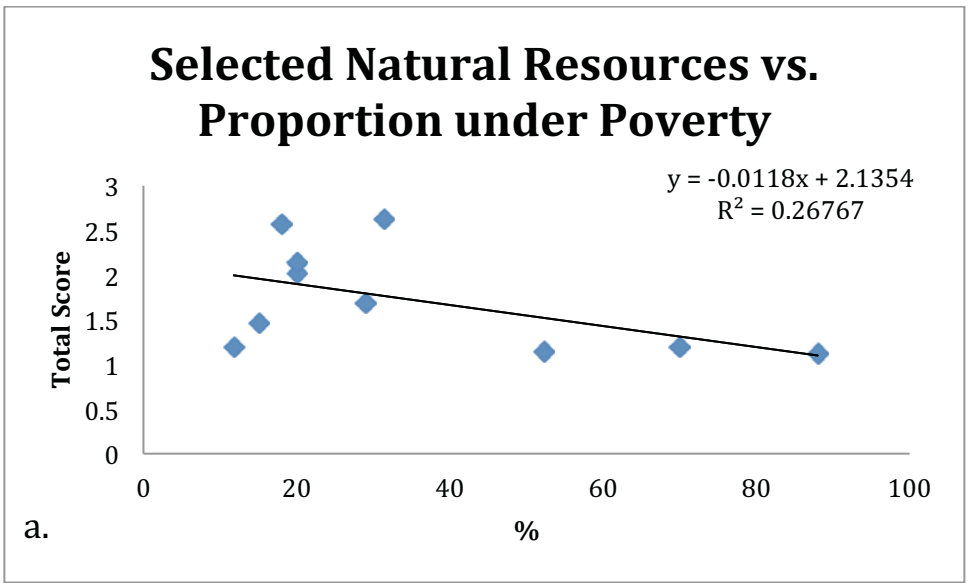
In *Section 4.2.3.1*, the analysis shows that the natural resources selected are independent of each other, and therefore, the analysis can be continued by combining the indicators' correlation into one value. Again, the author uses the same method to estimate the correlation between economics and selected natural resources.

Table 4-5. Summary of correlation coefficient between economics and natural resources indicators with and without Greater Accra included in the analysis

Correlation	Under Poverty	Under Poverty (w/o Greater Accra)
Mean time to H2O	0.0183[64]	0.0019[65]
Precipitation	0.019[66]	0.5715[67]
Oil Palm	0.1859[68]	0.1859
Cocoa	0.0619[69]	0.0619

With all these correlations, total correlation scores are calculated.

[64] Coefficient comes from Figure 4-32 a;
[65] Coefficient comes from Figure 4-32 c;
[66] Coefficient comes from Figure 4-32 b;
[67] Coefficient comes from Figure 4-32 d;
[68] Coefficient comes from Figure 4-33;
[69] Coefficient comes from Figure 4-34.



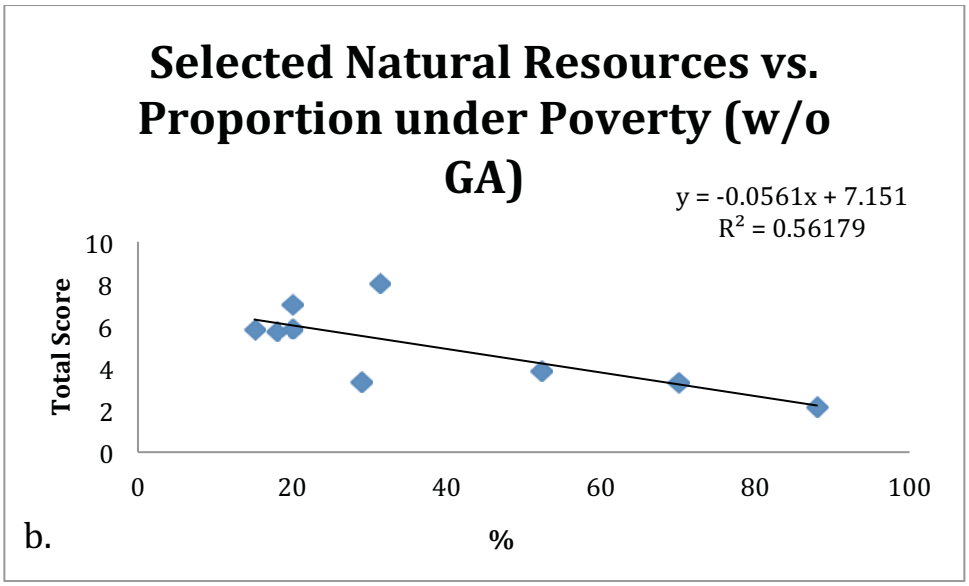


Figure 4-35 a and b. Linear correlation between all selected natural resources and proportion of population under the poverty line[70][71] in 10 regions (with and without Greater Accra)

Figure 4-35 a suggests that with all correlations between natural resources indicators (mean time to drinking water, precipitation, oil palm and cocoa) and economic indicators considered, the negative correlation between selected natural resources and proportion of people living extreme poverty is not strong (R^2= 0.27). After eliminating Greater Accra

[70] Central region precipitation data is missing and therefore, average precipitation of 5 regions that produce oil palm and cocoa (1991-2000 data) are use to estimate the precipitation of Central region.

[71] For regions that do not have certain resources, it will be ranked last. For example, northern sectors and Greater Accra are ranked 7 and the iScore received is 4.

Region, the negative correlation between the two become is moderate (R^2=0.56). Table 4-5 suggests that such a change with and without consideration of Greater Accra might due to the precipitation-under poverty coefficient change (R^2 from 0.019 to 0.57 (Table 4-5)), since other correlation coefficients are relatively low.

4.2.4.4 Economics and Selected Natural Resources Interpretation and Conclusion

The coefficient analysis in Figure 4-31 shows that the proportion of the population living under the poverty line has little correlation with mean time to drinking water and precipitation. Ranking analysis in Figure 4-32 also confirms that it is not likely that these natural resources indicators in water and economic indicator have a strong relationship. That is to say, natural resources rich regions in Ghana are not necessarily the regions with the lower proportion of population under the poverty line. As a tropical country, the Volta River system basin covers 70% of the country area and another 22% is covered by the southwestern river system (Bia, Tano, Ankobra and Pra rivers). Ghana is not lacking in water resources but rather it is lacking infrastructure to provide water supply and management (FAO, 2005; UNESO, 2012). Such evidence suggests that precipitation has little to do with the economics, because precipitation is not the only way to deliver water, Lacking money to provide irrigation for crops is another problem. According to Ghana Statistical Service (GSS) Multiple Indicator Cluster Survey in 2006, the proportion of population that has drinking water piped into their dwelling is low in all regions (GSS, 2006). The highest percentage is in Greater Accra, yet the proportion that has drinking water pipes in house is only 15.1% (Figure 4-36).

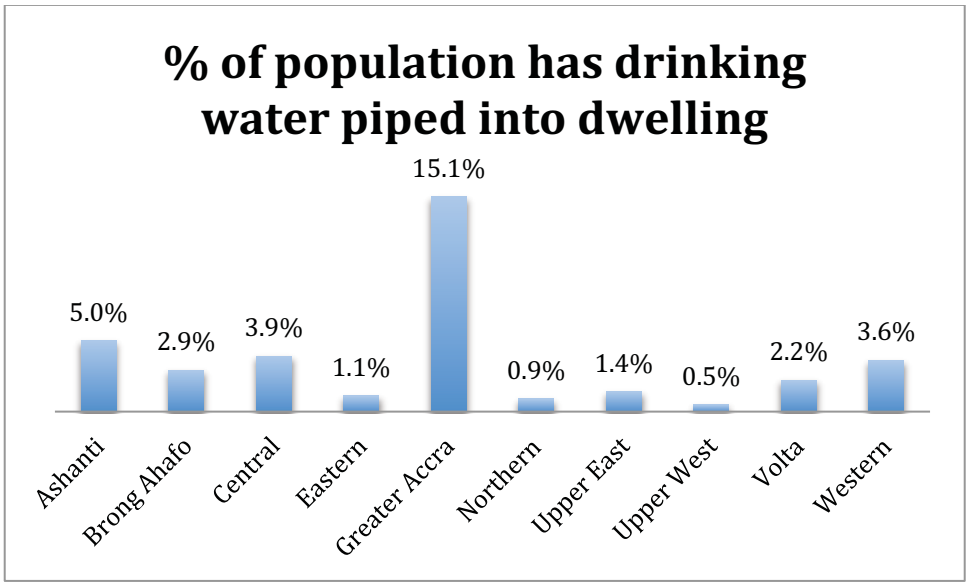


Figure 4-36. Proportion of population has drinking water piped into dwelling. Data source: Ghana Statistical Service 2006[72]

[72] Data collected online at: www.ghanainfo.gov.gh

All the percentages presented in Figure 4-36 are in fact lower than the proportion of population under poverty line (Table 4-6). That is to say piped water is not widespread in all regions in Ghana. However, there are a large portion of the people in all regions though above the poverty line, they do not have access to piped drinking water immediately at their dwelling. Therefore, the economic indicator proportion of population under the poverty line is very unlikely to correlate with the natural resources indicator mean time to source of drinking water. As the author has shown in the correlation analysis the correlation coefficient of the economic indicator (X1) and mean time to source of drinking water (Z1) is low.

Table 4-6. Comparison between proportion of population has drinking water piped into dwelling and proportion of population below the poverty line in 10 regions in Ghana

	Proportion of population below the poverty line	Proportion of population has drinking water piped into dwelling	Percentage difference (piped water-under poverty)
Western	18%	5.0%	-13.0%
Central	20%	2.9%	-17.1%
Greater Accra	11.80%	3.9%	-7.9%
Volta	15.10%	1.1%	-14.0%
Eastern	31.40%	15.1%	-16.3%
Ashanti	20%	0.9%	-19.1%
Brong Ahafo	29%	1.4%	-27.6%
Northern	52.30%	0.5%	-51.8%
Upper East	88%	2.2%	-85.8%
Upper West	70%	3.6%	-66.4%

Although cocoa is considered as the largest cash crop in Ghana and oil palm as a strong economic contributor (Bartle, 2012; Woodhill, 2011), Ghana's oil palm and cocoa are not correlated with the proportion of population below the poverty line. Figure 4-33 and 4-34 suggest that the productions of cocoa and oil palm are not substantially contributing to reducing the percentage of the population living below the poverty line. Those two figures also suggest that people living under the poverty line have not benefited due to the growth of cocoa or oil palm in these six regions. It is true that the Northern Sectors of Ghana where there is no oil palm or cocoa production have much a higher percentage of the population living under the poverty line; however, the six regions that do have these cash crops do not have a lower percentage of population under the poverty line than Greater Accra. The imbalance in poverty does not seem to have much to do with where the cash crops grow. This suggests that other variables and indicators such as ones having to do with wealth distribution should be investigated.

When all four selected natural resources indicators are combined and compared with the proportion of the population under the poverty line, the correlation between natural resources indicators (together) and economics indicator seems to increase slightly but not

strongly compare to all individual natural resources indicators. By eliminating Greater Accra region, selected natural resources become more correlated to the population living under extreme poverty, since Greater Accra is an important outlier. Although without abundant natural resources, the proportion of population under the poverty line is still low in Greater Accra. It is possible that, if more natural resources having were added into this analysis, the combined natural resources indicator might be more correlated with the proportion of population under the poverty line, under the condition of having Greater Accra eliminated from the analysis. In Gylfason's report, it mentions that natural resources abundance does not necessary enable economic growth (Gylfason, 2000). The analysis in this section also shows that in a regional scale in Ghana, water resources and major cash crops do not have a strong correlation with the economics indicator, percentage of the population under the poverty line.

Key Findings:

- **R^2 correlations between mean time to drinking water and poverty range from 0.002 to 0.57 (weak to strong) with and without Greater Accra;**
- **R^2 correlations between area under oil palm and poverty is 0.19;**
- **R^2 correlation between production of cocoa and poverty is 0.062;**
- **R^2 correlations between selected natural resources and poverty is 0.27 with Greater Accra and 0.56 without Greater Accra;**
- **Regions with more water resources and less time in accessing water on average are not necessarily the regions with lower proportion of population under the poverty line;**
- **Natural resources rich regions in Ghana are not necessarily the regions with the lower proportion of population under the poverty line;**
- **Differences between mean time to drinking water in regions are small, but between proportion of population under the poverty line are large.**

4.2.5 Economics, Education and Natural Resources

4.2.5.1 Correlation and Ranking Analysis

The United Nations has considered eradicate *extreme poverty*, achieve universal primary education and ensure environmental sustainability as key MDGs to be achieved by 2015. In the case of Ghana, the author has looked at three areas in economics, education and natural resources, with six indicators in total, and found that each set of two areas: economics and education, education and natural resources, or economics and natural resources, are moderately to strongly correlated.

To better understand the correlations between these areas and obstacles existing to achieving these three MDGs Goal 1, 2 and 7, two schematics are generated as a summary for the four indicators.

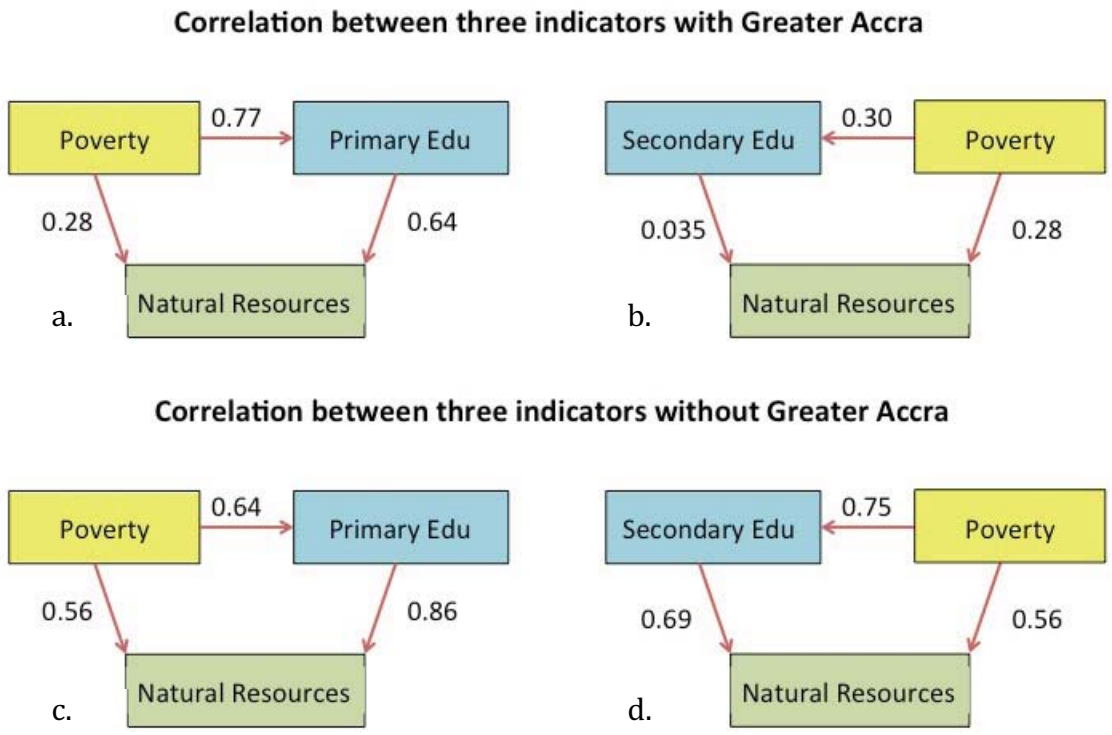


Figure 4-37 a-d. Correlation between three sets of MDGs indicators with and without Greater Accra.
*Note: the directions of each arrow do not mean causation of one indicator to another. Instead, it is meant to show how, in the previous analysis on correlations (Section 4.2.2 to 4.2.4) setup, where the arrow points from x-axis to y-axis.

In Figure 4-37 a and c, the setup of the schematics is based on two primary MDGs, which is ending poverty and achieving universal primary education, with an environmental sustainability key component natural resources. When compared with all the correlation coefficient, the Figures show that after eliminating Greater Accra from the analysis, all coefficients become higher, except the coefficient for the proportion of population under the poverty line and completed primary school (0.64) in Figure 4-37 a and c. Correlation between poverty and selected natural resources stay the weakest in analysis with and without Greater Accra (0.56 and 0.28 respectively).

Figure 4-37 b and d is a comparison for such correlations with secondary education. The idea is to take a step further to analyze the relationships between secondary educations and other economic and natural indicators. Figure 4-37 b and d show that, correlations between secondary education completion and natural resources, proportion of population under the poverty line and natural resources, as well as secondary education completion rate are higher when analyses do not consider Greater Accra. Figure 4-37 a - d show that all coefficients related to secondary education are lower than those to primary education, except correlation between poverty and secondary education for analysis without Greater Accra (0.75).

Ranking is also used to compare the total scores of each regions for the three sets of data based on the ranks of each region in three categories: (X1) Under poverty, (Y1 & Y2) Completion of primary and secondary school; (W) total score for selected natural resources indicators (Tables for calculation can be found in Appendix IV – VI).

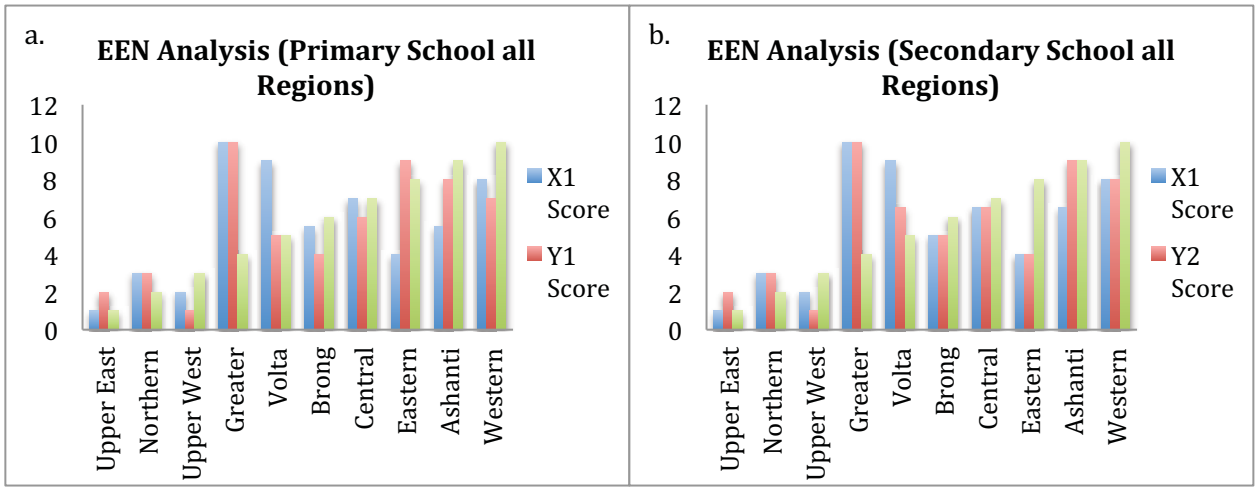


Figure 4-38 a and b. Economics, education and selected natural resources (EEN) indicators score comparison in 10 regions

Figure 4-38 a and b give a general trend for performance of the three indicators. It is not obvious to the author that when one indicator increases, the other two indicators follow. However, there are individual regions that are special compared to the other regions. For example, Figure 4-38 shows that Greater Accra has outstanding score performances in X1 (under poverty) and Y2 (completion of primary and secondary school); however, low score performance in natural resources. The three Northern Sectors (Northern, Upper East and Upper West) receive the lowest scores in all indicators, while Western region has relatively high score performances in all indicators compared to regions excluding Northern Sector and Greater Accra.

4.2.5.2 Advantages Analysis

Advantage analysis calculations (description can be found at Section 4.2.1.6) are done by using region's indicators (percentage of population under poverty, percentage of population completed primary school and secondary school, and total score performance for natural resource that each region has) minus the national average of these indicators.

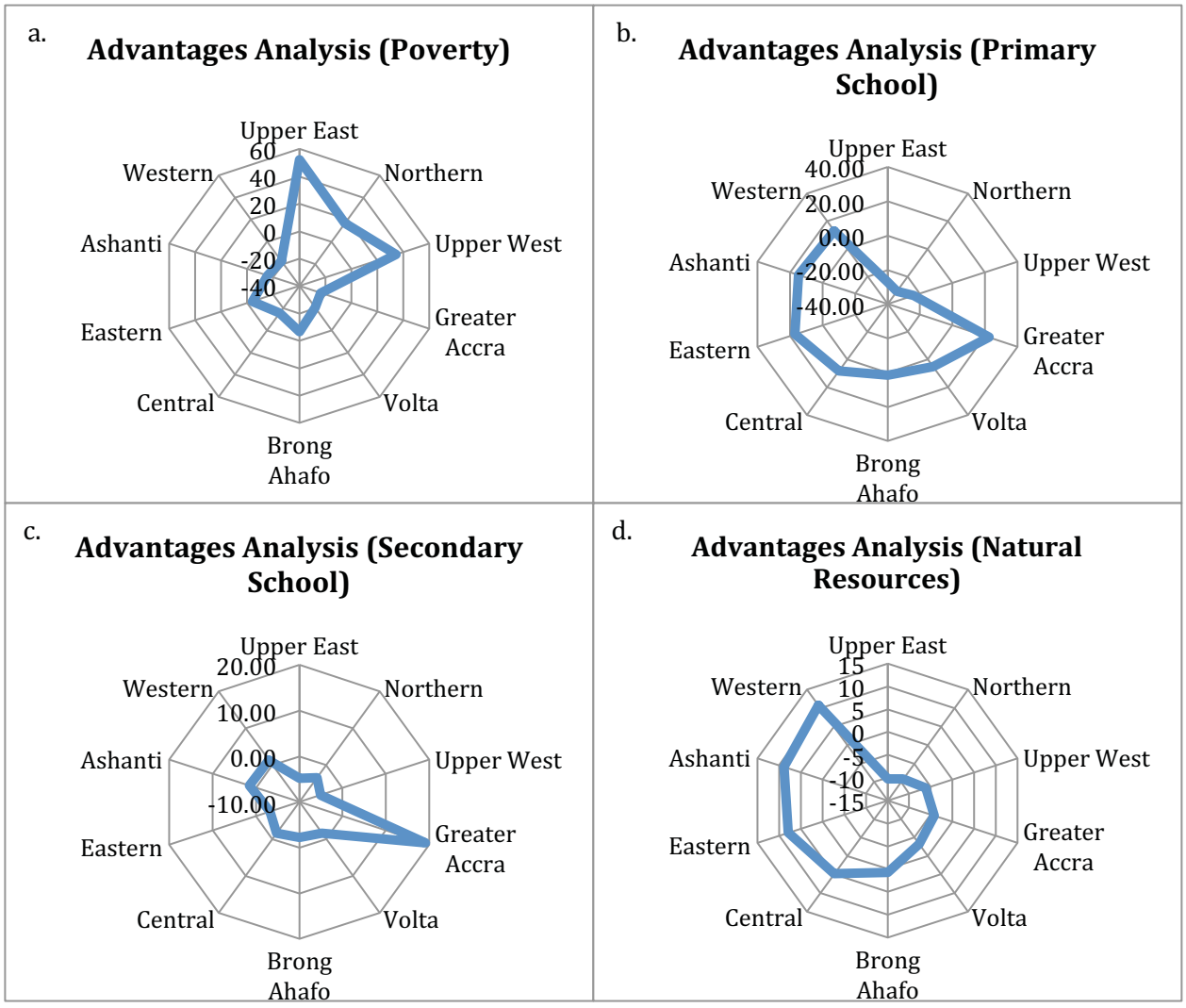


Figure 4-39 a-d. Advantages analysis for proportion of population under the poverty line, percentage of population completed primary and secondary school and selected natural resources.

In Figure 4-39 a., the Northern Sectors Upper East, Upper West and Northern Regions are disadvantaged due to proportion of population under the poverty line far behind the national average; while the proportion below the poverty line in Eastern and Brong Ahafo are slightly under the national level. In Figure 4-39 b, the completion of primary education is somewhat evenly distributed except in Northern Sector. Which lags behind the rest of the country. Greater Accra again shows a huge advantage in completion of secondary education compared to any other regions (Figure 4-39 c). Selected natural resources are well distributed in Western, Ashanti, Eastern and Central regions as shown in Figure 4-39 d.

4.2.5.3 Interpretation on Economics, Education and Selected Natural Resources

The correlation coefficients shown in Figure 4-37 are for economics, education and selected natural resources indicators. The overall weakest correlation among all is between poverty and selected natural resources. Education (both completion of primary and secondary educations) in general has strong negative correlation with both the population living below the poverty line AND areas where selected natural resources are abundant.

However, when Greater Accra comes into play, the correlations change quite a bit. Although overall natural resources performance score is below than the national average (Figure 4-37 d), Greater Accra has the highest completion of education for primary and secondary as well as the lowest population under the poverty line. As mentioned in previous section, Greater Accra has a historical advantage and it is where the capital of Ghana is located. Although without the support of natural resources, Greater Accra is able to establish development advancement in economics and education.

As one can see in Figure 4-39 b and d, Western, Ashanti and Eastern Regions have similar advantage patterns in natural resources and primary school completion compared to national scales. However, ample natural resources do not have the same advantage patterns for secondary school development. Figure 4-39 c shows that proportion of population completed secondary school in Western and Ashanti is only slightly higher than the national average, Eastern Region is much lower than the national average. On the other hand, these three regions have a much lower proportion of population under the poverty line (Figure 4-39 a), it might indicate that the proportion of population under the poverty line are similar in regions with abundant resources After all, regions that have abundant natural resources are also likely to have high percentage of population completing schools and less proportion that is below poverty line compared to Northern Sector.

In Northern Sector, poverty, primary school completion and natural resources availability and development seem to be large challenges compared to other regions in Ghana (Figure 4-39 a, b and d). Such disadvantages in natural resources, primary school completion and large proportion of the population living under the poverty line might confirm what has been mentioned in the previous paragraph. Areas with less natural resources are likely to have low percentage of primary education completion rate and a high poverty.

It is not clear whether the secondary school completion rate has much to do with natural resources, according to the correlation coefficient comparison (Figure 4-37), ranking (Figure 4-38) and advantages analysis (Figure 4-39) on a regional scale. However, both coefficient and advantage analyses show that only without consideration of Greater Accra region will the relationship between secondary school completion and population under poverty are clear.

From Figure 4-37 we have seen that the relationship between each set of indicators is moderately to strongly correlated on a national scale. However, we have also determined that the correlations between economics, education and selected natural resource are

likely to be regionally dependent, meaning that in regions that have similar economics, education and natural resources situations, the correlation are higher (Figure 4-39).

Key Findings:

- **The overall weakest correlation among all correlations is between poverty and selected natural resources;**
- **The correlations between economics, education and selected natural resources are likely to be regionally dependent;**
- **The Northern Sector lags behind the rest of the country in economics, education and natural resources components;**
- **In contrast to all the other regions, Greater Accra has made the correlation coefficients between economics, education and natural resources indicators different;**
- **Greater Accra has obvious advantages in economics and education despite of lacking natural resources.**

Objective 1 mentioned in Section 2 "to collect, review and analyze the most updated data for Ghana at both a national level and in Ghana's ten regions" is achieved with analysis shown in Section 4.1-4.2. The next chapter will separate Ghana into three areas that have similar economics, education and natural resources situation, and discuss the problems faced and opportunities have when achieving the MDGs, then provide recommendations for the designated Areas.

4.3 Area Recommendations for achieving the MDGs

4.3.1 Area Analysis

According to the analysis in Section 4.2, the author separates Ghana into three areas due to stronger relationship among economics, education and selected natural resources for area analysis.

Area I: Greater Accra. Greater Accra has been detected as an outlier in correlation and ranking analysis. Therefore, it is considered as one independent area for analysis.

Area II: Western, Central, Eastern, Ashanti, Brong Ahafo and Volta. These six regions are where natural resources are abundant and economics and educations are about average compared to the national average.

Area III: Northern Sector: Upper East, Upper West and Northern Regions. These three regions are different from all other regions. All three sets of indicators are far below average and no other advantages for these regions have been found so far.

4.3.2. Area I Recommendation

4.3.2.1 Economics, Education, Natural Resources and MDGs

Greater Accra Region is way ahead of other regions when achieving the Target 1.A in Goal 1 of the MDGs (Figure 4-39a), as its proportion of population under the poverty line is 11.8% percent (Table 4-2).

Primary education completion rate in Greater Accra is the highest among all the regions. Although the data shows that percentage of completion is not 100%, such data is for age from 15-49, where our discussion in Section 4.1.2.1. shows that following trends of an increasing number of the population completed primary school in younger age group (Figure 4-40/4-5) percentage of population completed primary school over different age groups), Greater Accra is extremely likely to reach the goal of universal primary education before any other regions. However, since regional data for different age groups' primary education attainment is not available, the author is unable to estimate the years it may take to fulfill this goal.

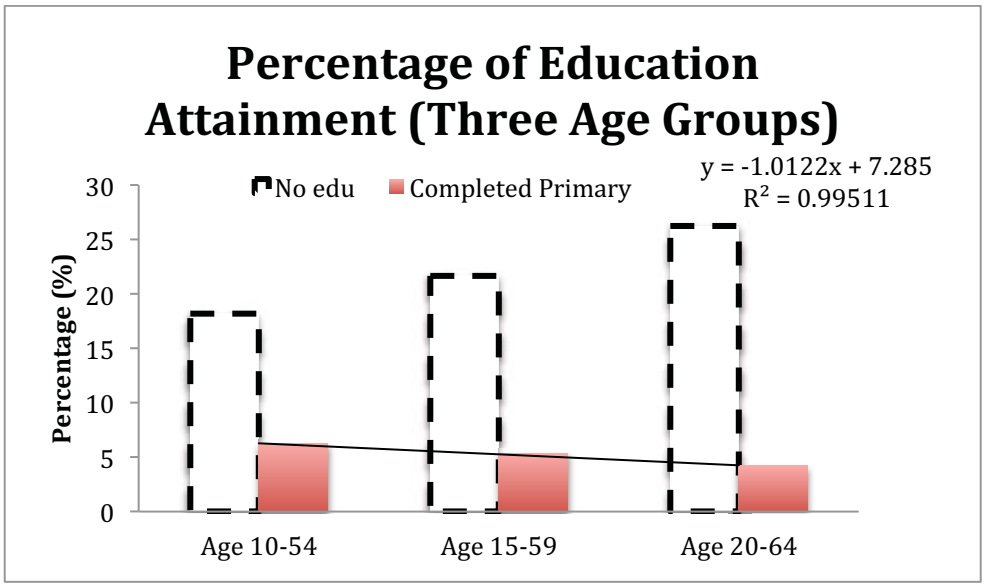


Figure 4-40. Percentage of education attainment in Ghana

For MDG Goal 7, the previous analysis in Section 4.1.3 shows that Greater Accra does not produce major cash crops such as oil palm and cocoa. According to Ministry of Food and Agriculture of the Republic of Ghana, the data available for agriculture production for Greater Accra shows maize, rice and cassava in 2010. Yet, these products are minimum and all of major agricultural production regions are outside of Greater Accra (MOFA, 2010[73]). Additionally, from the land use map in (Appendix X), dense forests and savanna are not

[73] Data collected from GhanaSTAT Ghana under "WFP" folder in "Agriculture and Access to Market By Region". Onliness access at: http://countrystat.org/index.asp?ctry=GHA&t=1&lang=1

within the Greater Accra Region; therefore, it is unlikely that Greater Accra has a loss of environmental resources due to the fact that it is not a region of heavy agriculture production.

The other important environmental sustainability target of MDGs 7.C "*halve the proportion of the population without sustainable access to safe drinking water* has also been achieved in Greater Accra, when compared with percentage of population that had access to improved water source 53% (national average) in 1990[74]. Currently only 0.2% of the population are still drinking unprotected drinking water (Figure 4-41). Over 67% of the population uses public taps or has piped water as their drinking source and this number is already lower than

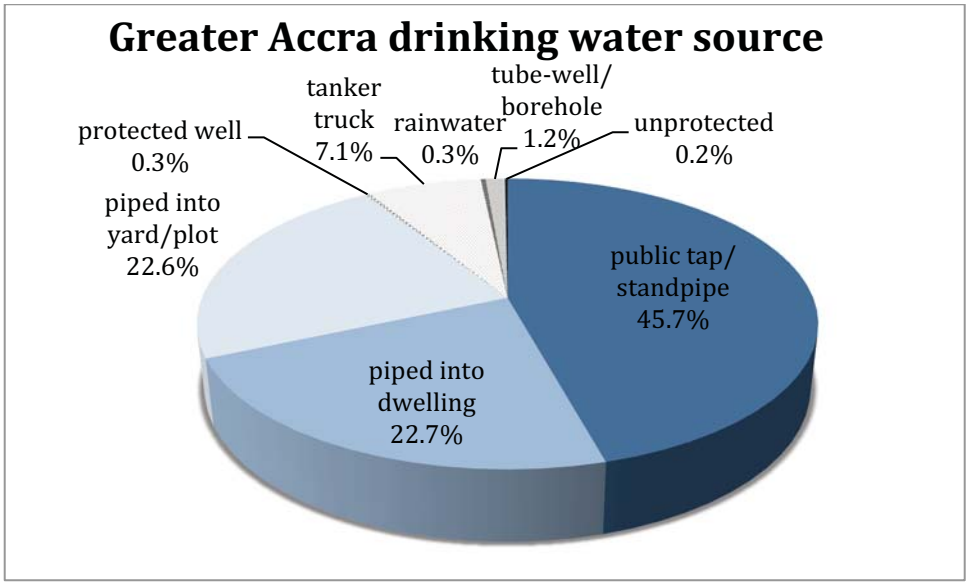


Figure 4-41. Greater Accra drinking water source. Data from Ghana Statistical Service 2006

4.3.2.2 Next Step for Area I

It is obvious from the previous analysis that, Greater Accra has been an exception since it has the highest primary education completion rate, a much higher secondary education completion rate as well as lowest percentage under the poverty line. However, it does not have abundant natural resources available compared to regions such as the Western and Eastern Regions.

Previous analysis Section 4.2.2.2 shows that at least 37% of the population that completed secondary school is living under extreme poverty in Area I. Although the secondary

[74] Data comes from the World dataBank, online: http://databank.worldbank.org/ddp/home.do?Step=1&id=4, Database: World Development Indicators & Global Development Finance -> Next -> Ghana -> Improved water source (% of population with access), accessed on August 13th, 2012

education rate is higher than other regions, it does not bring advantages to help the region reduce poverty. Compared to other regions, Greater Accra definitely has an advantage in secondary education since its starting point is higher and investment required in secondary education is therefore, less needed than in other regions. It is necessary for Greater Accra to utilize its advantages in education to develop economics in high technology due to its lack of natural resources. Investing in improving living standard of population living below the poverty line and who have already obtained a secondary education degree, or even encouraging them to pursue a tertiary education, will not only help Greater Accra eliminate extreme poverty, but also provide enough educated workers for the development of other industries that require workers with a higher education level than primary education.

4.3.3 Area II Recommendation

4.3.3.1 Economics, Education, Natural Resources and MDGs

On average, Area II has 22% of the population below the poverty line, and Eastern region has the highest proportion with 31.4% of the population living below the poverty line. Therefore, the MDGs Goal 1 is upon reaching in the regions.

In education, Area II has an average of 74% completion of primary education and 15% completion of secondary education among population ages from 15-49. Similar to the situation Greater Accra, it is likely that Area II will reach universal primary education in the near future; however, it is not yet clear how soon that date will arrive.

Area II is comprised of regions where natural resources are abundant, based on the analysis shown in the previous section (Section 4.2). Besides the major cash crops cocoa and oil palm, these regions are also major agricultural producers in Ghana, with crops such as maize, cassava, and yam (Figure 4-42) (MOFA, 2010). Cocoyam and plantain are 100% produced in Area II in 2010. Due to such a large agriculture demand on land use, these regions are facing huge challenge in environmental degradation (Lawson et al., 2012). Comparing land use and agricultural regions in Ghana, we find that the majority of the forests are, in fact, located in areas with lots of agricultural activities (Figure 4-43). The agriculture advantages might have brought much more pressure to the environment than areas with little agricultural activities. Such a national demand for agricultural products is making it difficult for Area II regions to achieve the MDGs Goal 7 Target A and B.

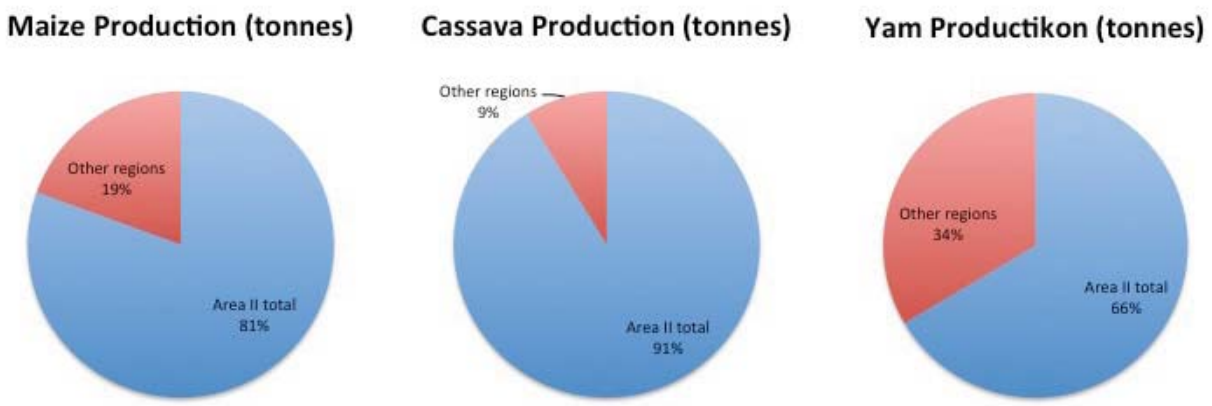


Figure 4-42. Food and agriculture production in Area II compared to other regions in Ghana in 2010. Data comes from Ministry of Food and Agriculture Republic of Ghana[75]

[75] Data collected in GhanaSTAT, Ghana. Online access at: ghanastat.gov.gh. Data accessed on July 14th, 2012.

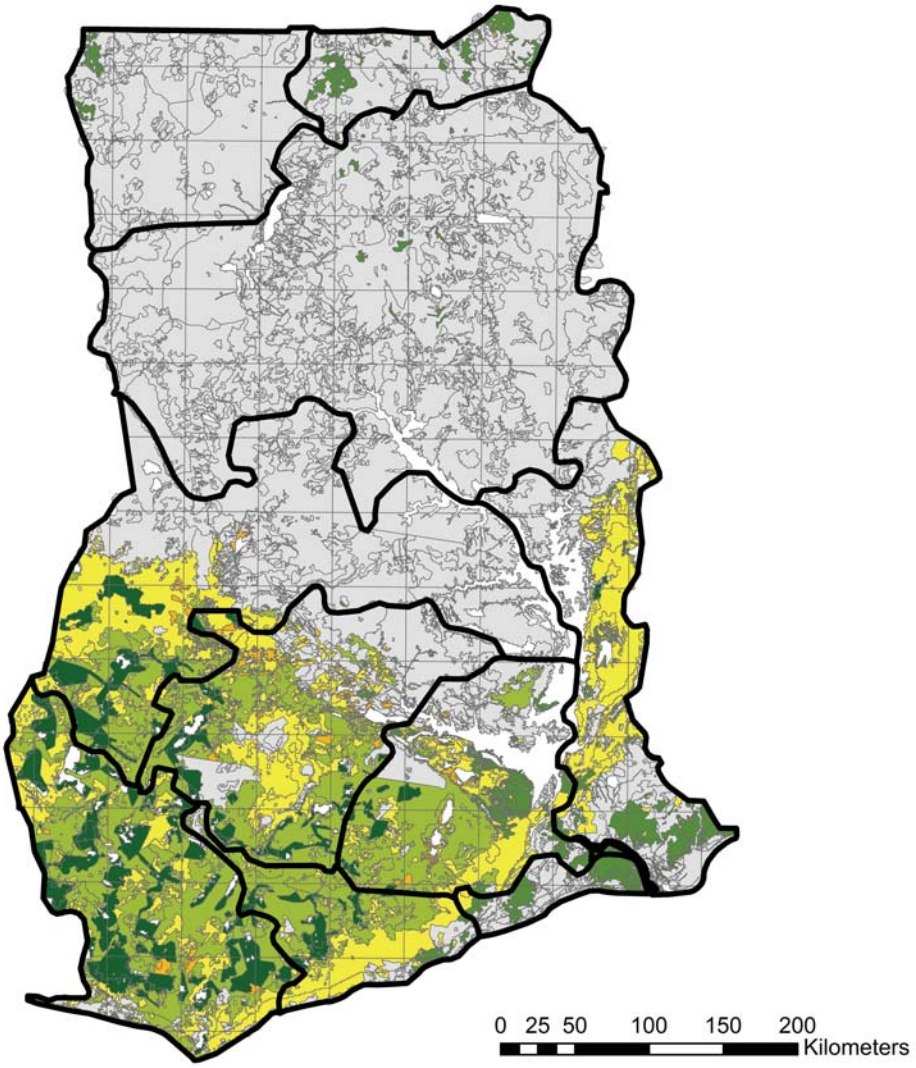


Figure 4-43. Land use (forests, herb and bushes) in Ghana. Mapped by Weini Qiu with ArcGIS. Data from National Renewable Energy Lab (NREL)[76]

[76] Data collected from National Renewable Energy Lab. Online access on July 1st, 2012 at: http://www.nrel.gov/international/geospatial_toolkits.html

In Area II, 37.9% of the population uses public tap as their drinking water source, while only 12.6% has piped water into their dwelling or yard (Figure 4-44). On average, Area II, like Area I, has ensured over half (50.5%) of the population has immediate access to tap water and 38.1% (7.7% use protected well and 30.4% uses boreholes) has access to improved drinking source. Comparing with the percentage of population with improved drinking water source 53% (national average) in 1990[77], total of 88.6% of the population have accessed to improved drinking water in Area II. In other words, the MDG Target 7.C drinking water threshold has been achieved.

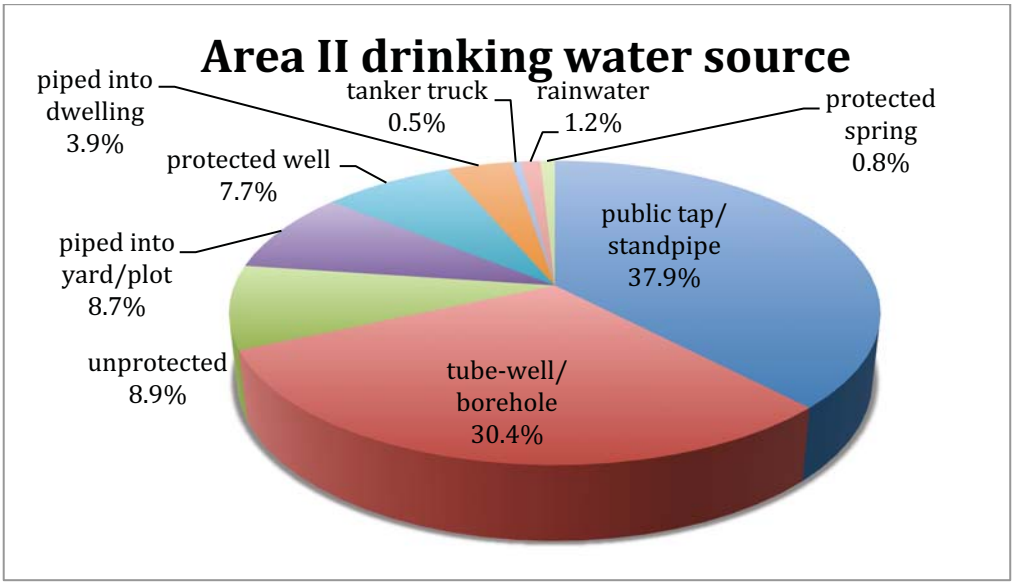


Figure 4-44. Area II average drinking water source. Data from Ghana Statistical Service

4.3.3.2 Next Step for Area II

Area II has a medium proportion of the population living below the poverty line as well as a medium proportion of population who have completed primary and secondary education. Area II also has abundant natural resources in agriculture and water resources (Figure 4-12, Figure 4-14 and Figure 4-16).

Agriculture in Area II has become crucial not just to the regions, but also the whole nation, as these regions have produced over 60% of the major food crops as well as 100% of the major exportable cash crops cocoa and oil palm. Such a natural resources advantage seems to bring some benefits to primary education and secondary education in these regions. The development of natural resources is labor-intensive and the yield rate of crops per plant is not as high as in some other countries that have similar environmental condition (MADSAR, 2012). Therefore, improving agricultural technology to achieve higher yield and

[77] Data comes from the World dataBank, online: http://databank.worldbank.org/ddp/home.do?Step=1&id=4, Database: World Development Indicators & Global Development Finance -> Next -> Ghana -> Improved water source (% of population with access), accessed on August 13th, 2012

practicing sustainable natural resources management are necessary. These require that a higher proportion of the population has an understanding of science and technology, and therefore, higher education than primary education. With the correlation between education levels and natural resources, Area II's agriculture sectors might benefit from more investments in higher education such as secondary school and tertiary school.

However, from the analysis in the previous section (Section 4.2.4.), the author found that the current natural resources advantages has not yet been helpful in reducing the population living under the poverty line to less than that of Greater Accra, where there is not as abundant resources as Area II. It is likely that people that live on more than $1.25 per day have some type of ownership of natural resources and the poor (those living below the poverty line) have not benefited from the growth of natural resources. With the environmental challenge Area II is currently facing, solving the problem of reducing extreme poverty is difficult. Hopefully, since the correlation between economics and educations is stronger, the economics indicator will benefit from the rise of primary and secondary education rates when natural resources attract more investment in education in these regions.

4.3.4 Area III Recommendation

4.3.4.1 Economics, Education, Natural Resources and MDGs

The average proportion of the population under the poverty line in Area III is 70.1%. Upper East and Upper West are not even close to achieving the MDGs Goal 1 target A. Although the author was unable to find data for the rate of poverty reduction in the past years, it appears that it will still be difficult for the Northern Sector to reach the goal of reducing by half the proportion of population (since 1990) under the poverty line by 2015.

In Area III the proportion of the population from age 15-49 who have completed primary school on average is 37% with none of the region with over 40% completion rate. Using the national average increasing rate of the population completed primary school shown in Figure 4-40, which is approximately 1% for the next five years, to estimate the education level, the Northern Sector are very unlikely to achieve the MDGs goal of *universal primary education* in the next 5 years, since completion of primary school for population age from 15-49 in Area III is less than 40%.

Area III is not suitable for producing major Ghana cash crops that require abundant precipitation, such as oil palm and cocoa. However, the three regions, especially the Northern Region is a major food crops producer (MOFA, 2010). Rice, millet (100%), sogrhum, g'nuts, cowpea and soybean are mostly produced in Area III (Figure 4-45). The author has not analyzed the environmental impacts due to the production of food crops displayed in the previous sentence. However, due to increasing demand on food in Ghana, the Northern Sectors are likely to face large environmental challenge in sustainable development. In Figure 4-43 it shows that only a small portion of forest in Area III and therefore, deforestation due to agriculture plantation is not as much as a concern compared to Area II. However, problems associated with deforestation, such as cutting trees as fuels,

have been raised (Anang et al., 2011). Therefore, the MDGs Goal 7 Target A might also be a challenge for Area III.

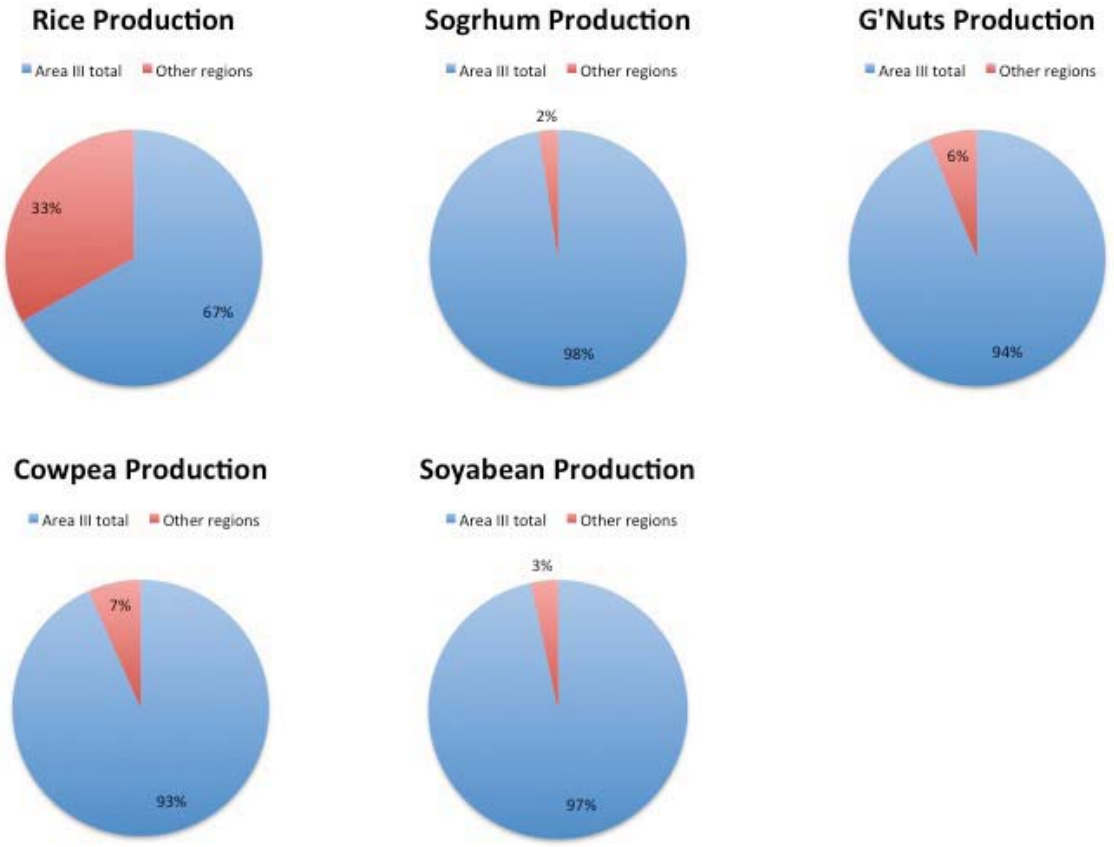


Figure 4-45. Food and agriculture production in Area III compared to other regions in Ghana in 2010. Data comes from Ministry of Food and Agriculture Republic of Ghana[78].

Area III seems to be lacking water infrastructure in each household as there is less than 5% of the population that has piped water in their own house (Figure 4-46). Over 66% of the population use boreholes as their main drinking water source. Although the Demographic and Health Survey has not explicitly explained the water quality of the borehole source, one thing that the author found is that people in Area III do not practice treating water before drinking (Figure 4-47). Only slightly over 12% of the population uses some methods to purify the water. Therefore, the MDGs Goal 7 target C. would have been achieved, only if all boreholes are protected and borehole water is not contaminated, since 85% of the population has access to improved water source (borehole, protected well, public tap, piped into yard and dwelling, protected spring), according tot this Ghana Statistical Survey data.

[78] Data collected in GhanaSTAT, Ghana. Online access at: ghanastat.gov.gh

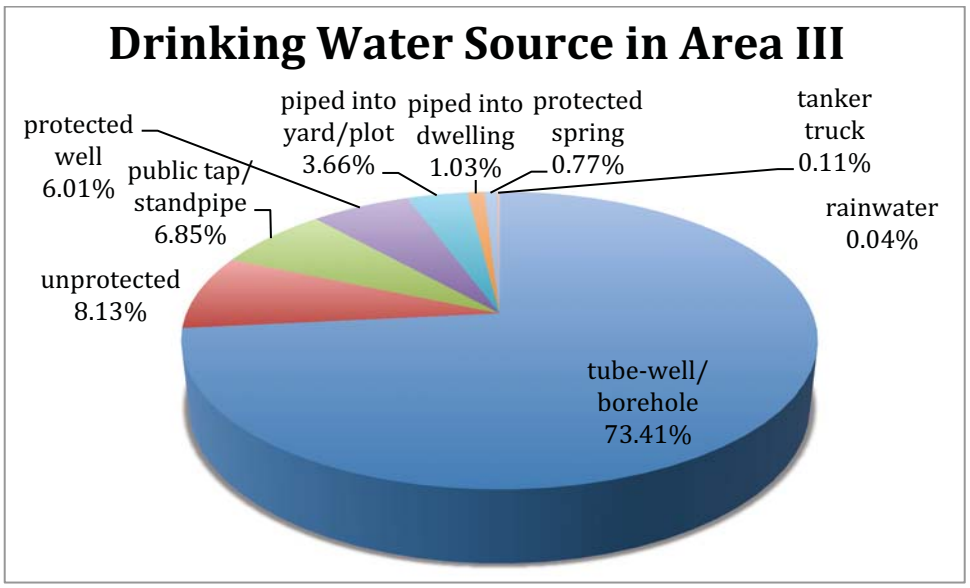


Figure 4-46. Drinking water source in Area III. Data from ghanainfo.gov.gh, accessed on July 13th, 2012.

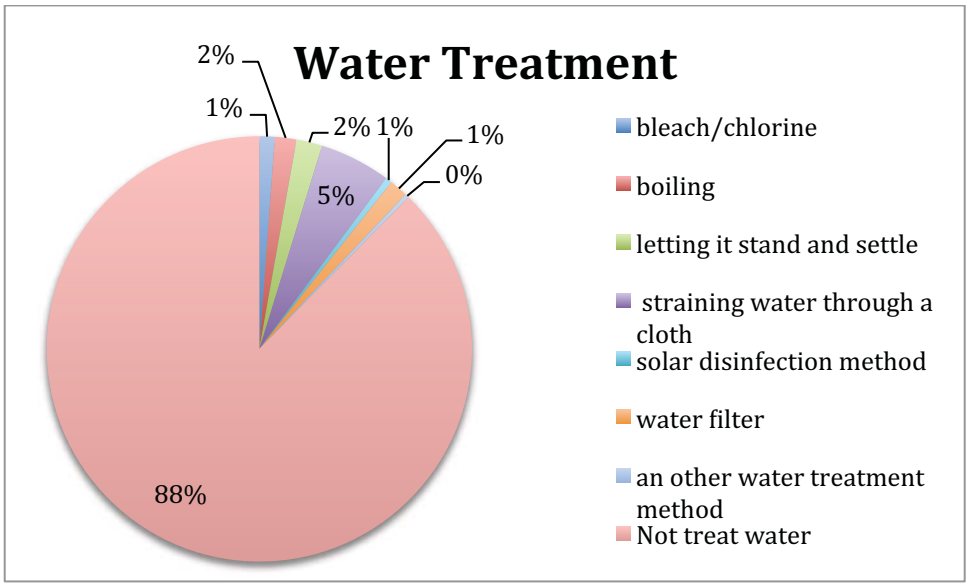


Figure 4-47. Water treatment methods in Area III after getting water from drinking source. Data collected from Ghana Statistics Service.

4.3.4.2 Next Step for Area III

Area III has high proportion of the population living under the poverty line, the lowest percentage of population that has completed primary school and the lowest performance score in selected natural resources oil palm, cocoa and water resources and its accessibility.

As an important producer of food crops for feeding the whole nation (MOFA, 2010), Area III has not been able to utilize this advantage to reduce population under poverty and increase

the completion rate of primary school compared to the whole nation. Although without major export cash crop plantations such as cocoa and oil palm in Area III, Area III might have to find other alternatives resources to help boost the economics and benefit the poor, since the majority of the populations live on less than $1.25 per day. The author has not found a strong correlation between selected natural resources, economics and education level in Area III. Therefore, no obvious clue suggests how the regions ought to develop.

Without either the natural resources support of export crops as has been available to Area II or economics and political supports as Greater Accra has, Area III, needs to first seek help in support for education, because the correlation analysis shown in this thesis suggests that completion rate of primary and secondary education has strong correlation with both economics indicator and selected natural resources in regions in Ghana. Additionally, the author also shows that it takes much more effort to achieve universal primary education in Area III than other regions due to its large population living under poverty without completion of primary education. On the other hand, Area III seems to have a higher rate of continuation towards further education after primary education compared to resources-rich regions such as Area II. It should be considered as a human resources advantage and should be taken advantage of when executing economic development. Putting the focus on education might lead to stronger labor force for utilization of undiscovered natural or human resources in the future as well.

The objective 2 mentioned in Section 2 "suggest broad regional planning priority recommendations based on correlations found between economics, education and natural resources" is achieved with recommendations given in Section 4.3 for three areas in Ghana.

4.4. Limitation of the Study

The analyses shown in Section 4 are only the correlations between four indicators. However, all these correlations do not mean causation. Although the author has also interpreted the correlation and provided extra data collected by other researchers in each *Interpretation and Discussion* section, it is simply background information that the author considers as helpful. It is left to the readers to find out the causation of each correlation. For example, in Section 4.2.3.6, with research conducted by MASDAR consulting, the author mentioned that "…educational facilities are more likely to be built in natural resources abundant regions and therefore, primary and secondary education are higher in six regions where oil palm and cocoa are cultivated". The author does not have enough data to support and confirm such a potential causation relationship. Therefore, other sources of information are provided in case readers suspect or are interested in further research into causation.

Additionally, due to the limitation of data and scope of the thesis, general results only provide one prospective on the development issue. For example, the author mentions in Section 4.3.4 that environmental stress due to land use in Area III might be less than that in Area II because of lack of cash crop plantations and forests and trees in Area III. However, other factors in Area III are out of scope of this thesis and therefore, not discussed. It does not mean that other factors are trivial. Instead, it is because the topic of environmental

sustainability is large and the author is unable to collect all information needed for comprehensive analysis.

What is Next?

We have shown that in the Northern Sector, poverty has little correlation with selected natural resources, especially water resources. It might imply that in order to achieve the two MDGs Target 1.A and Target 7.C, different strategies might be required for different regions due to the lack of linkage. At the same time, the analysis shown is unclear as to how these two MDGs Targets affect each other. In order to understand the empirical link between the two, the author conducted a market research in water sector in Tamale, capital of Northern Region, which we will discuss in the second half of the thesis.

5. BETWEEN MACRO LEVELS TO CASE STUDY IN WATER SECTOR

In the previous chapters, the author has introduced the relationship between economics, education and natural resources. The analysis suggests that there are moderate to strong correlations between natural resources and the proportion of population under poverty and completing primary school. As a public good resource, the author's analysis shows that water accessibility has little to do with poverty, especially in accessibility of water resources (in this thesis, the accessibility of water is the same as the mean time to drinking water), where the correlation coefficient square is 0.0183 and 0.0019 with and without including Greater Accra for analysis.

Will it be worthwhile to continue investing more in other water sector such as Household Water Treatment and Safe Storage (HWTS) products to improve water quality, although there is only little correlation between water accessibility and population under the poverty line? Will the lack of linkage between accessibility of water and poverty affect the correlation between improvement of water quality and economic development?

Therefore, a case study was conducted in Customers' Preferences on HWTS Products in urban Tamale, Northern Region where natural resources, education level and percentage of population above the poverty line are all lower than average. This case study is also a partial fulfillment of a project funded Water in African Through Everyday Responsiveness (W.A.T.E.R.) and the third objective to this thesis.

6.1 Introduction in Water Sector in Ghana

6.1.1 Ghana Water

Ghana is well endowed with water resources, yet the amount of water available is heavily dependent on season and year due to the fact that surface water is heavily reliant on recharge by precipitation (Water Resource Commission of Ghana (WRCG), 2012). There are three major natural water resources Ghanaians are able to get access to: 1. River systems; 2. Groundwater; 3. Rainfed groundwater. However, the availability of water is decreasing due to variation of rainfall, population growth, increasing environmental degradation, drainage of wetland and pollution of river and groundwater (WRCG, 2012).

Improved drinking water is not universally available in urban and rural regions of Ghana. Figure 6-1 shows that there are 9% (Figure 6-1a upper right) and 20 % (Figure 6-1b surface water plus other unprotected water sum of the two upper layers) of the population respectively in urban and rural areas in Ghana in 2010 (WHO/UNICEF, 2012b). In total, according to the United Nations Joint Monitoring Program data, 68% (Fiugre 6-1c second layer from the bottome) of the population has improved water sources in whole Ghana and 18% (Figure 6-1 c bottom layer) have piped into premises (WHO/UNICEF, 2012b).

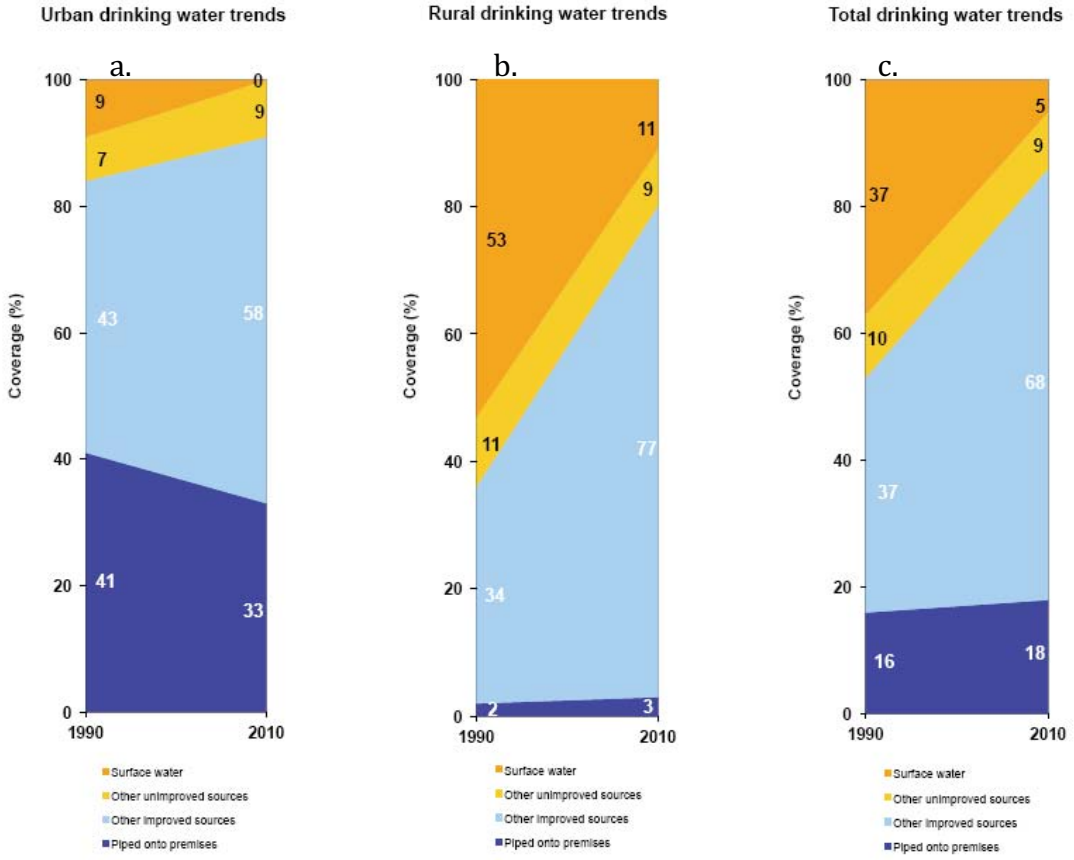


Figure 6-1. Improved and unimproved drinking water coverage percentage in urban and rural area in Ghana from 1990 to 2010.

According to the UN Joint Monitoring Program (JMP), improved drinking water includes: piped water into dwelling, piped water to yard/plot, public tap or standpipe, tubewell or borehole, protected dug well, protected spring and rainwater collection (JMP, 2012[79]). However, improved drinking water does not always mean safe drinking water (CDC, 2012a). As mentioned in the previous paragraph, water resources in Ghana are facing threats from both human and natural factors. Additionally, water infrastructure such as piped water connection has not reached rural areas widely (80% shown at Figure 6-1 b sum of two bottom layers).

6.1.2. Water Financing and Ghana Water Market

Up to April of 2012, there are total of 14 large donors for water related projects in Ghana. Donors provided over US$1 million in aid includes: International Development Association (IDA) (28), Belgium (26), EU Institutions (9), Canada (7), Africa Development Bank (AfDF) (6), France (3), Netherlands (2), Germany (1) and USA (1) (UN-Water Report, 2012).

6.1.2.1. Large Water Sector Investment

According to the World Bank, only about one-third of the capital's residents have water piped into their house (World Bank, 2011d). Recently, Ghana's government has partnered with the World Bank, Export-Import Bank, to finance projects in the water sector in Accra metropolitan area (World Bank, 2011d). Efforts have also been made to other urban and rural areas outside of the Greater Accra Region. Large organizations and the government of Ghana have invested millions of dollars in supporting water service and related infrastructure. The Northern Region Small Town project is supported by Canadian International Development Agency (CIDA) and the government of Ghana. It provides basic water needs for 30 towns in Northern Region of Ghana (CIDA, 2012). The World Bank approved two projects Urban Water Project (UWP) and Small Town Water Supply and Sanitation Project (STWSSP) in 2004, with contribution of German Development Agency and Government of Ghana on STWSSP to finance water infrastructural project and community subprojects (World Bank, 2004 a & b). With continuous financial support, the coverage of accessing to improved drinking water has increased in both urban and rural region to 91% and 80%, respectively.

6.1.2.2. Small Water Business Market

Due to Ghana's stable political environment and investment for the water sector, both foreign investors and local private companies have envisioned market opportunities in the water industry in Ghana. There are at least 20% and 10% of the rural and urban populations (respectively) (Figure 6-1) do not have access to improved drinking water, which accounts for over 3.6 million population (World Bank, 2010). To fulfill the needs for

[79] Definition of improved drinking water is from: http://www.wssinfo.org/definitions-methods/watsan-categories/ accessing on July 31st, 2012

clean drinking water, while the government and foreign donor agencies have yet to focus their investment in finance big projects and helping entrepreneurs in areas where the other 30% of the population (not having access to improved drinking water) come from, small business water market size is large and supportive. For improved drinking water, there are two small market potentials that current exist in Ghana: direct improved water supply and point-of-use treatment methods. Both approaches are profitable since they will charge users a fee for services or products provided.

6.1.2.2.1. Direct Water Supply

According to McGranahan, there are seven types of for-profit water utilities and companies in Ghana that provide water supply directly to Ghanaians (McGranahan et al, 2006)[80]:

1. Ghana Water Company (GWC)
2. Tanker operators
3. Cart operators
4. Domestic vendors
5. Neighborhood sellers
6. Sachet water/ice block sellers

Company charge a certain amount of water based on the quantity of water acquired. The enterprises provide centralized water treatment and or distribute treated water to customers. Except GWC, which is mandated to supply water to urban areas, other operators are called Small Water Enterprise (SWE) that also provides water supply from utility system to end-users (McGranahan et al, 2006). These SWE get water from either piped water system or natural protected water source such as groundwater in a large amount of quantity, and are an "important intermediary supply chain" to decrease the time to drinking water source for the urban and rural poor in Ghana.

Table 6-1. Supply chain and market share in Accra (McGranahan et al, 2006)

Supply chain	Customer
Network → Tanker → Kiosk → Households	~70% of households normally; ~95% in times of shortage
Network → Cart operator → Households	~8% of households normally; ~0% in times of shortage
Network → Kiosk → Cart operator → Households	~20% of households normally; ~5% in times of shortage
Network → Kiosk → Households	~2% of households normally; ~0% in times of shortage

[80] The author combined McGranahan's finding with the most updated organizations/agency's water supply model, where point 1-6 are generated from McGranahan and No. 7 is not.

Another type of direct water supply that has not been mentioned in McGranahan's article is non-profit water supply agency. One of the examples for SWE is Community Water Solution (CWS), a non-profit corporations that handles both centralized treatment of dugout water normally used by a community and distribution of treated water (CWS, 2012). Their business model is a for-profit enterprise which allows them and partnered entrepreneurs to generate enough capitals to run the business continuously.

6.1.2.2.2. HWTS Enterprise

Another small water business market potential in Ghana is Household Water Treatment and Safe Storage (HWTS). The approach of HWTS is to treat water at the point of consumption instead of at a centralized point such as drinking water treatment facility that GWC owns, and provide safe water storage (CDC, 2012b). In emerging market, HWTS is usually used to treat small amount of water in household, schools, health clinics, etc. that are 1.far away from centralized treatment facility; 2. SWE have not reached out to; 3. Contamination is likely occurred during transport and storage (Minnesota Department of Health, 2011; Sumaila, 2009). Customers will be charged on products that will be used to treat their water. Commonly, products of such enterprises are sold in a subsidized price or distributed out for free (Dupas, 2012). The adaptation rate of HWTS varies in different aresearch. For example, Luoto found that HWTS have low adoption rate in developing countries in general (Luoto et al, 2011). However, in Karaga Township in Upper East Region of Ghana, after the education and training program, 90% of the households in the community still actively use ceramic filters provided by PHW one to five months after distribution (PHW, 2009).

6.1.3 Water Market Target

For the objectives of this thesis, the author is interested in further understand the correlation between water quality and poverty in micro level, and whether the disadvantage of accessibility of water and water quality in Northern Region can bring benefit to economic development. Therefore, we selected HWTS products as our target that allows the author to communicate with end-users and potential customers face-to-face.

6.2. Objectives of Case Study

Household Water Treatment and Safe Storage (HWTS) products face challenges due to correct, consistent and sustained use by low-income communities. To enhance the improvement of HWTS products and understand on a micro scale the relationship between water and poverty, the objective of this case study is to a) find out the customers product preference in order to increase usage and accessibility of HWTS in Northern Region of Ghana; b) provide recommendation on how to potentially improve current products in terms of both design and technology in order to attract more customers to the buy products without subsidy, or replace with new or improved products that are more favored; c) use market research results to suggest whether HWTS, as a water quality improvement product, can help create economic development opportunities in Northern Region to shorten the difference in economics with other regions in Ghana.

6.3. Literature Review on Product Preferences and Markets

6.3.1. Overview of HWTS Products

6.3.1.1. Selection of the Market Research Products

According to the following classification system, there are five core categories of HWTS products in the emerging market (Murcott, 2006):

1) *Safe Storage;*
2) Disinfection including boiling, chlorination and SODIS/UV disinfection;
3) Particle removal products (cloth filter, ceramic filter, biosand filter and settling/precipitation only;
4) Combined system, including mixture for coagulation and chlorine disinfection (e.g., *PUR*), filtration and disinfection (e.g., *Life Straw® Family*);
5) Chemical removal systems (e.g. to remove arsenic or fluoride).

Based on a contract between W.A.T.E.R and their sponsor Diageo Foundation, W.A.T.E.R and Pure Home Water (PHW) selected six products from these options for market research based on the availability and potential of the products in Tamale Ghana. The six products are listed as followed:

Chlorine disinfectant: *Aquatabs*
Particle removal: *CrystalPur™/Tulip Siphon Water Filter, Kosim Classic, Kosim Deluxe*
Combined treatment: *PUR, Life Straw® Family*

6.3.1.2. Aquatabs

Aquatabs are chlorine disinfection tablets that used for everyday household and emergency water treatment. They are considered the largest selling brand of water purification tablets, with more than 13 million daily users globally (Medentech, 2012). The active ingredient is Sodium Dichloroisocyanurate (NaDCC), which has been proven to reduce the number of thermotolerant coliforms and other waterborne microbes (Medentech, 2012). A dose of one 3.5mg *Aquatabs* can treat 10 liters of water. In the Ghanaian market, *Aquatabs* are sold in tablet form in a package of 10 tablets. The product does not coagulate any particles and it is not sold along with cloth filters. Based on the author's survey of 203 shops in greater Tamale during January 2012, *Aquatabs* are not available in urban Tamale, as none of the drink shop/convenient store, household products shop and supermarkets in major roads of Tamale carried *Aquatabs*. However, a USAID supported project, Ghana Sustainable Change Project (GSCP) has implemented the "Purified Water: A Better Life: campaign, where volunteers utilize media such as theater and road shows, radio and posters to educate and promote the usage of *Aquatabs*, this has been reported to have increased the sales volume of *Aquatabs* in Southern Ghana, treating 4,545,820 liters of water between Octorber 1st 2008 to March 30th 2009 (USAID 2009).

Figure 6-2. *Aquatabs* displayed in Ghana

6.3.1.3. CrystalPur™/Tulip Siphon Water Filter

CrystalPur™/Tulip Siphon Water Filter is a small ceramic siphon filtering device that is put in water bucket or water tank. It is impregnated with silver which prevent the growth of a biofilm in the filter pores. Based on prior research of the *CrystalPur™/Tulip Siphon Water Filter* conducted in Northern Ghana by Master of Engineering student S. Ziff, the removal rate of total coliform and *E.coli* was 90.7% and 94.1% respectively (Ziff, 2007). *CrystalPur™/Tulip Siphon Water Filter* is described as "extremely affordable" by the World Health Works, a for-profit company specializing in the marketing and distribution of health-related products to low-income consumers in emerging economies (World Health Works, 2007). In western Ashanti and Greater Accra region, 3,500 *CrystalPur™/Tulip Siphon Water Filter* filters were donated by Diageo Foundation and 15,000 filters are being distributed by Relief International with the help of the Arthur Guinness Fund (Relief International, 2011). However, based on author's observation, *CrystalPur™/Tulip Siphon Water Filter* is not available in the market in Tamale Ghana. In addition, *CrystalPur™/Tulip*

Siphon Water Filter has been marketed in other developing countries such as Uganada, with the goal of creating a market for inexpensive water filter (EntrepriseWorks, 2008). In India, Water Needs Pvt Ltd, is manufacturing the filters locally for less than 500 Rupees ($11 each) (Akvo, 2010; BasicWaterNeeds, 2012).

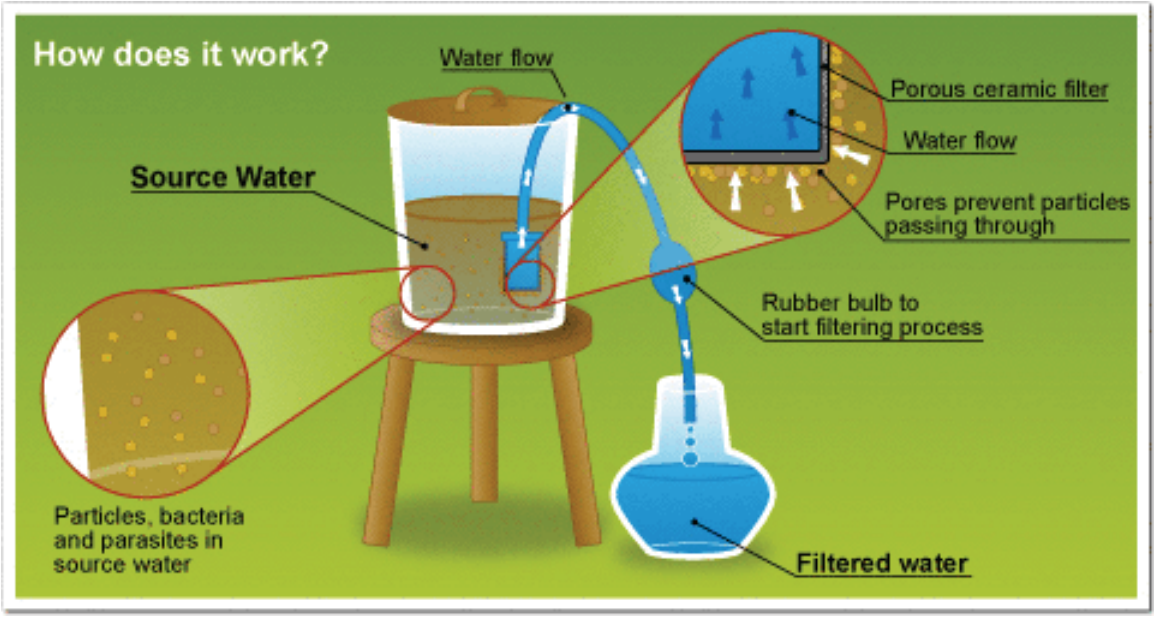


Figure 6-3. Schematic showing *CrystalPur™/Tulip Siphon Water Filter* filtration process
*Photo courtesy: Giving for Good Program

6.3.1.4. Kosim Classic & Kosim Deluxe

Kosim Classic & *Kosim Deluxe* have the same interior ceramic pot filters that are sold and distributed by PHW in northern Ghana[81]. Filters are made with rice husk and Gbalahi and wayamsa clay, and painted with silver to prevent growth of bacteria at the surface and in-between pores of the filter. It filters 5-10 liters of water per hour and removes particles. The current hemispheric filter producing by PHW (12 kg of Gbalahi clay, 4 kg of Wayamba clay and 4 kg of Rice Husk) is able to remove 93.7% and 99.7% of bacteria removal without and with applying silver[82], respectively (Miller, 2012). *Kosim Classic* is defined as the original version of *Kosim* Ceramic Filter, which parts for which (Ring, Lid and Storage Receptacle) are purchased from a manufacturer Quali Plastic in Accra and assembled in Tamale Ghana. The receptacle for the *Kosim Deluxe* is imported from Cambodia and it is a water treatment and storage device called "Super Tunsai"in Cambodia. It was redesigned by PATH's product development team to make the original *Tunsai* product more aesthetically pleasing (Lennon, 2011). Only *Kosim Classic* is currently available in Tamale Ghana and it is sold by Pure Home Water and local retailer stores as well as the

[81] The idea of using the same interior ceramic pot filters during the market research is to find out if appearance matters to the respondents.
[82] Silver is used to keep in contact with water after production of pot filters to continue disinfecting pathogens (Lantagne, 2001).

manufactures such as Cermica Tamakloe Ltd in Accra. (Fitzpatrick et al, 2008). Researches has been done by the Department of Civil and Environmental Engineering at MIT on *Kosim Classic* filter varying from contaminants removal rates to implementation in northern Ghana (Swanton, 2007; Miller, 2010; Kleiman, 2011; Hester, 2011; Miller, 2012).

Figure 6-4. Outlook of *Kosim Classic* filter with cone-shaped filter inside. Photo taken by Weini Qiu

Figure 6-5. *Kosim Deluxe* filter from Cambodia ("Super Tunsai"), interior ceramic filter element is manufactured by PHW. Photo taken by Weini Qiu

6.3.1.5.PUR™

PUR™ is a product produced by Procter & Gamble and designed to use under emergency situation or during everyday or outdoor activities where clean water is not accessible. It contains Calcium Hypochlorite (0.022g) to disinfect water and iron sulphate (352 ferric iron) to settle particles and microorganisms (Purifier of Water, 2012). The idea of using iron sulphate is similar to coagulation that is commonly used for drinking water treatment plant for settling colloidal solids and suspended solids[83] (Safe Drinking Water Foundation, 2012). Similar to *Aquatabs*, it is a one-time use product and each package (4g) treats 10 liters of water. The official manufacturer claims that PUR™ removes turbidity, cysts and poluttants as well as viruses and bacteria, It does not indicate the biological or undesired solutes' removal rate. Through P&G's Children's Safe Drinking Water program, PUR has been distributed to 30 developing countries to clean more than 850 million

Figure 6-6. *PUR* to be sold in Ghana

[83] Colloidal solids are un-settable solids that do not dissolve into water but electrically charged; suspended solids are those that can settle out of water over time. Information comes from: http://water.me.vccs.edu/courses/env110/Lesson4_print.htm, accessed on August 7th, 2012

liters of water and avert more than 30 million days of diarrhea (Buiness Courier, 2007). According to the P&G Health Science Institute, P&G will be providing 350 million sachet of PUR™ (3.6 billions liters of purified water) to developing countries by 2012 (P&G, 2012).

6.3.1.6. Life Straw® and Life Straw® Family

Life Straw® and *Life Straw*® *Family* are series of products designed by Vestergaard Frandsen as HWTS household treatment products in developing countries (Vestergaard Frandsen, 2011). *Life Straw*® *Family*, Vestergaard product that we focused on in Ghana, has water receptacle with a prefilter that removes particles that are larger than 80μm, and a purification cartridge with ultra-filtration membrane (20nm) that removes turbidity, protozoan parasites, bacteria and viruses (Figure 6-7) (Vestergaard Frandsen, 2011). The *Life Straw*® *Family* also has a backwash function that sustains the use of the device for filtering up to 18,000 liters of water (Clausen, 2009). According to Vestergaard promotional brochure of *Life Straw*® *Family*, the flow rate averages 9 liters per hour and a removes minimum of 99.9999% bacteria and 99.99% virus. Life Straw Family has been distributed to Democratic Republic of Congo, Cambodia, Ethiopia, Mexico, Kenya etc., to investigate the adaptability of the device (Clasen, 2010; Vestergaard Frandsen, 2011; Lundy, 2011).

Figure 6-7 *LifeStraw*® *Family* displayed in a household in Ghana

6.3.1.7. Products Calculations and Explanation

A summary to each of these 6 HWTS products is provided below in terms of costs, lifespan, flow rate, price per volume, etc. The HWTS products will be compared to the piped water price at Table 6-2.

Table 6-2 Comparison of six HWTS products, piped water and tank water

	Costs (GHC[84])	Lifespan	Flow Rate	Price/Volume (GHC/m^3)
Aquatabs	0.5/tablet	One time use	N/A	50.00[85]
CrystalPur™ /Tulip Siphon Water Filter	20	3-6 months[86]	4-5 L/hr[87]	2.86[88]
Kosim Classic	45	2 year +	6-10 L/hr[89]	2.57
Kosim Deluxe	75	2 year +	6-10 L/hr	0.86
PUR	5/bag	One time use	N/A	500.00[90]
Life Straw® Family	60	3 years	6 L/hr	3.33[91]
Piped water	0.478/m^3	N/A	Continuous	0.48
Tank water	2.942/m^3	N/A	Continuous	2.94

The cost listed above is not necessary the actual price that the products will be sold or are being sold. The price was determined between Jim Niquette, consultant for Pure Home Water and the author, as part of the market research, to find the acceptable price point of each product in the urban region of Tamale. *Life Straw® Family*'s flow rate was calculated

[84] Currency exchange rate for Ghana cedi to US dollars is about 1.6:1 in January 2012. Information can be found: http://www.exchangerate.com/currency-charts/USD/GHC/last-9-months/

[85] Assuming one tablet treats 10 liters of water

[86] The range depends on quality of source water. Available at: http://www.enterpriseworks.org/pubs/CrystalPur%20(rev%20MAR%204%202012%20)%20JN%20AK[1].pdf. Source: Enterpriseworks.org accessed at March 23rd, 2012.

[87] Information can be found on the website: http://www.tulipwaterfilters.com/product-details/

[88] Calculation is based on reference given by enterpeiseworks.org: filter needs to be replaced per 7000 liters of water

[89] Information given by Matt Miller, member of the MIT Ghana Master of Engineering Project, using current hemispheric pot filters produced by PHW. The flow rate of *Kosim Deluxe* and *kosim Classic* is the same.

[90] Assuming one bag of PuR treats 10 liters of water

[91] Calculation is based on reference given by Vestergaard Frandsen.com: filter can treat 18,000 liters, available at: http://www.vestergaard-frandsen.com/lifestraw/lifestraw-family/features. Accessed on March 23rd, 2012

assuming that it takes one second to fill the tube with dimension of 2.9 mm diameter and 25 cm length (direct measurement). Price per volume was calculated to compare the price that customers need to pay for each product/service. The volume is based on water that can be filtered or treated before replacement is recommended due to clogging or finishing up of disinfectants. It is recommended by the official manufacturing website that *CrystalPur™/Tulip Siphon Water Filter* can filter up to 7000 liters of water before replacement (Enterpriseworks, 2012); while *Life Straw® Family* can treat 18,000 liters water that are microbiologically clean (Vestergaard Frandsen, 2012). The cost per volume of *Kosim Classic* and *Kosim Deluxe* was calculated assuming 16 hours of the filter usage daily, and midpoint of the flow rate range was taken (1.5 L/hr and 7.5 L/hr, respectively).

6.3.2. Market Research Literature Review

6.3.2.1. Product Market Testing

It is said that in a general market platform, "one in ten new product makes it to market, the rest are most likely to be screened out at the early stage" (Hague and Jackson, 1999). In addition, about 40 per cent of new products that are launched, actually fail (Chay, 1989). Furthermore, finding new products to replace those in decline occurs through serendipity for most of the companies.

Unlike water treatment products sold in the market in developed countries, HWTS products are usually not tested by the proponents before they are offered to potential customers, because the majority of them are subsidized or donated by international development organizations. In a report on *Implementation, Critical Facts and Challenges to Scale up of Household Drinking Water Treatment and Safe Storage*, among variety of financing approaches of 34 organizations, only 12 percent use commercialization (also known as "for-profit" model) to implement HWTS products (Murcott 2006). Jeffrey Sachs also pointed out that *social marketing is* "always a bad idea" (Wordpress, 2012). That is to say, HWTS products should be treated as normal products sold in the market, regardless of whether this is with or without subsidies. Conducting product testing for HWTS products in emerging markets is necessary to help organizations decide what should be done to improve HWTS products and spread out the usage of HWTS products in both urban and rural areas. Nowadays, more than 780 million people still do not have access to improved water and addition of 1.2 billion people *use water from sources or systems with significant sanitary risks* (JMP, 2012a and Onda et al., 2012). It is important to understand such testing allow HWTS to expand its market, especially in the low-income countries by using normal commercialization approach, which requires for the market to choose the best product(s) for local communities (Mintz et al., 2001).

6.3.2.2. Methods in Market Research

This section is used as guidelines to define and design market research for HWTS products that have potential in Tamale, Ghana. General methodology will be introduced below and the specific methodology applied will be discussed in the last part of this chapter.

6.3.2.2.1. Quantitative and Qualitative research

It is somewhat true but not exactly that "quantitative" and "qualitative" imply quantity and quality in market research (Hague and Jackson, 1999). As Sampson described, "qualitative research is centrally concerned with the understanding rather than the measurement of things" (Sampson 1967). Qualitative research will helps interviewers understand and explore the problems rather than finding out an exact answer; while quantitative research can help measure market aspects and consumer population that make up the market (Hague and Jackson, 1999).

There are four major differences in qualitative and quantitative research: 1. Types of problems to be solved, 2. Sampling methods, 3. Methods of approach and 4. Style of collecting information (Goodyear, 1990). In addition, quantitative research tends to generate certain answers and qualitative research will help provide information far beyond yes or no responses (Shuttleworth 2008). Detailed discussion of these differences will not be discussed in the thesis. However, key considerations of both quantitative and qualitative research will be introduced, as it pertains has the market research design of this thesis.

6.3.2.2.1.1. Methods of Quantitative Research

Quantitative research is able to collect three classes of data: 1. Market measures; 2. Customer profiles and 3. Attitudinal data (Hague and Jackson, 1999). Direct measurement, such as via retail audits, etc, is a method that allows interviewers to analyze what people actually do in a real setting (Hague and Jackson, 1999). Interviewing is another method to collect quantitative data for market measurement and scales are often used, for example, to obtain attitude data on satisfaction with a certain product (Hague and Jackson, 1999).

6.3.2.2.1.2. Methods of Qualitative Research

Focus group, in-depth interviews, and observation are ways for interviewers to obtain information and collect opinions on designs and products (Hague 1999). Focus group can yield more ideas than one-to-one interviews since group members are encouraged to share their opinions. In-depth interviewing involves conducting intensive individual interviews to explore the person's perspectives on a particular idea, program or situation (Boyce and Neale, 2006). It is believed that "(in-) depth interviews may be the only option in business-to-business markets" when it is not possible to recruit a sufficient quantity of people to join the focus group discussion (Hague 1999). Another effective method is observation, although it does not sound formal, which indeed is critical in qualitative research method. Focus groups and in-depth interviews might yield a great deal of information about what customers like or dislike; yet observation will discover "how real decisions are made" (Hague et al, 2004).

6.3.2.2.2. Direct and Indirect Question

Hague points out that direct questions might *draw a blank or invoke an answer given in ignorance but which is believed to be correct* (Hague, 1999). This method might create embarrassment or sensitivity or simply an inability to articulate an answer by the respondents. On the other hand, Lehmann mentions in *Market Research and Analysis* that indirect questions may sometimes "trick" respondents into giving a more truthful answer (Lehmann, 1989). During MIT's Independent Activities Period in 2011-2012 in Tamale Ghana, Lu found that for certain questions an indirect method for survey were more appropriate for some questions that people tend to have bias on. She discovered that by asking "do you wash hands with soap?", one hundred percent respondents said "yes"; while changing the answer to "what do you use soap for?", only two interviewees said they used it for washing hand (Lu, 2012).

6.3.2.2.3. Closed and Open-ended Question

Closed and open-ended questions are usually used as interview techniques to collect information during in-depth interviews. It is important to understand the values of these techniques as "individual do respond differently depending on question format" (Kealy and Turner, 1993). Closed questions allows respondents to answer the questions with simply "yes" or "no" and/or within a few word; while open-ended questions will solicit additional information from the respondents that require more than one or two words to respond (Richardson, 2012). Richardson also points out that closed questions are quick and requires little time investment, however, it might irritate users and result in misinterpretation of information collected. Open-ended questions are able to develop trust with users but also might lead to unnecessary information (Richardson, 2012).

6.3.2.2.4. Ranking Question

Ranking questions, which is used to identify the order of importance of various factors, is introduced due to its importance specifically to this thesis. As we are interested in knowing which products are more popular when in the market at the same time, it is crucial to find a scientific methodology to support and analyze key findings. In Hague's book, he describes a similar question method used to indicate the top three important factors (Hague, 2004):

"Typically this (order of importance of various factors) is achieved by presenting the list and asking which is most important, which is the second most important and so on, in ranking questions it is usually not valid to ask respondents to rank beyond the top three factors."

As described above, there will be limitations in ranking question. Unlike open & closed questions or direct & indirect questions, which can be somewhat compensate for each other, ranking questions need to be twisted to adjust its disadvantages. Therefore, when interviewing respondents, we might consider develop a modified method for ranking questions.

6.3.2.2.5. Behavioral, Attitudinal and Classification Question

Besides categorizing questions into direct and indirect, survey questions can be classified based on their purpose: behavioral, attitudinal and/or classification questions (Hague and Jackson, 1999). In addition, Hague and Jackson have well explained information gathered by questions designed. Behavior questions are used to get factual information on who the respondent is, what s/he does and owns; similarly, classification question is also factual information but respondents are grouped depending on ages, gender, etc. Attitudinal question gives information on what people think and their rating of things (Hague and Jackson, 1999).

6.3.2.3. Samples and Sampling Errors

There is no rigid definition for samples size for qualitative and quantitative research Sample size, of 30 or 200 or less have been considered as the defined line for qualitative research based on different research methods (Hague and Jackson, 1999). Nonetheless, it is crucial to recognize sample errors when large numbers of survey interviews are not possible. However, interviewing 1000 people or 10,000 in a random sample might end up getting a similar result. Further explanation on the accuracy and sample size determination is thoroughly explained in Hagues and Morgan's book (Hague et al, 2004):

It is worth repeating this very important principle of random sampling – the sample size required to give an accurate result to a survey bears no relation to the size of whole population, it is the absolute size of the sample that counts.

Under the constraints of time and budget for most of the research, sampling error should be calculated statically (Hague and Jackson, 1999):

$$\textit{Sampling error} = \frac{1.96\sqrt{\left(p\%(100-p\%)\right)}}{n}$$

Where: p = the measure taken; n = sample size.

The sampling error will also be used to calculate the error of this thesis survey with 95% confidence interval.

6.3.3. History of Research and Market Research in Emerging Market

6.3.3.1. Lessons learned in the past

In contrast to philanthropic behavior, which can be defined as of giving based on what the donor perceives that the recipients lacks, selling HWTS products in the market is based on the current market demands. More and more international development organizations, especially social enterprises, are paying attention to market research into what customers

desire in products, rather than simply giving out what they are lacking. According to this presumption, it is believed that if customers' demands are met, this will help to ensure products are in good use.

Many studies have found that HWTS are in fact not in use after a period of time. For example, Chulli water purifier was installed in 114 households in southeastern Bangladesh; however, only 21 percent out of 101 respondents reported regular use their purifier after 12 months of installation (Gupta et al, 2008). Products such as SODIS that are free of charge were also abandoned by local users. Study conducted in Bolivia showed that although a rigorous SODIS promotion campaign was carried out, the usage of SODIS was only about 32% after 10 weeks (Mausezahl et al, 2009). A study of the combined systems, *PUR*, has been done in Guatemala. Twenty-two out of 514 households in 12 villages said they actively repeat using *PUR* and yet only 7 household's drinking water have chlorine residual, which is an indication that the *PUR* product had not been used (Luby et al, 2008). In other words, product had been used but was not being used consistently and sustainably. The ceramic pot filter, which some people considered as the most promising options for treating drinking water for households (Thompson et al, 2003; Clasen et al, 2004), is facing similar decline in usage as time goes by. In Cambodia, the use of ceramic pot filters in household droped rapidly and only 31% households used filters regularly up to the time of follow up (UNICEF, 2007). It does not seem to have anything to do with the design. *LifeStraw®,* for example, received numerous design awards and was described by the *New York Times* as a "straw that saves life". However, this product is not widely spread anywhere in the world (Albert et al., 2010). Recent study in 2009 in Tamale Ghana shows that only 46% were using the Kosim filter at the time of the interviewed and the interview was conducted after the sale period from September 2005 to June 2008 (Clopeck, 2009).

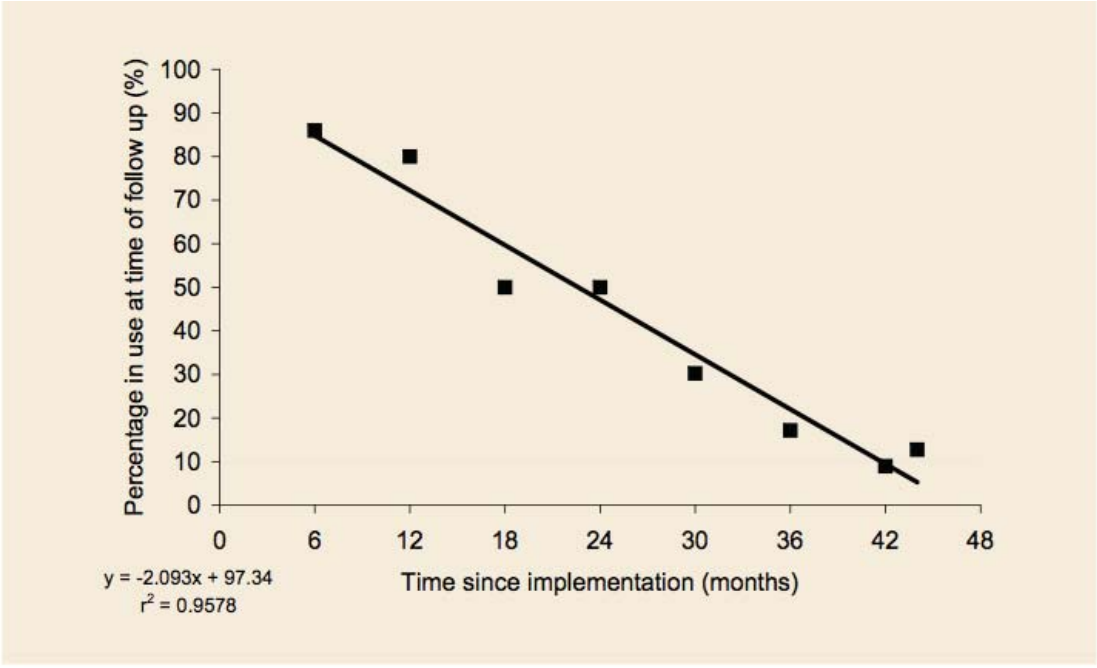


Figure 6-8. The percentage of filters remaining in Cambodian household as a function of time (UNICEF, 2007)

Data from different organizations have showed that it is hard to bring HWTS products into the market, sometimes even with subsidy for low-income communities. Therefore, various market research studies have been conducted in order to find out customer's preferences.

6.3.3.2. Market Research Focus on HWTS Products in Emerging Market

6.3.3.2.1. Sample Size and Duration

Besides conducting a literature review in order to determine the theory regarding sample size and duration, we also looked at the practice as it has been discussed in prior emerging market research, in order to finalize reasonable numbers of interviewees during our three weeks of field studies in Ghana.

Few market research studies and surveys focusing on HWTS products have been done by implementing organizations. The program for Appropriate Technology in Health (PATH) has done a baseline survey for the Safe Water Project, in which the researcher interviewed 3,720 households with over 110 surveyors (Blanton, 2011). In Tamale Ghana, Green introduced 237 households for customer preference with 8 surveyors in 4 rural and 3 urban communities during the month of January 2008 (Green, 2008). In Nepal, Solutions Consultant (P.) Ltd. interviewed total of 80 mothers in four districts over 3 days with 30 days of product implementation for customer's preferences (Kathmandu, 2005).

6.3.3.2.2. Objectives and Focus

To comprehend the market needs, literature review on market research for water products in emerging market has been done, to set research goal comprehensive but not replicated to each other. Program for Appropriate Technology in Health conducts two kinds of surveys for each pilot on water filters: baseline survey and endline survey which will measure uptake of filters, attitudes toward the water filters, and customer satisfaction (PATH, 2011). Customers' choices (characteristic preference) were studied by Green to understand which products are most desirable (Green, 2008)(Figure 6-9). A similar study was conducted in Nepal where the research was to develop a Point-of-Use products marketing strategy, a hygiene improvement strategy and implementation work plan (Kathmandu, 2005) (Table 6-3).

Table 6-3 Survey handout of Kathmandu's report including brief explanation of methodology (Kathmandu, 2005)

SECTION C: DWELLING/ OWNERSHIP					
Q. No.	**QUESTIONS, INSTRUCTIONS and SKIP PATTERN**	**RESPONSES**	**CODE**	**SKIP TO**	**OFFICE USE**
C1	Roof Construction of the House **OBSERVE**	Cement	1		
		Tin	2		
		Tiles	3		
		Bamboo/ Wood	4		
		Straw	5		
		Other (specify)	6		
C2	Facilities Available or Ownership at the Household **READ OUT THE CHOICES AND VERIFY, MULTIPLE RESPONSES POSSIBLE, CIRCLE CODES IF MENTIONED, OTHERWISE LEAVE BLANK**	Electricity connection	A		
		Water Tap	B		
		Radio	C		
		Television	D		
		Telephone	E		
		Bicycle	F		
		Mortorcycle	G		
		Biogas plant	H		
C3	What does your family generally use as a fuel for cooking	Firewood	1		
		Kerosene	2		
		Biogas	3		
		Other (specify)	6		
C4	Does your family own livestock	Yes	1		
		No	2	**C6**	
C5	How far is the animal shed from your kitchen ? **OPEN ENDED**				
C6	Does your family members use a latrine for defecation?	Yes	1		
		No	2	**END**	
C7	How far is this latrine from your house **OPEN ENDED**				

6.3.3.2.3. Methods and Questions Design

Methods used and question design might be slightly different because the literacy rate is generally low in less developed countries (DESA, 2011). In emerging market research conducted by PATH in Vietnam, focus group discussion, observation and interviews (individual woman) were used to explore consumer attitudes and HWTS practice (PATH, 2010). In Green's market research conducted in Tamale, behavioral questions were asked in order to develop HWTS customer profiles and attitudinal questions combined with pictures (due to illiterate Dagbani-speaking respondents) were used to gather information about customer preference for different HWTS products features (Green, 2008) (Figure 6-9). In Kathmandu's research done on HWTS water products, the majority of the questions were closed and direct questions mixed with open-ended questions (where respondents can express their own opinions); methods used include observation, focus group discussion and in-depth interview focusing on women (Kathmandu, 2005).

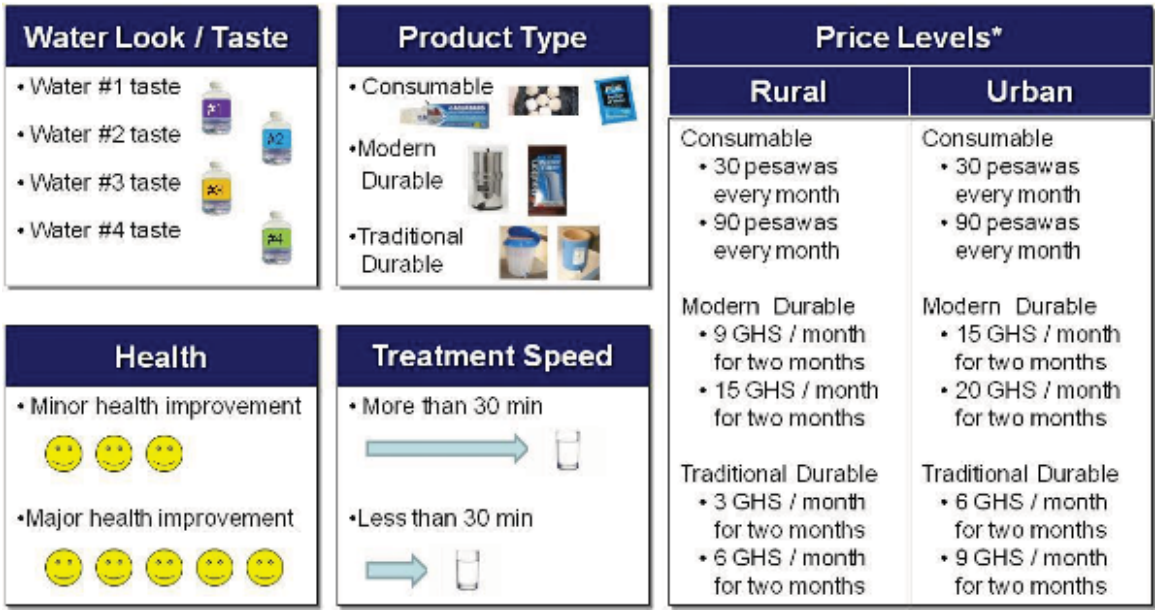


Figure 6-9. Screenshot of survey handout of Green's market research (Green, 2008)

6.3.3.2.4. Results and analysis

In PATH's report on the HWTS products market in eight African countries (Nigeria, Senegal, Tanzania, Uganda, Kenya, Ghana, South Africa and Zambia), it points out several key findings are described: 1. Choices are limited; 2. Consumables (*Aquatabs*, *PUR*, etc.) dominate; 3. Durables present an opportunity; 4. Cost is key (PATH, 2010). It seems to the author that these market findings are co-related. Consumables become the dominant product is due to lack of product choices, which gives an opportunity for durable products to enter the market. However, all HWTS products have to consider cost if the target customers are those households with low income. While PATH report has given important information regarding market in the greater region of Africa, Green's thesis presents detailed findings about Ghanaians' HWTS feature preferences.

6.4. Survey Methodology and Key Elements

6.4.1. Sample Size

Sample size calculation for the author's HWTS market research was based on the time it takes per survey and on the number of visitors to designated survey location each day. It took approximately 15-20 minutes to conduct each survey and there were around 80-100 customers visit to the shop per day. Due to the time constraint and limitation in human resources, we determined that the size of the sample would be 100 people in the urban market of Tamale, Ghana and the duration of surveying would be 10 days. Based on the reference mentioned in the previous section (samples and sampling error; sample size and

duration), this HWTS number of surveys is within the range for sample sizes of both quantitative and qualitative research.

Green's research is based on feature preference, but not product preference, though features introduced in Green's survey, such as water taste, look, etc. are generated from the HWTS products and their functions. However, customers might not know what they want until they see and experience the actual product (Cuban, 2011; Isaacson and Jobs, 2011). Being able to bring actual products into the market research allows customers to make informed decisions as well as to enable the organizations to decide a business strategy (Davis and Meyer, 1998). We decided to offer six different HWTS products that have market potentials at a specific centrally located distribution point in located downtown Tamale, and allowed the customers to choose their product preference based on the real products. In addition, we collected baseline information of the interviewees. The focus of the market survey was to: 1. Obtain quantitative data on water source, basic family and individual profile, and attitudes towards six different HWTS products; 2. Measure their market potential; 3. Use qualitative methods to understand potential customers concern, and 4. Provide recommendation that might improve design and sales strategies; 5. If it is possible to benefit the population under the poverty by bringing water products to the Northern Region and if so, 6. How to do so.

6.4.2. Survey Methods Used and Rationale

Getting customers attitude towards the six selected HWTS products was key to our market research, and therefore, we conducted 15-20 minutes interview with all interviewees. The number of sample size and duration of the survey would also allow us to collect information and develop customer profile and water resources using a quantitative approach. Getting comprehensive information would help us to provide better recommendation to PHW as to which different products would attract potential customers in different tiers. Last but not least, we also wanted to observe customers' purchasing behavior. Therefore, we set up actual sales days to observe and analyze customers' reaction and actual action on whether to purchased any of the 6 products and what concerned them the the most when making the actual decision.

6.4.3. Product Quality Testing

Six HWTS products were tested for bacteria removal in the lab at PHW. The author collected Taha dugout water in Tamale, and tested the initial total coliform and *E.coli* using IDEXX Quanti-Tray®[92]. For instruction of how to use Quanti-Tray® can be found at: http://www.idexx.com/view/xhtml/en_us/water/quanti-tray.jsf. Data presented regarding the number of bacteria per 100 mL is recorded using Most Probable Number (MPN). Instruction on counting the MPN using IDEXX Quanti Tray® can be found at: http://oe.oregonexplorer.info/umpquabasin/MPNCalculator/Default.aspx MPN in the

[92] IDEXX Quanti Tray is used by researcher to provide easy, rapid and accurate counts of coliforms, *E.coli* and enterococci. Information can be found at: http://www.idexx.com/view/xhtml/en_us/water/quanti-tray.jsf?SSOTOKEN=0

Taha dugout and effluent from the six HWTS products were recorded. Experiences the author encountered with the HWTS products were also recorded.

6.4.4. Question Design

The survey included both open & closed questions, and direct & indirect questions, where interviewees could choose answers directly from answers listed, rank Top 3 choices and explain the reasons for their choices. The types of questions included behavioral, attitudinal and classification questions. The survey itself is shown on Appendix VIII.

6.4.4.1. Customer Profile

Question 1 is a question used to collect geographic location of respondents. The question is "where do you live in Tamale?" with multiple choices "urban" "sub-urban" "rural" and "others (do not live in Tamale)". Question 3 is to determine if the respondents can make decisions at home, which will help understand the culture of Tamale and design better sales strategies in the future. The question is "are you the decision maker at home?" with multiple choices "always" "open" "sometimes" and "never". And during the interview, after building a trustful relationship with respondent, questions about 1. Occupation and 2. Number of people in the household were asked, with potential follow-up questions of family structure, i.e., how many wives does the father have. Since these questions are more sensitive and we decided to ask them as voluntarily answered and open questions. During the survey, these two questions might not be asked when the author observes that the interviewees are in a rush, annoyed by previous questions asked, or not comfortable to answer.

6.4.4.2. Source of Water

Question 2 asks where the respondents dwelling water comes from. Based on prior field investigation on possible water source in this region, we designed the question as a closed-ended question with answers "Tap water" "Dugout" "Sachet & Bottled" "No Water Supply" and "Others". Such data may also be able to suggest which HWTS products to target to which customers and therefore, potentially enhance the design. Understanding the source of water would also be helpful to compare to the data provided in the report the WHO/UNICEF at Figure 6.1 (WHO, 2012).

6.4.4.3. Product Choices and Reasons of Choices

The major part of the interview was to analyze customers' HWTS product preferences when six products were all available at the same time. First, interviewees were given brief introduction on names, basic function, and usage procedures of six HWTS products. In order to allow respondents to give feedback on different HWTS products, we used an open-ended method for the following questions:

1. "Pick and Rank your Top 3 choices"

2. "Why do you NOT choose the others?"

In the first round of asking these two questions, respondents were not told the price of the products. Then we asked the first question again after the price of each product was provided. And we switched the second question into "why did you make a change" or "why not you not make a change" based on the answers and ranking given. Thus we are able to compare the results before and after the actual price is known. We believed such methods would allow us to suggest a price point/range, and figure out whether price is the key hurdle for HWTS products entering the emerging market, or whether potential customers in urban areas are willing to buy HWTS products with a subsidized price or not.

Another question on "why NOT choose other products" allowed us to get direct complaints from customers on the six products. So that we would be able to give better suggestions on improvement of each product based on feedbacks given directly from customers.

6.4.4.4. Products Distribution Point

Road mapping on shops counting and locations in major roads in Tamale were completed prior to the market research and were used as background information. Based on types of shops available in Tamale and local volunteers' feedback, we asked a closed question: "where would you prefer to buy the product?" with fixed choices "in fixed location such as this shop (where the survey location is)" "Supermarket" "In shops that I see everywhere (e.g. drink shop)" and "from village volunteers". The question was introduced to allow us to find a prime distribution center, or retail stores to sell the products. In addition, this would let us understand the buying habit of potential customers.

6.4.4.5. Field Notes

Each survey lasted about 15-20 minutes. Within and after each question the author had a normal chat with the interviewees and took notes in order to try to understand the bigger picture: how might be possible, in local Ghanaians' opinion to help the poor get out of poverty as it results to having unsafe water to drink.

6.4.5. Location of Market Research Conducted

The location selected for interview was at Tridewa Co. Ltd., an Indian family owned business operated at the junction between the taxi station and the marketplace in the center of Tamale. This is a prime central location in downtown Tamale and an area where people go both for transportation and daily grocery shopping. The shop sells household wares and appliances and it has *Kosim Classic* for sale as well. The shop owner, Prakesh Ramchandani, is generously offered us space right next to the main entrance of the shop and allowed us to display six different products so that interviewees can easily see or touch them if they liked. There are approximately 80-100 visitors per day to this shop and based on author's observation, the number of visitors is large compared to other family owned retail shops, excluding supermarkets.

Figure 6-10. Picture of the author conducting research near Tridewa Co. Ltd. with a woman in traditional dress

The location and distribution of other shops on major roadways (Rotary Road, Louisville Road, Tamale Navarongo Road and Dagomba Road) was also recorded due to the fact that such data is not available on Google Map and it is important for HWTS products distribution and sale strategy recommendation.

Figure 6-11. Urban setting in Tamale (Tamale Navargongo Road)

Figure 6-12. Semi-urban setting in Tamale (Dogomba Road)

6.4.6. Market Research team

The market research team consisted of the author and two local Ghanaians Zainab Salifo and Daniel Appiah (both are PHW employees), who speak English and local Dagboni language. The author was responsible for designing the market survey and conducting in-depth interviews in English. Zainab helped identify shops along major roads in semi-urban and urban Tamale. Daniel helped assist the author to set up mockup distribution points in the market sales pilot day at Tridewa Co. Ltd, and acted as the sales person to promote six products and handed out flyers. He was also responsible for calling customers who showed their interest in buying certain HWTS products during the interview. Daniel was trained to use all six different products and be familiar with their pros and cons prior to mockup sales. The market research was conducted in English.

6.4.7. Time and duration of the survey

Over one hundred surveys were conducted within 10 days. Research was only conducted from Monday to Saturday from 10:00 am to 6:00 pm with a lunch break around 1 to 2 pm (also a normal break time for Muslins). In addition, mapping of shops distribution were done in 5 days in the afternoon due to availability of the translators and weather conditions.

6.4.8. Awards System and Setting Display

To attract customers and make it easier to start conversation, IDEXX Quanti Trays with different water quality results were displayed and a bag of sachet water was given to each interviewee after the completion of survey. Products such as *Lifestraw*® *Family* and *CrystalPur*™/ *Tulip Siphon Water Filter* were displayed according to the way it is supposed to be used in the home. Chemical products were stored in a box to show proper storage of these products (not displayed under the sun and out of reach of children). *Kosim Classic* and *Kosim Deluxe* were put on the floor to avoid damage of the ceramic filter element inside due to mishandling by customers..

Figure 6-13 Market research setup at Tridewa Co. Ltd. Note: *Kosim Classic* and *Kosim Deluxe* are not shown in the picture but they are at the left and right bottom corner of the picture.

6.4.9. Total Preference Score Calculation

The methodology of the total preference score calculation is based on the total numbers of Top 3 ranking of the potential customers choice. For each product, assume the total numbers of top choices No.1, No.2 and No.3 are X, Y, Z, then the total preference score (S) calculation will be: S = X*3+Y*2+Z*1, where each vote for No.1, No.2 and No.3 will score 3, 2 and 1 point, respectively.

6.4.10 Road mapping

In addition to market research, road mapping has been done prior to the market research in order to better understand general locations of shops, especially drink shop and household products shops that could potentially carrying HWTS products in the future. Google map was used to target and generate major roadways map at the center of and around Tamale.

Figure 6-14. Zoom out map of Tamale from Google map[93]. The red star is Tridewa Co. Ltd, where the survey took place.

The author combined information gathered to identify roadways that we should prioritize and were able to survey within a short amount of time. Due to the fact that not all roadways were present on the current Google map, Zainab and the author had also re-created a map for shops. We had identified Rotary Road, Louisville Road, Tamale Navarongo Road and Dagomba Road as our major focus based on the number of people passing by daily and number of shops along the road. Shops were included based on the primary products sold and categories were listed below:

Beauty shop/salon, drink shop, tailor/fashion, household products, food shop/restaurants, tech convenient store (most of the stores sell SIM card and a few of them fix computers and sell second-hand TV, etc.), bookshop, pharmacy, bank/money transfer, supermarket, and others

6.4.11 Actual Sales of HWTS Products

During the survey the author found that some respondents were interested in purchasing HWTS products. Therefore, the author asked for cell phone numbers of respondents who were interested in buying. Daniel would be continue contacting these respondents after the author left Ghana. Additionally, the author also held a market research pilot study for three days (January 25 to January 27 of 2012), to see which HWTS products would be sold during

[93] If map is vague, map can be accessed at: https://maps.google.com/maps?q=Tamale,+Northern,+Ghana&hl=en&ll=9.417226,-0.809212&spn=0.175444,0.307617&sll=34.747746,-104.329271&sspn=37.055221,78.75&oq=tamale,+ghana&hnear=Tamale,+Tamale+Municipal,+Northern,+Ghana&t=m&z=12 . Online retrieved on August 4th, 2012

the sale period; and if possible, to compare the actual sales results with the market survey to see if these results on product preference are congruent. Promotion strategies used:

- Promotion handouts for advertisement for particle removal products (*Kosim Deluxe, Kosim Classic, Aquatabs, CrystalPur™/Tulip Siphon Water Filter*) (Appendix XI-a and XI-b);
- Brochures for all six HWTS products (Appendix XII);
- 10 % off for all products during the market sales pilot study period.

6.5 Results Present

6.5.1. Product Quality Results

Data shown in Table 6-4 and Table 6-5 are used as background information on water quality, bacteria removal tests of the six HWTS products and author's experience while handling these products. Table 6-4 shows that water in Taha dugout (water source for Taha village adjacent to PHW Filter Factory) is very contaminated with bacteria and has total coliform over 2419 MPN per 100 mL and *E.coli* of 122 MPN per 100 mL. Table 6-5 shows that MPN per 100 mL for *CrystalPur™/Tulip Siphon Water Filter*, *Life Straw® Family* and *Aquatabs* are all less than one per 100 mL having been fed with dugout water and then left to filter for an hour. In the case of the *PUR* product, the treated water result was two total coliforms per 100 mL of water after sitting for an hour without using cloth filter to strain the treated water.

Table 6-4. Total coliform, *E.coli* and pH in raw water collected from Taha dugout.

Raw water MPN per 100 mL	Total Coliform MPN per 100mL	*E.coli* MPN/100mL	pH
Taha dugout (1/7/2012)	>2419.6 (49 L, 48 S)	122.2 (33 L, 28 S)	8.94

*Note: L means the large wells in one sample of Quanti Tray® and S stands for the number of small wells in the same sample of Quanti Tray®.

Table 6-5. MPN and author's experience with six HWTS products

After filtering Taha water MPN per 100 mL	Immediately		After 1 hour		Author's Experience	
	Total Coliform	*E.coli*	Total Coliform	*E.coli*	Handling	*Reasons of rating*
Kosim Ceramic (Comp: 20kg Gbalhi, 6.7kg wayemba, 3.3kg rice husk. Majority of the filters were in this composition)	-	-	*<1*	<1	Easy	Require only one step: pouring water
CrystalPur™/Tulip Siphon Water Filter	<1	<1	<1	<1	Hard	Require extra force to squeeze water, installment is long
Life Straw® Family	<1	<1	<1	<1	Hard	Take time to install, and the design takes time to understand how to use it
Aquatabs	<1	<1	<1	<1	Easy	Dissolve easily
PUR[94]	<1	<1	2 (2 L, 0 S)	<1	Medium	Require extra cloth filters

**Note: Kosim Ceramic* bacterial removal (immediately) is not available due to the oversight found after the trip. However, more information on the new *Kosim* ceramic filter produced by PHW can be found in Millers thesis (Miller, 2012).

6.5.2. Profile of the Interviewees

6.5.2.1. Customer Location

Among 103 respondents, all but two live in the Tamale area. The majority of the people were from the urban area (73), 10 live in peri-urban or outskirt of Tamale, and 19 live rural area around Tamale (Figure 6-15).

[94] When testing bacterial removal performance of *PUR*, cloth filters were not used for understanding whether cloth filter is necessary for *PUR*.

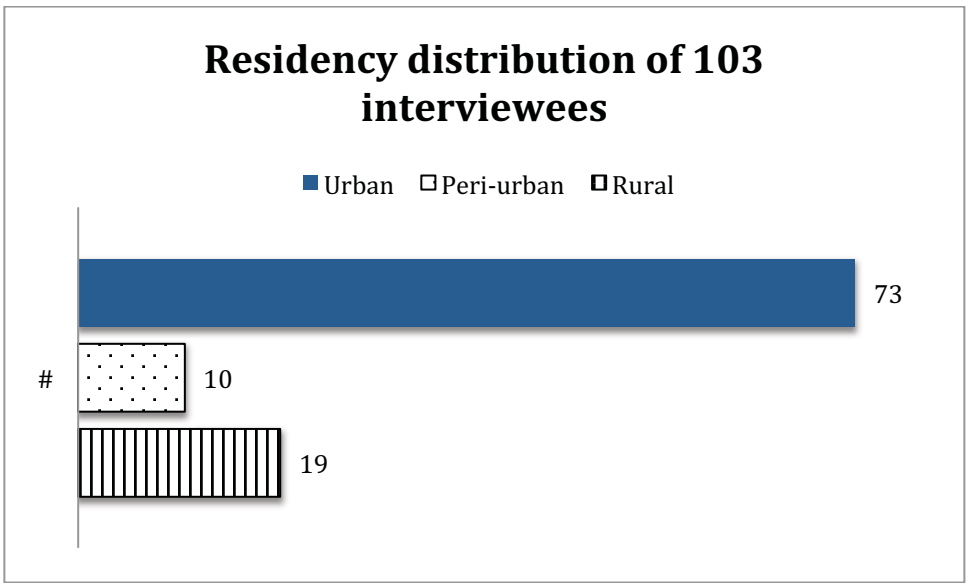


Figure 6-15. Residency distribution of interviewees in Tamale (N=103)

6.5.2.2. Occupation

Seventy-seven interviewees were asked for their occupation. In total, there are 23 different types of occupations. Among which, students were the most common (22 out of 77) (Table 6-6).

Table 6-6 Numbers of occupations among interviewees

Student	22	Carpenter	1
Teacher	12	Sale	1
Businessman	6	NGO	1
Health worker/assistant	5	Housewife	1
Medical assistant	4	Soldier	1
Nurse	3	Engineer	1
Accountant	3	Researcher	1
Bank	2	Cashier	1
Hair dresser	2	Doctor	1
Household keeper	2	Constructor	1
Farmer	2	Sailor	1
Unemployed	2	Deliver	1

6.5.2.3. Number of People in Household

Similar to the occupation question, not all interviewees were asked about the number of people in their household. Of 93 respondents, the average number of people in the interviewees' household was 5.9. Some interviewees have big family with up to 21 people in one household. Reasons for large households included *the "father have several wives*," "*living with sisters and brothers".* However, 14 interviewees lived by alone.

6.5.2.4 Household Decision Maker

According to the survey, household decision is mostly made by men at home (Figure 6-16). It includes father, husband, elder brothers or uncles. About 37% of the households make decisions mainly by women, which include mother or wife.

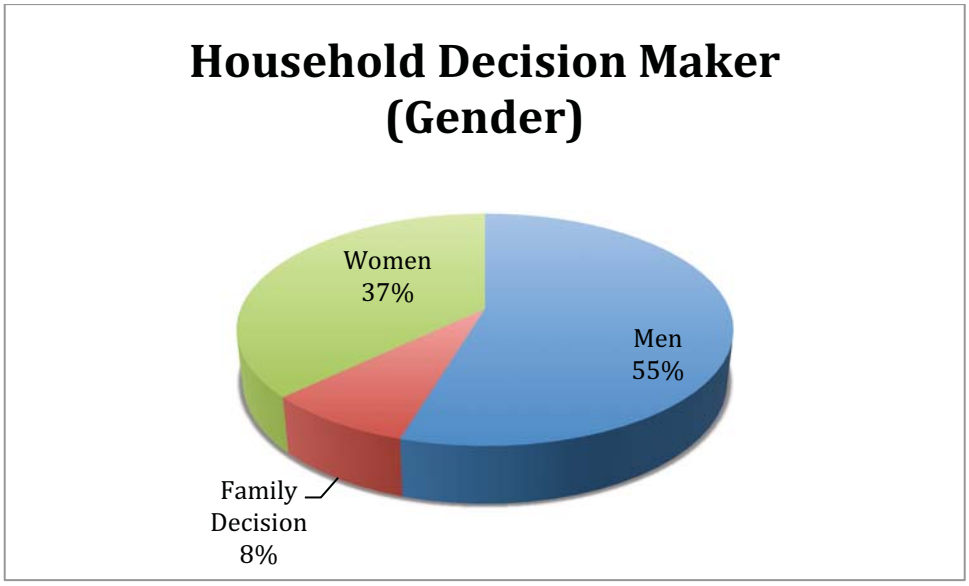


Figure 6-16. Decision maker among interviewees' household in Tamale

6.5.3. Comparisons of Six Products

6.5.3.1. Final Ranking Results

As mentioned previously, the six HWTS products were set up and displayed at the household product shop (Tridewa Co. Ltd.), so interviewees could see them visually and interact with the products. The highest number of people picked the *Kosim Deluxe* (Figure 6-17 a) as their first choice, with and without consideration of the price. The least number of people picked *CrystalPur™/ Tulip Siphon Water Filter* (Figure 6-17 f) as their first choice, with and without the impact of price. Raw data of the 103 interviewees was shown in Appendix IX. The following graphs show the number of top three choices among each product when all six products were offered for consideration.

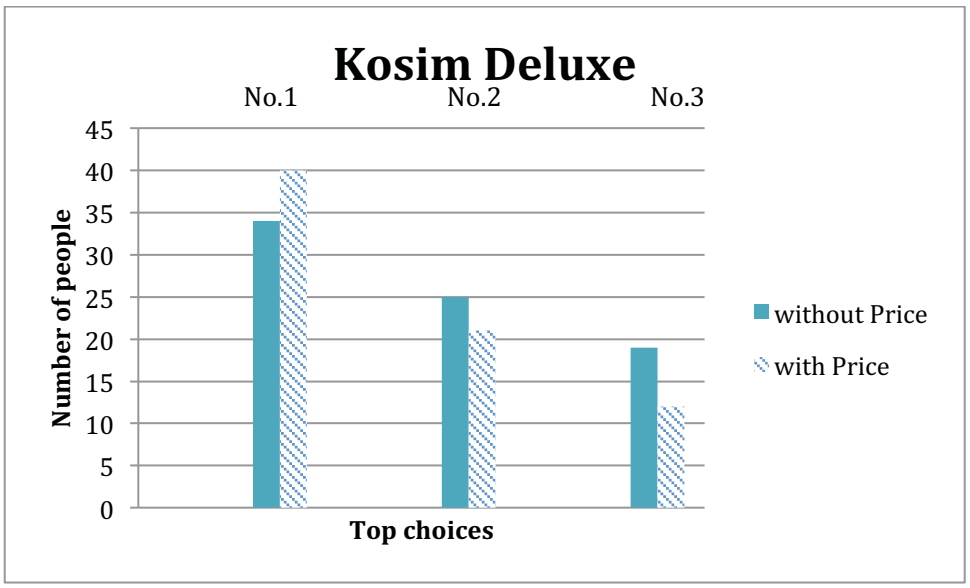


Figure 6-17 a. Number of people (among N = 103) that selected *Kosim Deluxe* as their top three choices.

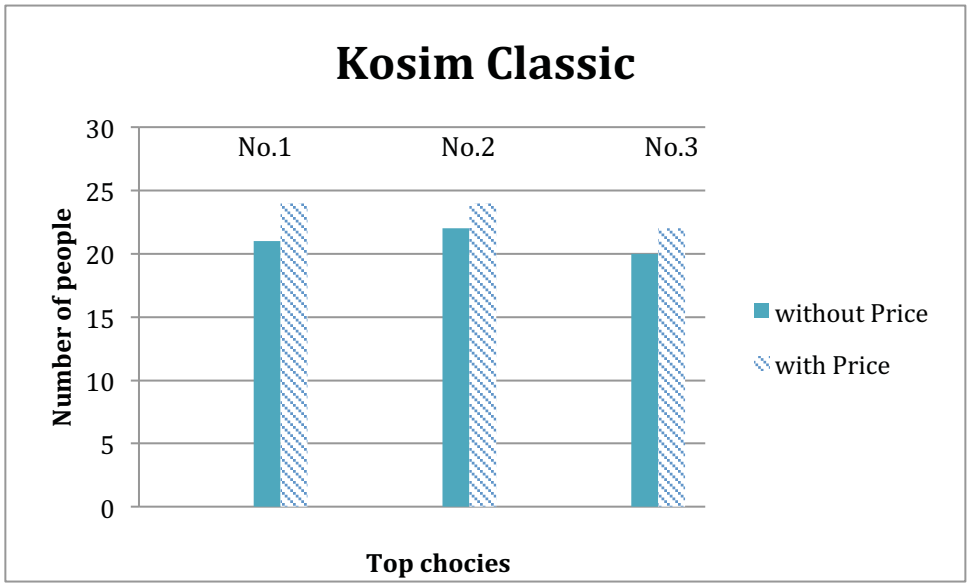


Figure 6-17 b. Number of people (among N = 103) that selected *Kosim Classic* as their top three choices.

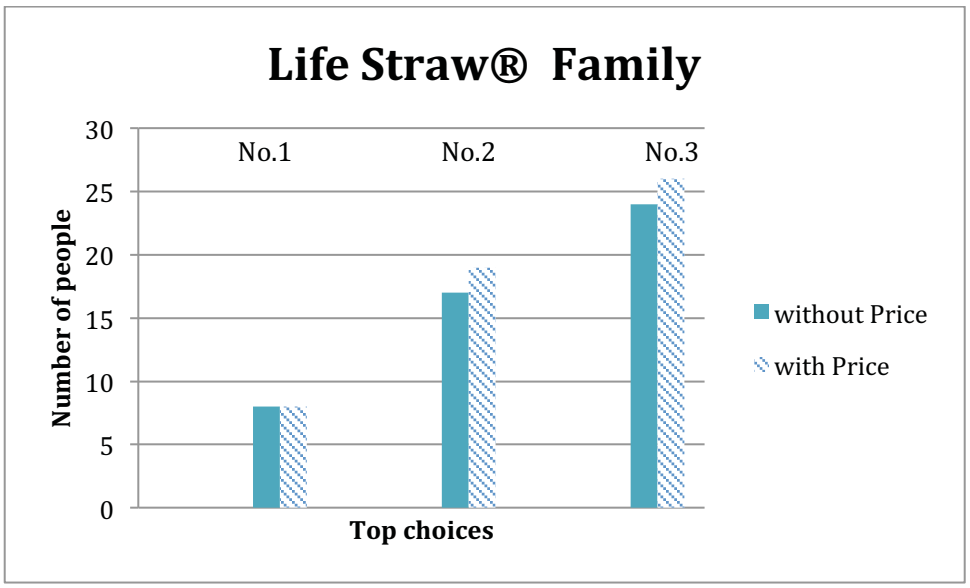


Figure 6-17 c. Number of people (among N = 103) that selected *Life Straw® Family* as their top three choices.

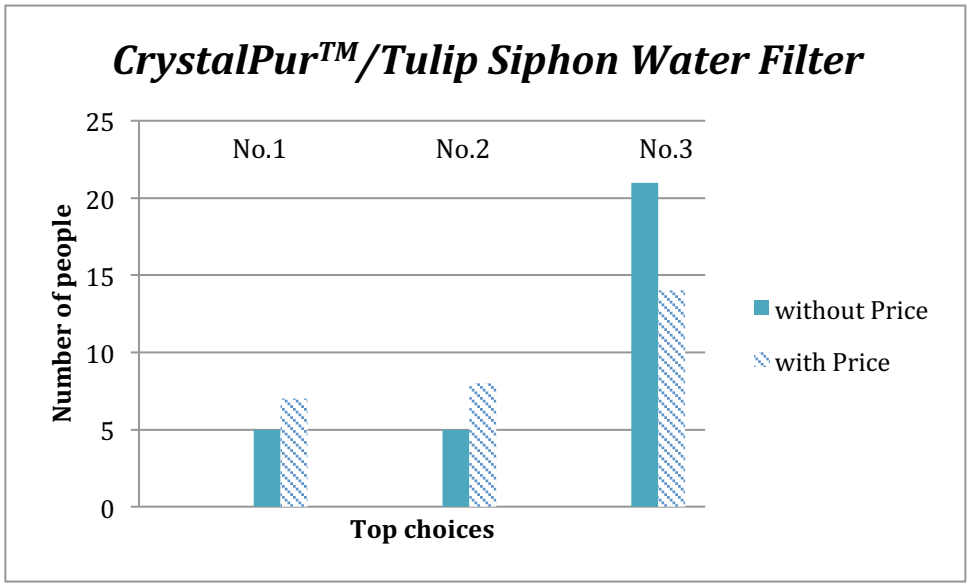


Figure 6-17 d. Number of people (among N = 103) that selected. *CrystalPur™/Tulip Siphon Water Filter* as their top three choices.

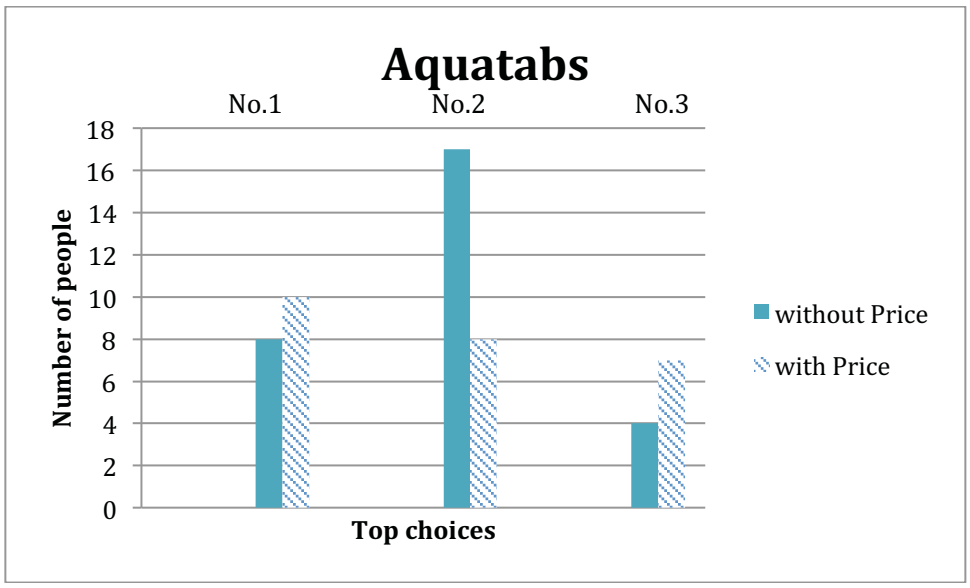


Figure 6-17 e. Number of people (among N = 103) that selected *Aquatabs* as their top three choices.

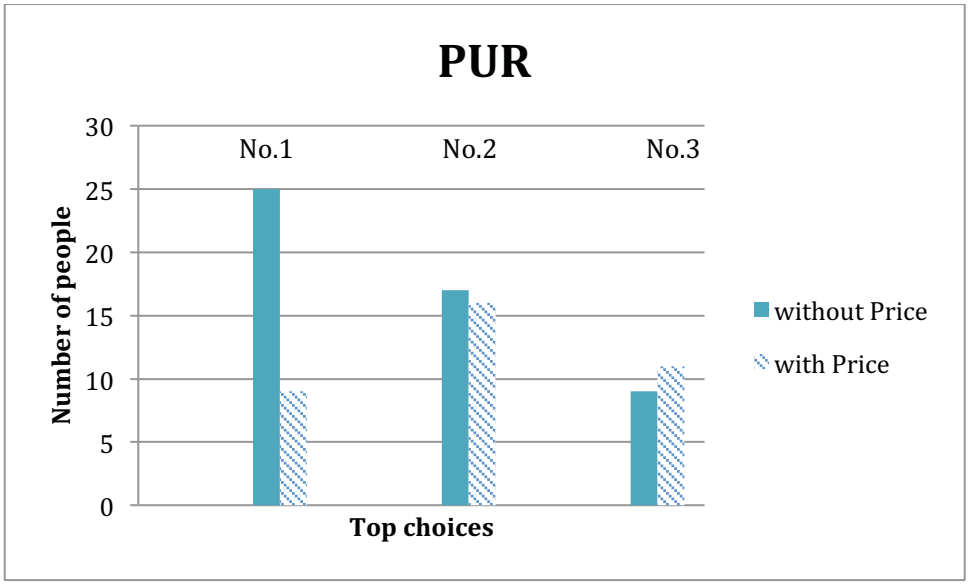


Figure 6-17 f. Number of people (among N = 103) that selected *PUR* as their top three choices.

6.5.3.2. Feedback from Interviewees

The feedback on different products coming from the interviewees varies. In general, the concern of products include: size, appearance, flow rate, safety (within reach by children, etc.), necessity to use, chemicals affecting health, price, convenience, durability, user-friendliness, time consuming, ability to remove dirt, etc. The major concerns among all products are size, user-friendliness, removing dirt and time consuming to use. Due to the flexible inputs allowed from the interviewees, however, some concerns about each individual product might not be the same for each product, even though the comment came

from the same interviewee. Namely, for example, the size of some HWTS products might be too "large" for interviewees who have small family (say 3-4 people per household, where they will think *Kosim Classic* is too large for their family), yet interviewees might think *Kosim Deluxe* is "small" is also a concern but for large family. The major feedbacks directly coming from customers are as followed:

Kosim Classic: 1. Size: Large (14 votes); 2. Appearance (8 votes)
CrystalPur™/Tulip Siphon Water Filter: 1. Size: Small (15 votes); 2. No cover (11 votes)
PUR: 1. Chemicals (22 votes); 2. Finish (means products will be used up) (6 votes)
Life Straw ® Family: 1. Size: Small (15 votes); 2. User friendly: Seem hard to use (4 votes)
Aquatabs: 1. Chemical (19 votes); 2. Ability to remove dirt (18 votes)
Kosim Deluxe: 1. Size: Small (5 votes); 2. Durability: easy to break (2 votes)

Except *Kosim Deluxe,* all other products have two dominant concerns (as listed above); though science/technology behind each product and brief instruction of how to use them were introduced. Interviewees were asked why they had not considered the other three products as their Top three choices. *Kosim Deluxe* and *Life Straw® Family* received the least complaints (12 and 27, respectively), while *CrystalPur™/Tulip Siphon Water Filter and Aquatabs* were pointed out with most concerns (51 and 52). However, when answering these questions, they were not only considering their family's circumstances, but also considered other end users. Data reflected include both family-based end users as well as their opinions on other users. Figures (6-18 a-f) are also presented to summarize the major concerns of each product.

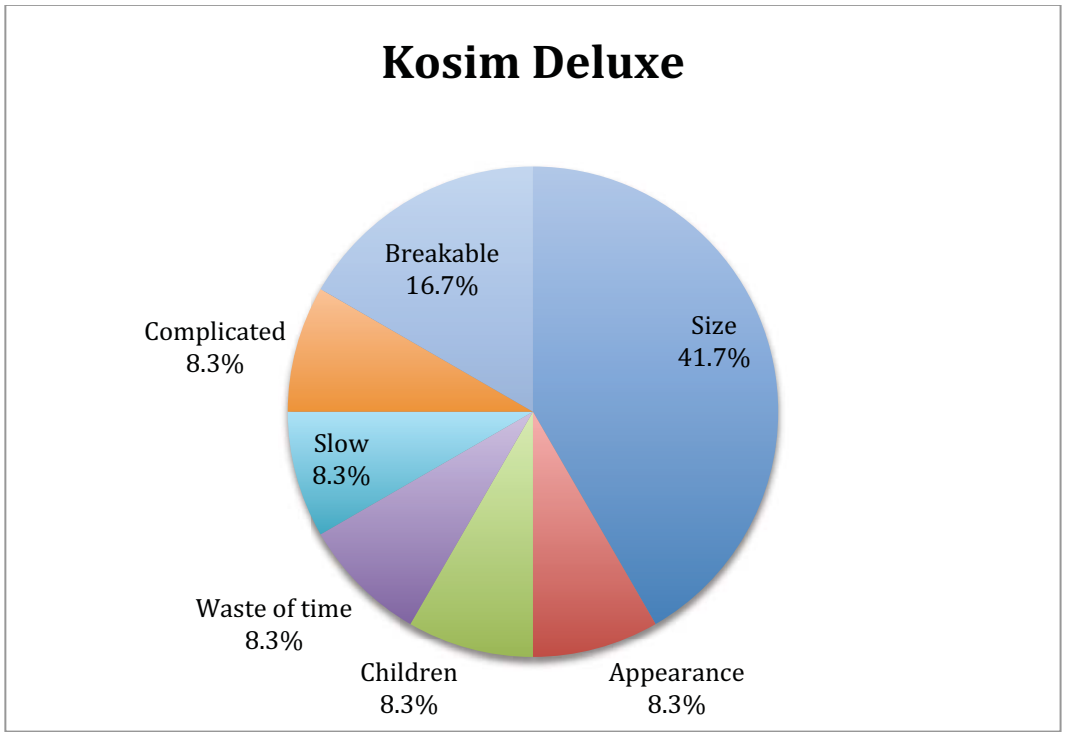


Figure 6-18 a. Percentage of major concerns of *Kosim Deluxe* (N=12)

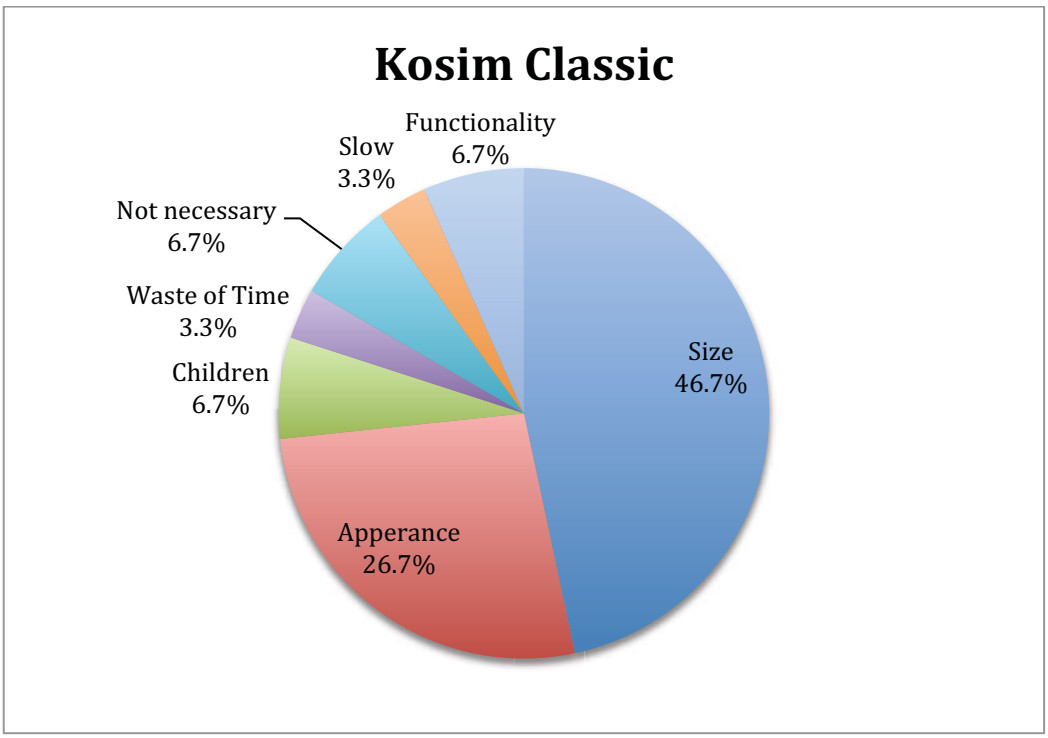


Figure 6-18 b. Percentage of major concerns of *Kosim Classic* (N=30)

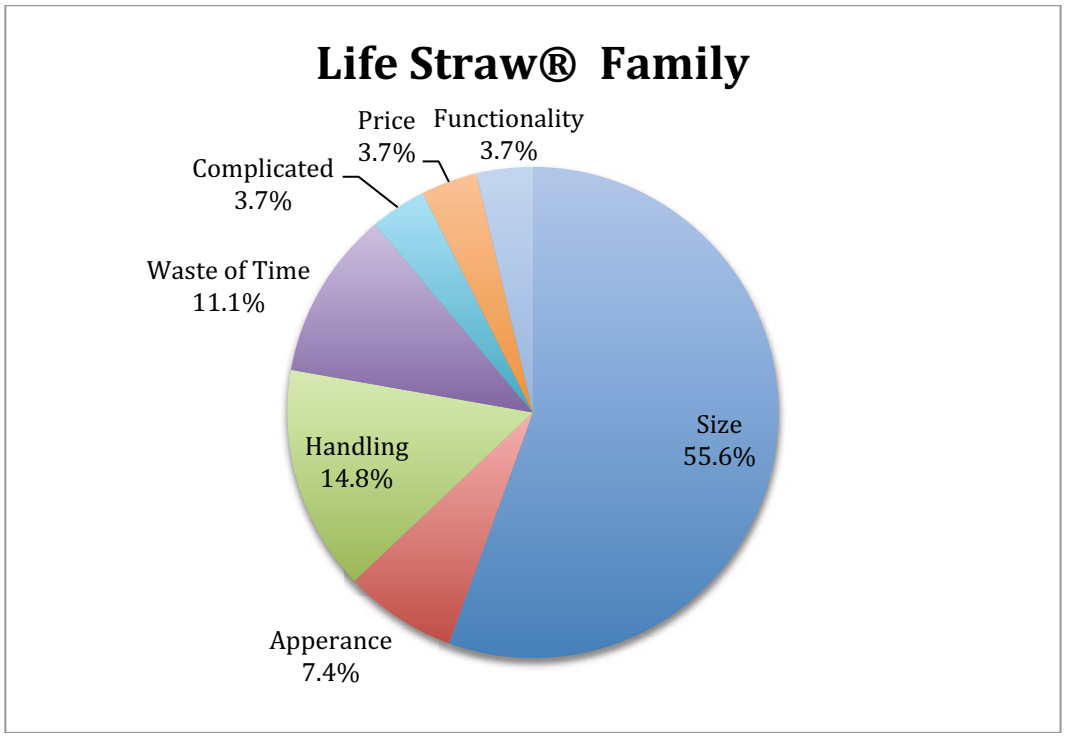


Figure 6-18 c. Percentage of major concerns of *LifeStraw® Family* (N=27)

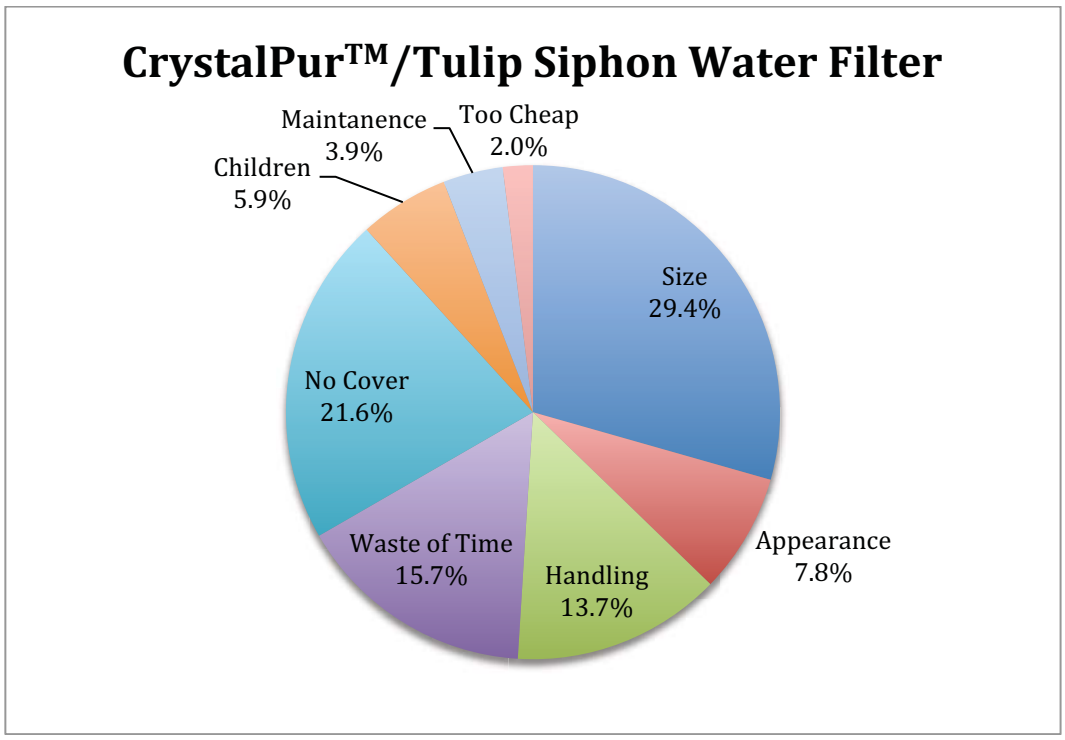


Figure 6-18 d. Percentage of major concerns of *CrystalPur™/Tulip Siphon Water Filter* (N=51)

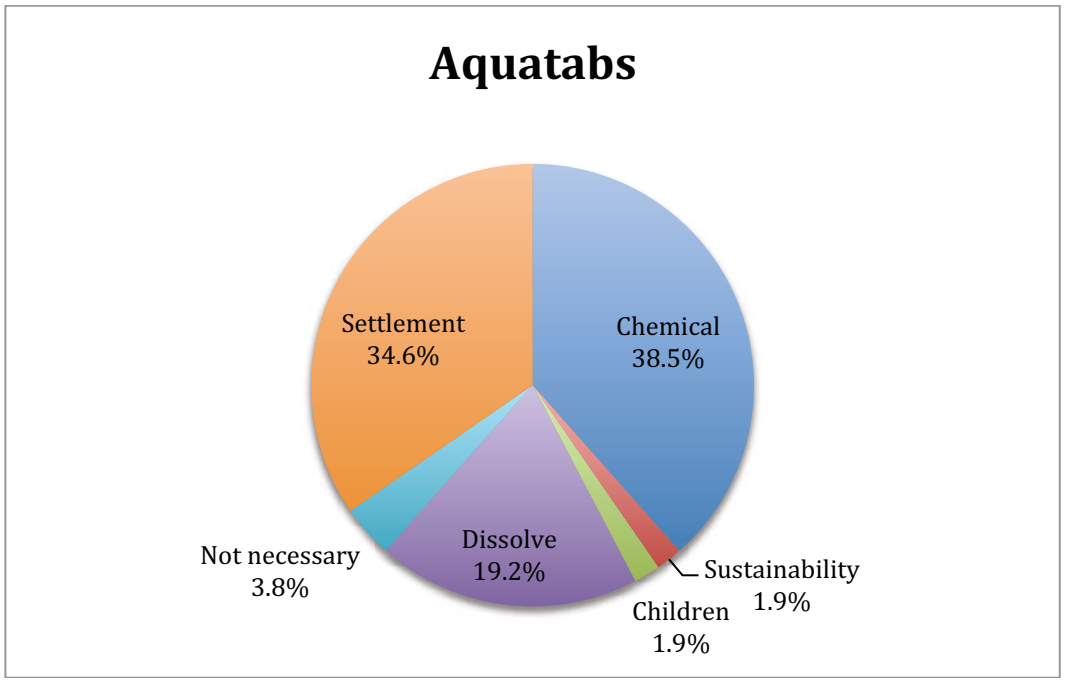


Figure 6-18 e. Percentage of major concerns of *Aquatabs* (N=52)

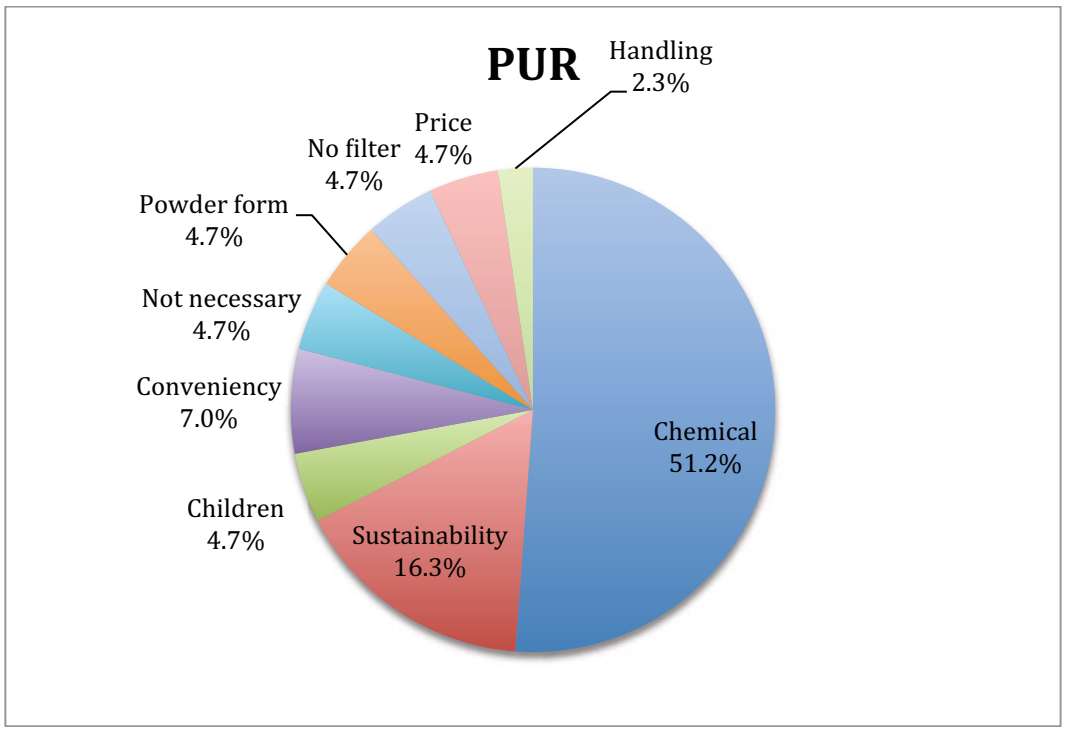


Figure 6-18 f. Percentage of major concerns of *PUR* (N=43)

6.5.4. Comparison between Chemicals and Physical Removal Products

According to the previous six products ranking results, and pricing analysis in the Section 6.5.3.1, the author found that chemical products received the most concerns but yet the most expensive. Therefore, this section is particularly comparing the chemical and physical removal products.

6.5.4.1. Chemical and Physical Removal Products Ranking

Both *PUR* and *Aquatabs,* are defined as chemical products where the chemically treated water is considered in this thesis. Though *PUR* is categorized under "Combined system" in Murcott's definition (Murcott, 2006), since powder is added into the water and respondents see *PUR* as a chemical product._Physical removal products are those that remove bacteria and dirt physically and without producing byproducts that human consume after water is treated. *Kosim Deluxe, Kosim Classic, Lifestraw® Family* and *CrystalPur™/Tulip Siphon Water Filter* are in this category. Total performance scores of chemical and physical removal products are added up separately to compare the customer's preference for chemical versus physical removal products. The ranking is as followed in Figure 6-19.

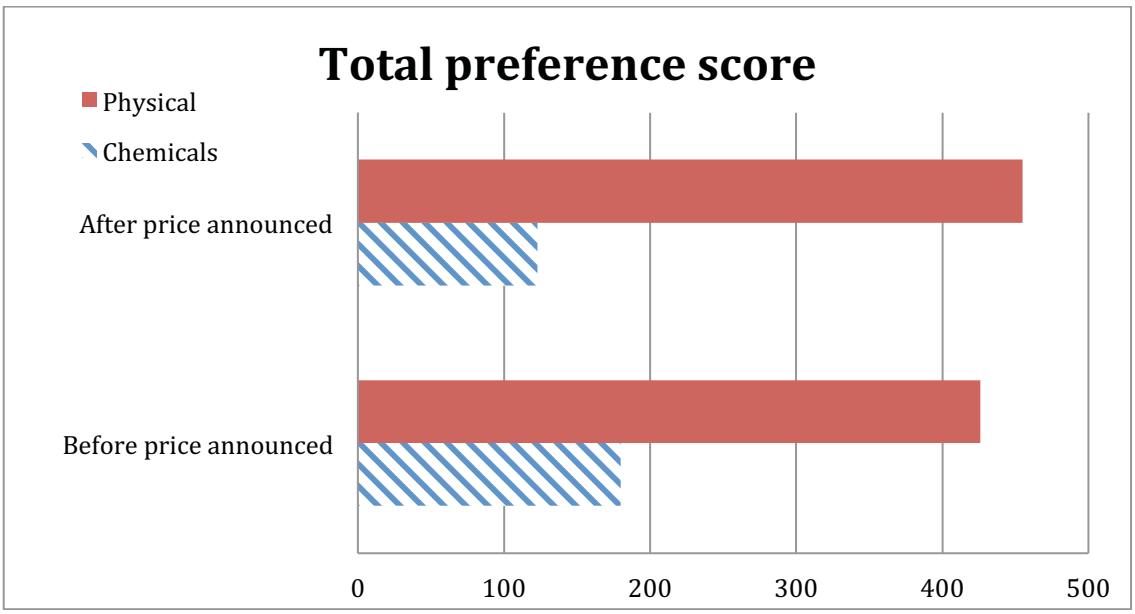


Figure 6-19. Comparison of total preference score for physical products and chemical products

6.5.4.2 Preference and Reasons of Preference

The open question "why other products were not Top 3 choices" were asked to avoid bias. During the interview, 42 out of 103 interviewees thought that chemicals as an addictive to water is the major issue, as 100% of the 42 interviewees consider chemicals have side effect to human body. Though they were told that the purpose of the chemicals is to disinfect and the ingredient of these chemical products were introduced, and even some interviewees had heard of the products, they were not willing to take a risk to consume chemicals into their body if given a choice.

In addition, 20 complaints come from the fact chemicals do not physically remove particles, although complete setup for using chemical products were not displayed and customers were told that *PUR* does settle down suspended dirt. Extra items such as cloth filters to filter out the suspended solids are still needed.

Another reason for not choosing chemicals is due to their being expendable products. While most of the physical removal products introduced during the interview have 3-5 years lifespan, *PUR* and *Aquatabs* as household water treatment products, will be finished and required continual re-purchasing purchase. Reponses from the interviewees show this as a concern. Seven out of 92 complaints on chemicals are because they will be finished after one use. For these seven customers, all of them chose only physical removal products as their top three choices, before and after the prices were announced.

Other complaints include: easily reached by children, easy to be accidentally swallowed and, easy to make measuring mistake. According to customers review, all these concerns

have meant that physical removal HWTS products ranked higher than chemical HWTS products.

6.5.5. Shop Categories in Major Roads

Based on three days of observations, the author and Zainab found three main roads are one of the locations that attract most of the people streams in downtown Tamale (Figure 6-20).

Figure 6-20. Populated roads in downtown Tamale. Section 1 is the east of Dagomba Road, intersecting with Rotary Road on the East and Louisville on the west. Section 2 is the other half of Dagomba Road, between Louisville and Tamale Navarongo Road. Section 3 is the north of Tamale Navarongo Road

As a background for the market research, the numbers of shops and their categories on these three main roads (Section 1, 2, 3) are shown (Figure 6-21).

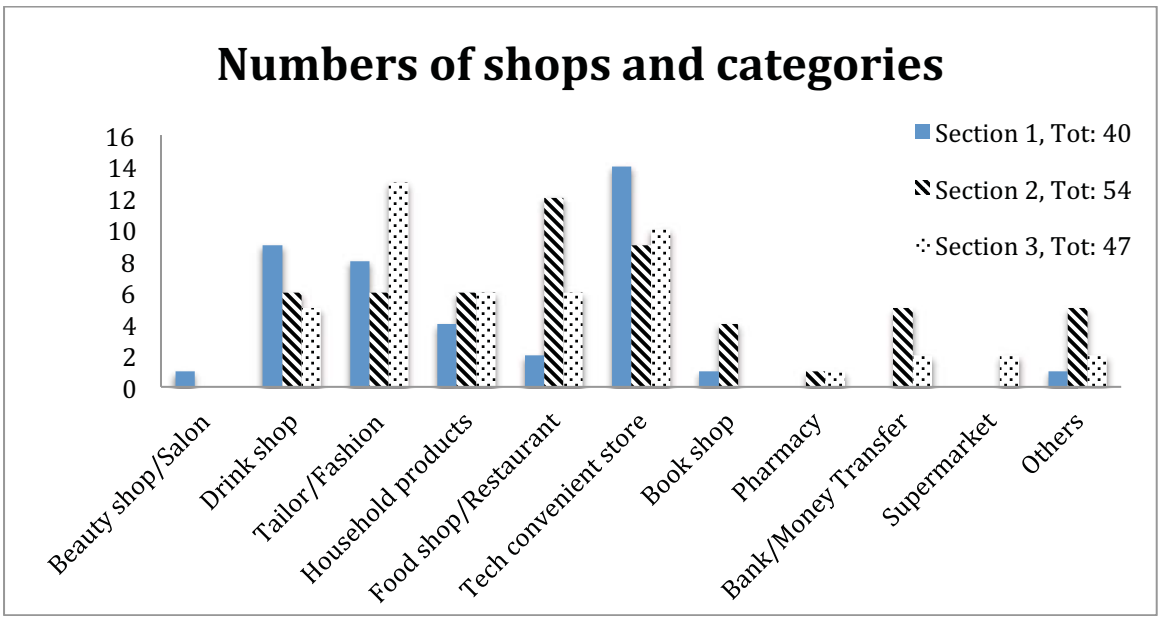


Figure 6-21. Numbers of shops and their categories in three major sections of roads in downtown Tamale

Figure 6-20 and 6-21 show that the majority of the shops are tech convenient stores (total of 33) in all three sections, followed by tailor/fashion (27), drink shop (20) and food shop/restaurant (20).

6.5.6. Actual Sale Result

During the survey period, only eight out of 103 respondents showed their interest in buying one of the six HWTS products. Daniel continued to call the eight respondents and by June, two of them purchased three and one *Kosim Classic* filters respectively at a price of GHC 45. According to follow-up with Daniel, all these people are currently living outside of Tamale. Their occupations are unknown. During the three-day market sales pilot study event, only one *CrystalPur™/Tulip Siphon Water Filter* was sold at GHC 18 (discounted price compared to original price GHC 20) and one customer ordered two *Kosim Classic* filters (for GHC 40 each, discounted from original price GHC 45). However, due to lack of follow up prior to the author's departure, *Kosim Classic* filters did not transit successfully.

6.6 Discussion

6.6.1. Six Products Analysis

The top three choices of different products have a unique pattern that reflects customers' preference due to the influence of price. *Kosim Classic* and *Life Straw® Family* had increasing supports on all three ranking tiers when the price was announced. At prices that

Diagio and Jim Niquette determined, both *Kosim Classic* (GHC 45) and *Life Straw® Family* (GHC 60) are among higher range, which *Kosim Deluxe* is the highest among all. The product *PUR* had the largest fall at the customers 1st choice before versus after the price was announced. The major reason for the change in ranking, according to the respondents, was due to the high price (GHC 30 per 6 packets).

Interviewees have been told that the interior, which is the filter itself, of *Kosim Classic* and *Kosim Deluxe* have no difference. Yet, more interviewees picked *Kosim Deluxe* as their first choice (34 [*Kosim Deluxe*] vs. 21 [*Kosim Classic*]). More interestingly, the number of customers picked *Kosim Deluxe* after the price announced increased.

In order to better compare the impact of price, total scores based on number of Top 3 tiers were generated (Top 1st : 3 points, Top 2nd : 2 points, Top 3rd, 1 point).

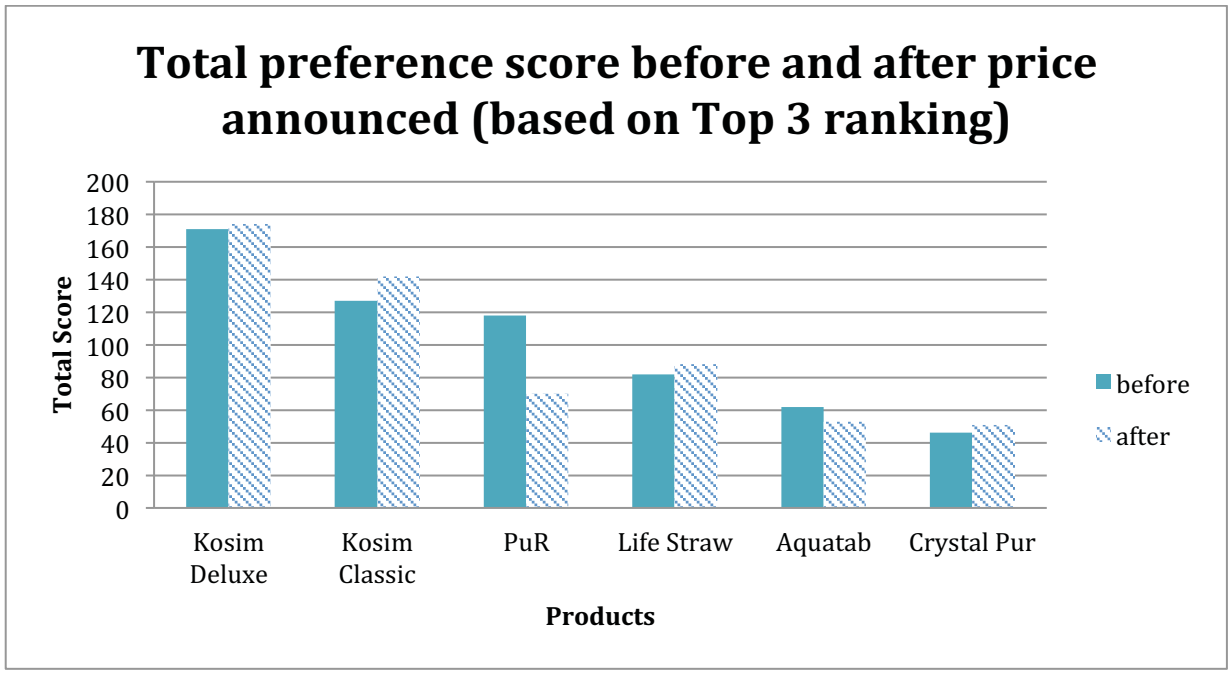


Figure 6-22 Total score comparison within six products before and after price was announced

From Figure 6-22, it is obvious that the *Kosim Series* (both *Classic and Deluxe*) received the highest score (127:142 and 171:174 for before vs. after price announced, respectively). In fact, though the price of *Kosim Classic* and *Kosim Deluxe* are relatively high (*Kosim Deluxe* is the highest and its price was set at GHC 75), the total score of both products increased after price was announced. *"The higher the price, the better the quality"* has been mentioned several times during the interview, and it is believed to be one of the driving forces for such a change for *Kosim Deluxe*.

The lowest score received before and after is *CrystalPur™/Tulip Siphon Water Filter* (46:51) and *Aquatabs* (62: 53). It is apparent that the reasons behind such low scores differ. Yet, these two products were the least expensive among all (*CrystalPur™/Tulip*

Siphon Water Filter for GHC 20 and *Aquatabs* for GHC 5 per 10 tablets). Customers reviewed that the size of *CrystalPur™/Tulip Siphon Water Filter* is small, though they were introduced the way of using it. Another major concern is that *CrystalPur™/Tulip Siphon Water Filter* does not have cover like other products. It is understandable that having a cover for water source is very important for city like Tamale, where in dry season it is windy and dusty, to prevent recontamination.

Residents in Tamale have a perception that the water is not clean and safe to drink because of dirt, yet only few interviewees know the microorganisms are ones that cause major water-borne diseases. It seems reasonable that products that are introduced as having the ability to "remove dirt" are preferred. Since *Aquatabs* does neither settle nor remove dirt, it has lower preference score compared to other products (except *CrystalPur™/Tulip Siphon Water Filter*).

6.6.2. Feedback Analysis

It was surprising that people considered chemicals used for water disinfection, in general to potentially cause side effects. Yet we already know that Sodium Dichloroisocyanurate (NaDCC), an alternative source of sodium hypochlorite used in *Aquatabs*, is a safe and proven technology (Clasen, T. and Edmondson P., 2006). The occupations of most of the interviewees who thought chemical has side effect are students and teachers, who likely were taught science. There might be a correlation between occupation and product preference.

One of the biggest disadvantages of the selected chemical HWTS products, compared to physical removal HWTS in this thesis, is its ability to remove particles in one step (such as *PUR* requires cloth filter) or do not remove particle at all (e.g.: *Aquatabs*). Although all six HWTS products can treat water to a safe drinking level (total coliform and *E.coli*[95]) and last for at least an hour, (Table 6-5), people are reluctant to take the extra effort, such as filtering water using cloth filter to remove suspended particles after water is treated, for example, with *PUR*, with respondents' complaints like "not convenient", "no necessary" and "no filter". More interestingly, people surveyed in Tamale considered water is "dirty" if dirt is present (respondents who use tap water), which is a problem of most piped water and storage tank water when the water is not continuously flowing and which is the case of Tamale. When interviewees were told that chemical products (such as *Aquatabs*) only kill bacteria, interviewees were not satisfied with it and prefer to choose other products that also remove particles, although some questions such as the flow rate of these filters were asked and in real practice, the flow rate is slow when using *Kosim Series*[96] and

[95] According to the U.S. Environmental Protection Agency, the Maximum Contaminant Level (MCL) for total coliform is 5 mg/L (EPA, 2012). Online access: http://water.epa.gov/drink/contaminants/index.cfm, on August 10th, 2012.

[96] During the interview, the author were asked several times about how fast the water would go through the filter, where parabolic-shaped filter was installed in *Kosim Deluxe,* during the interview. Respondents were told that the device can filter 3 liters per hour and

CrystalPur™/Tulip Siphon Water Filter interviewees are still more willing to buy physical removal HWTS than chemical products.

The price of *Aquatabs* is set at GHC 5 per 10 tablets and *PUR* is GHC 30 per 6 packets. Each tablet/packet is able to treat 10 liters of water. From the user perspectives, such a price is too high and the performance does not meet the expectation as other products do (for example, the inability to settle suspended solid, etc.). The size of the product is also an issue. Interviewees who consider chemical will be finished up are most likely those with large family size (number of members from 8- 20).

6.6.3. Customers Products Perception

6.6.3.1. Higher the price, better the quality

As we can see from comparing the results before and after the price of the products announced, the total performance score of *Kosim Deluxe* increased more than other products. When asked the reasons for re-ranking, 12 out of 17 interviewees switched their first choice to *Kosim Deluxe* because the price is the highest among all. However, the concept does not imply that people are able afford, or that they will purchase the most expensive product. In the last three days of our market survey, Daniel and the author also tried to engage the customers with several different sales strategies, such as giving out coupons, limited time sale, etc., and after the author departed from Tamale, Daniel continued to call respondents who show interests in HWTS products. The two products that were sold were *CrystalPur™/Tulip Siphon Water Filter* and *Kosim Classic*. The discounted products and limited sales strategy have driven people to ask more questions about *Kosim Deluxe*, yet when making the decision, they would simultaneously ask for performance of other products and ask for promotion on products that they prefer. However, the author experienced that bargaining is not what most locals in Tamale do, and therefore, when choosing between higher price versus lower price, they tend to give up on the higher one without negotiating, although the survey shows that most of the interviewees consider the *higher the price, better the quality*. In actual practice, such a concept does not hold true.

6.6.3.2. Chemicals have side effects

During the interview, 41 out of 94 did not choose either *PUR* or *Aquatabs* because it contains chemical. In Green's thesis she pointed out that chlorine has a strong taste yet people liked it anyway because being able to afford chlorine to disinfect water represents status in the society. However, when introducing *PUR* and *Aquatabs* as chemicals, most of the people are scared away, even though they might ask the ingredient of the products and

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they considered it as "slow". However, according to Miller, flow rate of parabolic-shaped filter produced by PHW is 1.04 liters per hour (Miller, 2010).

know in advance that *PUR* contains ferric sulfate[97] and *Aquatabs* contains NaDCC[98], and the purposes of such chemicals are to settle the particles (*PUR)* and kill bacteria (*PUR* and *Aquatabs*). Customers are not fond of adding chemicals to the water, as some of the customers already know their municipal drinking water in Tamale "already has chemicals in it". An exception, however, is when they have used or heard about the products before. Four customers pointed out that they would use *Aquatabs* (or continue buying it), while some customers pick *PUR* as their first choice because they have heard of alum, similar to ferric sulfate functional ingredient used in *PUR*. "*Chemicals have side effects*" might be a misconception and from the survey results, it seemed that such a myth could be altered by putting energy into marketing and public education, such as giving out free samples and broadcasting the benefits of using such products while emphasizing the chemicals will not cost side effect.

6.6.3.3. Perception of product design

There are two main perceptions on customers understanding on product handling and complexity. One is when the products require constant external force to get water out of the filter, such as squeezing, interviewees would describe the device as "hard to handle and complicated"; another is the sophisticated design of a product will drive people to think that the products are "hard to use". One of the best illustrations is *Life Straw® Family*. People found the design interesting, yet would not consider buying it because the product is not compatible to the current living environment; some interviewees thought that *Life Straw® Family* is like a hospital device, which make them not consider it as among their Top 3 choices.

The co-founder of Apple, Inc. Steve Jobs had said:

"Simplicity is the ultimate sophistication"

It seems to hold true in water filtration products in the emerging market as well. Although simple handling instructions were demonstrated during the interview for each product, potential customers pointed out that sophisticated or complex design and operation is not attractive to them.

Kosim Classic is rated as not appealing, based on the reasons given for not considering products as Top 3 choices. However, it received the second highest total performance score and it received no comment in regards to "hard to use" or "look complicated". Similar product *Kosim Deluxe* however, had very few complaints such as "too fancy" on its design. The majority of the interviewees thought the design was great and worth the price. Interviewees chose *Kosim Deluxe* because it is simple and presentable. The results on designs were from respondents' words, and respondents were able to compare with all

[97] When introducing the ingredient, ferric sulfate was substituted by phrases "ingredient similar to alum", because respondents are more similar with alum than ferric sulfate.
[98] When introducing the ingredient, NaDCC was substituted by phrases "ingredient similar to chlorine", because respondents are more similar with chlorine than NaDCC.

products at the same time during the interview, therefore, it is unlikely that compliments on design of *Kosim Deluxe* is a courtesy response.

6.6.4. From Case Study to Correlations of Macro Scale

6.6.4.1 What Found in the Case Study to What Shown in the Analysis

Majority of the interviewees do not have a plan to purchase the product in the near future and only 8 out of 103 left their phone numbers with us having expressed interest in purchasing one of the six products. From the survey on source of water (Figure 6-23), approximately 86% of the interviewees claim that they drink piped water without further treatment. This percentage is much higher than the national average percentage of urban population (33%) having water piped into premises in 2010 (WHO/UNICEF, 2012b). At least 89% of the interviewees are currently drinking improved safe water, because a. piped water (86%) and boreholes (3%) are considered as *improved drinking water* from the JMP definition (JMP, 2012) and; b. another 8% of drinking source is sachet water and according to Okiga, one out of 15 factory-produced and one out of 15 hand-tied sachet water was found to have *E.coli* (Okiga, 2007). However, according to the owner of Tridewa Co. Ltd Prakesh Ramchandani, there are 60 sachet water companies present up to 2011[99]. Therefore, the author is not sure whether the sachet water sold in the market, or those drunk by the respondents are "safe to drink". Overall, the majority of the respondents surveyed have at least "intermediate access" (access measure: *water delivered through one tap on-plot (or within 100 m or 5 minute total collection time*) (Table 4-1) (Howard and Bartram, 2003). If all people who live in urban Tamale have at least "intermediate access" to drinking water, as the respondents did, then on average, people who live in rural areas might take an even longer time to get access to drinking water than 26.1 minutes (presented in the previous section).

[99] Personal communication.

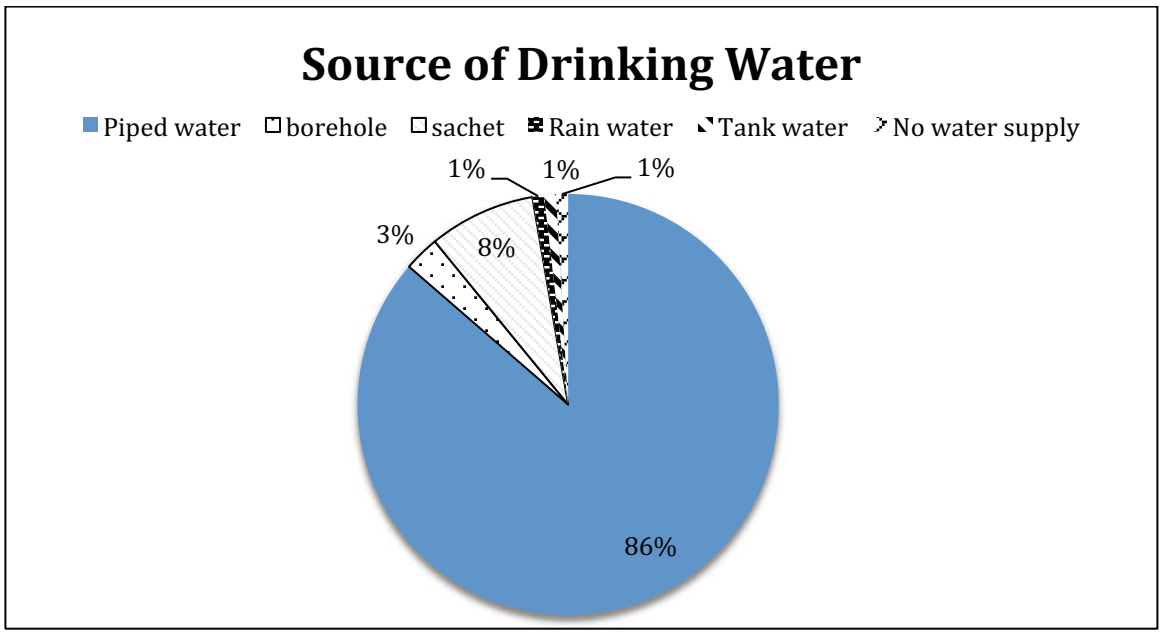

Figure 6-23 Source of drinking water distribution in Tamale, Ghana. Data collected from 103 surveys in urban area of Tamale in 2012.

6.6.4.2 From Water Accessibility and Quality to Economics Development

A few interviewees told the author that they do not further filter the water from the pipe, even though dirt was present. The high percentage of population using piped water in urban areas (Figure 6-23) suggests that the people in Tamale are highly relying on public facilities for water delivery. Only five out of 19 interviewees who live in rural area around Tamale do not use piped water; as an alternative, four households use sachet and one out of these five interviewees uses a borehole. According to an interview with drink shop owner in the outskirt of Tamale, however, only rich families or tourists could afford sachet water (a bag of sachet water costs 5 Ghana pesewas, which is approximately US 3.3 cent). It is very likely that the people that the author interviewed, including those come from rural, semi-urban and urban, are coming from the middle class and for wealthy tier of the society, which are not from population under the poverty line.

The market research indicates that safe water accessibility is very likely to relate to the income of household. Households with higher incomes will be likely to have safe drinking water, and they are likely to have public facility such as piped water, or tank truck water delivered to their house regardless of living in rural or urban area. Those with middle or high income will rather rely on public facility for clean drinking water.

One customer who bought *CrystalPur™/Tulip Siphon Water Filter* during the market sales pilot study said that he purchased the product because he wanted to remove dirt from the water. It might be an indication that some middle class customers would buy a HWTS product in order to drink high quality water. The other two customers, who purchased *Kosim Classic* after Daniel follow-up with them, live outside of Tamale and they came to PHW for picking up the filter. In other words, there are some interests in HWTS products

and those people are willing to pay full price for the HWTS products when they have a need for the products.

6.7. Recommendation

6.7.1. HWTS Products Market Recommendation

Product, price, promotion and place (distribution) are the 4 P's described in the *Producer-oriented Model*[100] that has been used by marketers widely throughout the world (McCarthy, 1960). The author is aware of the 8 P's (product, price, promotion, place, publics, partnerships, policy and purse strings) for social marketing pioneered by Shaklee Corp. (Shaklee Corp., 1956). However, due to the time limitation of the market survey, the author was only able to focus on product, price promotion and place survey during the research.

Although the thesis's objective No. 3 primarily focused on "product", the survey also asked respondents' opinions on price, promotion and place. Therefore, besides providing product recommendation for each product, this section will also provide brief recommendations on Price, Promotion and place.

6.7.1.1 Products Improvement Recommendation

Section 6.7.1.1 addresses the case study Objectives a and b mentioned in Section 6.2, on product preferences as well as improvement of design and technology recommendation.

6.7.1.1.1 Aquatabs

Our interviewees mentioned that, using *Aquatabs* on a daily basis, product will be finished and it is not applicable for a large family. Recommendation given could be making *Aquatabs* larger for communities that share same water source. In Tamale Ghana, there are rural communities that share dugout water and due to the effort made by international development organization such as Community Water Solution (CWS[101]), a storage tank is built and water is brought from dugout and treated prior to supply. Using larger *Aquatabs* tablet to treat water for the whole community might help provide more safe water and lower the cost of treatment. In addition, such a model will require less people to deal with technical information about *Aquatabs*, such that people will not need to worry about issues such as making measurement mistake, dissolving tablet, etc. in a daily basis.

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[100] Producer-oriented model is four functions (product, price, promotion and place) that marketing has to perform before planning and movement of a product from the supplier of that offering to end-users (Fine, 1981; McCarthy, 1960).
[101] Approach of Community Water Solutions can be found at http://www.communitywatersolutions.org/approach.html. Online accessed: August 7th, 2012.

6.7.1.1.2 CrystalPur™/Tulip Siphon Water Filter

CrystalPur™/Tulip Siphon Water Filter is the only product that was successfully sold during the market sales pilot study period. The customer considered *CrystalPur™/Tulip Siphon Water Filter* to be convenient as it can be put into the water tank directly (which is one of the common water storage methods wealthier, middle class people in Tamale use). However, the size is considered by the customers to be too small and customers' reviews said that it is a waste of time, since it sometimes requires mechanical force to get the water out. Additionally, interviewees also mentioned that they would like to have a bucket, most importantly a cover to protect the filter from windy and dusty environment in Tamale. It would be a good idea to sell this product with a covered storage bucket as an option. *CrystalPur™/Tulip Siphon Water Filter* should target its market in small households because the flow rate might not be fast enough to satisfy the need for a large family or school.

6.7.1.1.3 Kosim Classic

The size of the *Kosim Classic* received compliments from the majority of the interviewees, which will be a perfect product for family and/or schools. However, the appearance of *Kosim Classic* is not appealing and in fact, it has become one of the major reasons that interviewees did not choose *Kosim Classic,* once *Kosim Deluxe* was presented. In addition, the flow rate of the ceramic filter has slow flow rate due to the design and size of the filter was an obstacle. Improving flow rate without lowering the quality of bacterial removal should be a priority of ceramic filter.

6.7.1.1.4 Kosim Deluxe

Interviewees have given a lot of compliments to *Kosim Deluxe* due to its appearance. However, because of its outstanding look, some interviewees were relevant to consider it among the Top 3 choices, as appearance seems like an indicator for price in the customer's opinions. When displayed at the shop as part of the consumer survey, the *Kosim Deluxe* was always touched because they would like to see what is inside, and because of its design (two separate plastic parts), the two layers are detached easily. While the upper plastic part has to support the filter, that was a concern for family that have children. Similar to *Kosim Classic*, flow rate should be increased in order to encourage people to use the filter rather than drinking tap water. The current filter that can fit into the receptacle of *Kosim Deluxe* ("Super Tunsai") is the coned-shaped ceramic filter element. Since PHW is producing a new hemispheric-shaped filter element, the receptacle should also be re-designed to fit the newly designed hemispheric filter element as well as to make it less fragile.

6.7.1.1.5 PUR

One of the advantages that *PUR* has over *Aquatabs* is that *PUR* settles down particles, whereas *Aquatabs* is only a chlorine disinfectant. In the lab, we tested whether the

supernatant layer of water was initially safe to drink but after an hour of settling, bacteria started to go back up to the upper supernatant. Therefore, it is recommended that cloth filter is sold together with *PUR*, and to provide clear instruction for customers on how to use *PUR* properly. The price of *PUR* is higher yet *PUR* powder seemed to be more acceptable than tablet, but the windy weather has made powder form into a disadvantage if the treatment tank is outdoors. It is not recommended to sell such product to a large community. Instead, *PUR* should be targeted at families whose water has a quite high turbidity.

6.7.1.1.6 Life Straw® Family

To create a pressure difference, *Life Straw® Family* must be hung high up on the wall. Based on user's response, such a design is an inconvenience to customers, which requires users to climb up and down to fill the water container. Such a design also causes potential hazards as *Life Straw® Family* might fall off, being pulled off by children at home. In addition, the size of *Life Straw® Family* is relatively small and people who considered *Life Straw® Family* for their Top 3 choices are usually one-person households. The two tubes design, one for drinking water another for cleaning (backwash) purposes, is somewhat confusing to customers. Users might drink dirty water by mistake since the tube for cleaning purpose is more obvious and easy to use. Customers are not fond of the design in general, as it is not compatible with their house, or they consider it look like a hospital device. Although the price indicates that *Life Straw® Family* is the second most expensive product among the six, the general performance score had not changed much before and after the price was announced. Unlike *Kosim Deluxe* which customers think *the higher the price, the better the quality*, Life *Straw® Family* should be re-designed to be more acceptable by the end-users, because its higher price did not seem to attract interest among customers.

6.7.1.2 HWTS Market Recommendation

Section 6.7.2 is a further recommendation building on top of the Objectives a and b and elements discussed, price, promotion and place.

6.7.1.2.1 Price

According to the market research conducted in the urban area of Tamale, although respondents consider *high price is equal to high quality*, it does not mean that the price should be so high that local people cannot afford it. For example, respondents consider *Kosim Deluxe* sold at GHC 75 as expensive. From the result difference in before and after price of each HWTS product, this indicates that price might potentially affect the sale of HWTS products. However, more research should be conducted for how exactly price will affect the sale of HWTS products. In terms of subsidy, the author did not find strong evidence to prove that people in urban area would need subsidies. From the successful sale of *CrystalPur™/Tulip Siphon Water Filter* as well as sale of four *Kosim Classics*, the price set for these two products (GHC 20 for *CrystalPur™/Tulip Siphon Water Filter* and GHC 45 for

Kosim Classic) might be acceptable for local people. Again, more research should be done to support these findings.

6.7.1.2.2 Promotion

One HWTS product (*CrystalPur™/Tulip Siphon Water Filter*) was sold during the market sales pilot study period, during which the author lowered the prices for all products by 10% and handed out brochures for advertising purpose. It turned out that people paid attention to the products. The other four *Kosim Classic* filters (GHC 45) were sold without price reduced after the market sales pilot study period. The successful sales of these two products are due to (1). Limited time price reduction and (2). Periodic phone calls to potential respondents. Promotion efforts should be continued in order to understand the benefits of HWTS products.

6.7.1.2.3 Place

It is recommended that HWTS products should be sold in a well known or fixed location shop (such as supermarket, large household product merchants, etc.) in urban Tamale, because more than 90% of the respondents prefer to purchase the products in a trustworthy shop. However, the author considered that the market for HWTS products in the urban areas of Tamale is not large, since the majority of the population in urban areas of Tamale are already drinking piped water and they do not seem to like the idea of further filtering piped water. Therefore, the author does not recommend HWTS to be sold by individuals, or small shops in the urban area of Tamale.

As the author mentioned earlier, respondents are aware of their water "having dirt". Additionally, respondents were introduced to HWTS products, e.g. *PUR* or filters that can remove particles in the water. If the demand for high drinking water quality comes from customers drinking unimproved water supplies, can ones utilize the opportunity of poor water quality to develop a business for the population living under or at the edge of the poverty line? Can the poor distribute the HWTS products in urban areas to gain extra income? The survey shows that in urban area, 86% of the interviewees prefer to see displayed water products in a fixed shop which they have heard of or seen, such as Tridewa, Co. Ltd, or quality guaranteed shops such as a supermarket (7%) or drug store (3%) in urban area (Figure 6-24). It is not likely that the poor in the urban area will benefit from the sales of water products such as HWTS, as the majority of the people will prefer to buy water products from shops that are family-owned or large and well known locally.

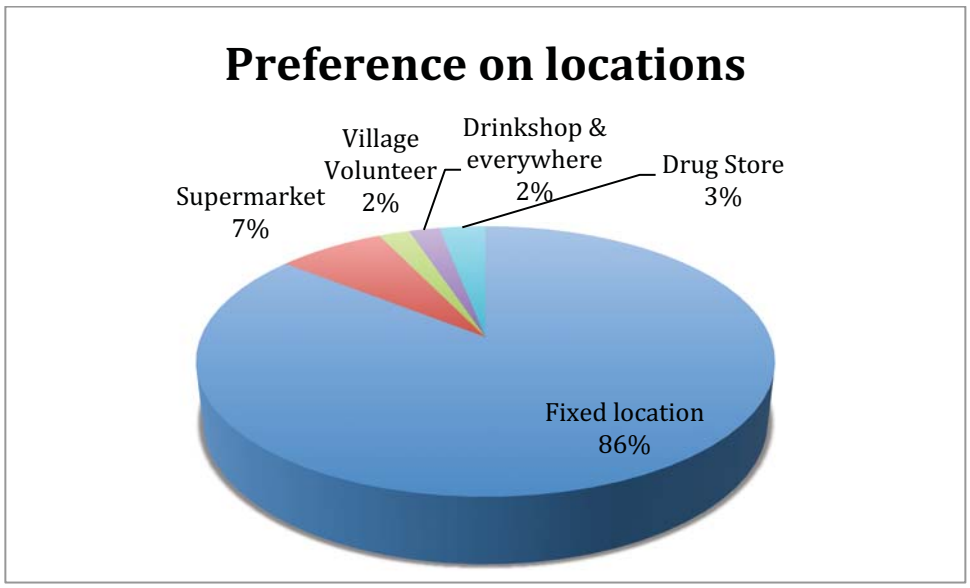

Figure 6-24. Preference on water production distribution location in Tamale

From the actual sale of HWTS products, there are two people coming from outside of Tamale who subsequently picked up filters in PHW directly (instead of the fixed shop in the center of Tamale where the survey was conducted. This indicates that if the customers are willing to buy, it might not matter to them where they need to pick up the product. Rather, where they have heard of the products is more likely to be important. Therefore, places where HWTS products should be promoted seem more important.

6.7.2. Water Sectors and Economic Development

From questions asked during the interviews in downtown Tamale, the author noticed that there are more people have access to improved drinking water in urban Tamale than expected. It was surprising that from the survey 87% of the interviewees have access to piped water and 18% indicated they were from rural areas of Tamale. It is not likely that economic opportunity is found in **water accessibility** issue in this context.

Additionally, from potential customers of HWTS products and from the shop owners, the author noticed that most of the people drink piped water directly from the tap. While wealthier people consider tap water as safe to drink, they would choose not to drink it because of dirt (other alternative is to drink sachet water). In the surveyed region of urban area of Tamale, people seem to heavily rely on public water supply although they have noticed that municipal water is not as clean as they prefer. Therefore, **HWTS product economic opportunities might exist in urban Tamale if its target is wealthy families who would like to further filter their water to obtain a luxury water.** From the example of successful sales as well as customer response towards selected HWTS products, HWTS products should be branded as a not too expensive luxury water filter device that can remove un-dissolved particles and bring additional health value to end-users. However, if a market demand for luxury water exists, HWTS products might not benefit the poor

directly, since the majority of the respondents in urban Tamale prefer to buy products in a well-known shop. But it might potentially create indirect opportunities for the poor, for example, promotion and delivery job opportunities.

The Objective 3 mentioned in Section 2 "to conduct market survey on Household Water Treatment and Safe Storage (HWTS) products and customers' preferences in Tamale" is achieved, with results and analysis shown in Section 6.

6.8 LIMITATION OF THE STUDY

The market survey conducted is from respondents' view towards the HWTS products in urban Tamale. Therefore, the results do not reflect those in rural region of Tamale. Market research should be done in rural Tamale in order to better understand the situation and people's attitude towards HWTS products.

Additionally, the market research is only able to show that HWTS products can potentially help economic development. However, the research is not yet sure why water accessibility has little correlation with proportion of the population under the poverty line (as for the analysis done in first half of the thesis). And the author is unable to link water accessibility with poverty reduction with the case study.

7. CONCLUSION

This thesis has collected several data in economics, education and natural resources indicators, with the main focus of analysis on: proportion of population under the poverty line, completion of primary school and secondary school, mean time to source of drinking water, annual average precipitation, oil palm and cocoa.

The author found that there is moderate to strong correlations between each indicator. Among all correlations, the strongest relationships are proportion of population completed primary education and selected natural resources (water resources, oil palm and cocoa combined) as well as proportion of population under the poverty line. The weakest among all is proportion of population below poverty and selected natural resources. Mean time to source of drinking water as an individual natural resources indicator, has the least to do with proportion of population under the poverty line, which correlation coefficients square R^2 are 0.0018 and 0.0019 with and without Greater Accra respectively. Such a weak correlations is confirmed by analysis on correlation of mean time to drinking water source and ranking in poverty in different regions. The correlation is 0.052 and 0.0046 with and without Greater Accra in the analysis.

Based on the correlation analysis, ranking analysis and advantage analysis, the author separated Ghana into three Areas (Area I, Area II and Area III) due to their similar economics, education and natural resources conditions, for recommendation purposes. The author suggests that, in order for areas yet to overcome the obstacles for achieving the MDGs and post-2015 development, three areas need to primarily focus on:

- Area I (Greater Accra): invest in proportion of population under the poverty line that have a secondary school degree, encourage and support them for higher technical education and increase their employment rate

- Area II (Western, Central, Eastern, Ashanti, Brong Ahafo and Volta Regions): develop agricultural technology to increase crop production per acres and develop sustainable agriculture; increase investments in primary and secondary education.

- Area III (Northern, Upper West and Upper East): find investment to support primary education in rural area; discover alternative natural resources that are suitable for Area III.

The issues targeting at economics, education and natural resources are complex. With the weak correlation between water accessibility and proportion of population under the poverty line, the author conducted a market survey to:

a. Introduce HWTS products (*Auqatabs, CrystalPuR, Kosim Classic, Kosim Deluxe, PUR* and *Life Straw® Family*) and find out customers product preferences;
b. Identify economic opportunities in HWTS products in rural and urban areas as potential solutions for achieving the MDGs and post-2015 MDGs.

Among all six products, *Kosim Deluxe* received the highest preference scores both before and after the price is announced. Those performance scores ranks are in Table 7-1 and Table 7-2.

Table 7-1. Total preference score before price is announced.

Rank	Product	Score
1	*Kosim Deluxe*	171
2	*Kosim Classic*	127
3	*PUR*	118
4	*Life Straw® Family*	82
5	*Aquatab*	62
6	*CrystalPur™/Tulip Siphon Water Filter*	46

Table 7-2. Total preference score after price is announced.

Rank	Product	Score
1	*Kosim Deluxe*	174
2	*Kosim Classic*	142
3	*Life Straw® Family*	88
4	*PUR*	70
5	*Aquatab*	53
6	*CrystalPur™/Tulip Siphon Water Filter*	51

Size becomes the most common concerns among physical removal products (*Kosim Deluxe* (42%)*, Kosim Classic* (46%), *CrystalPur™/Tulip Siphon Water Filter* (29%) and *Life Straw® Family* (55%)), followed by appearance/design of the products. Between two chemical products *Aquatab and PUR*, the most concern is use of chemicals (38% for *Aquatab* and 51% for *PUR*), followed by settlement issue. In general, interviewees prefer physical removal products to the chemical removal products.

The author summarized several key results on customers' opinions towards products from the survey:

- Higher the price, better the quality
- Chemicals have side effect
- Product design reflects complexity of the product

For recommendations:

1. Among our respondents, 87% claim that piped water is their major drinking water, and the second major drinking source is boreholes. None of the interviewees we interviewed drank dugout water.

2. According to the market sale pilot study, HWTS products were sold or ordered by local people in Tamale and therefore, the acceptable price of HWTS products should be between GHC 18 to GHC 45.

3. About 86% of the interviewees prefer to buy HWTS products in a fixed shop; while other options such as supermarket and drug store, places where quality is guaranteed are also peoples' choices.

4. Household Water Treatment and Safe Storage products should not advertise as "providing safe water" (potential post-2015 MDG) in urban Tamale, because according to the respondents, people in urban Tamale consider piped water safe to drink. However, HWTS can be advertised as "providing luxury water". Additional value related to health and better appearance might help increase the sales of HWTS products in the urban area. Such a market strategy might help bring economic development and provide extra barrier of protection of water for people (i.e., those who would like luxury water) in Tamale.

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9. APPENDIX

Appendix I Education attainment in men

Education Attainment in **Men** by age					
Age	No education	Completed Primary School	Some Secondary Schools	Completed Secondary School	More than Secondary
6-9	49.9	0.1	0.2	0	0
10-14	8.3	8.4	13.6	0	0
15-19	6.8	9.5	59.7	5.8	0.4
20-24	10	3.9	43.3	27.8	7.5
25-29	13.7	4.6	40.7	19.5	14.2
30-34	16	4.8	43.6	18.5	10.9
35-39	22.5	3.2	42.2	14	8
40-44	24.2	3.8	44.9	10.8	9.3
45-49	25.5	2.4	43	13.2	10.4
50-54	20.4	2.2	42.5	11.3	14.2
55-59	21.5	2.1	44.1	12.8	14.3
60-64	37.1	2.7	34.6	7.9	11.1
65+	53.2	2.2	26.9	3.9	6.5

Appendix II Education attainment in women

Education Attainment in **Women** by age					
	No education	Completed Primary School	Some Secondary Schools	Completed Secondary School	More than Secondary
6-9	48.2	0.1	0.1	0	0
10-14	7.9	9.7	14.6	0	0
15-19	10.1	9.4	58.7	5.7	0.3
20-24	16.8	5.7	41.6	19.8	4.8
25-29	23.1	5.3	39.2	12.9	6.9
30-34	30	5.6	37.6	9.2	4.2
35-39	33.3	4.8	39	6.3	2.8
40-44	36.1	5.1	38.3	5.4	2.6
45-49	38.9	3.6	35	5.8	4.3
50-54	42.1	4	32.7	4.4	4.7
55-59	50.5	2.9	26.1	5.1	5.1
60-64	65	0.7	18.7	3.1	4.6
65+	79.9	1.2	9.4	1.1	1.3

Appendix III. Comparison within selected natural resources (all regions)

Region	(Z1) Mean Time to source of drinking water	(Z2) Precipitation	(Z3) Oil palm	(Z4) Cocoa	Z1 Rank	Z2 Rank	Z3 Rank	Z4 Rank
Western	14.3	1153.65	28	422223	2	4	2	1
Volta	24.9	1247.83	4	1075	9	3	6	6
Eastern	22.7	1319.89	32	55871	7	1	1	4
Ashanti	15.5	1273.17	10	133026	3	2	4.5	2
Brong Ahafo	15.9	1088.08	10	72766	5	7	4.5	3
Northern	26.1	1119.52	-	-	10	5	7	7
Upper East	23.9	975.1	-	-	8	8	7	7
Upper West	20.6	1093.57	-	-	6	6	7	7
Greater Accra	11.3	728.97	-	-	1	9	7	7
Central	15.6	NA	16	55497	4		3	5

Appendix IV. Comparison within selected natural resources (without Central region)

Region	(Z1) Mean Time to source of drinking water	(Z2) Precipitation	(Z3) Oil palm	(Z4) Cocoa	Z1 Rank	Z2 Rank	Z3 Rank	Z4 Rank
Greater Accra	11.3	728.97	-	-	1	9	6	6
Western	14.3	1153.65	28	422223	2	4	2	1
Ashanti	15.5	1273.17	10	133026	3	2	3.5	2
Brong Ahafo	15.9	1088.08	10	72766	4	7	3.5	3
Upper West	20.6	1093.57	-	-	5	6	6	6
Eastern	22.7	1319.89	32	55871	6	1	1	4
Upper East	23.9	975.1	-	-	7	8	6	6
Volta	24.9	1247.83	4	1075	8	3	5	5
Northern	26.1	1119.52	-	-	9	5	6	6

Appendix V. Comparison within selected natural resources (data completed regions only)

Region	(Z1) Mean Time to source of drinking water	(Z2) Precipitation	(Z3) Oil palm	(Z4) Cocoa	Z1 Rank	Z2 Rank	Z3 Rank	Z4 Rank
Western	14.3	1153.65	28	422223	1	4	2	1
Ashanti	15.5	1273.17	10	133026	2	2	3.5	2
Brong Ahafo	15.9	1088.08	10	72766	3	5	3.5	3
Eastern	22.7	1319.89	32	55871	4	1	1	4
Volta	24.9	1247.83	4	1075	5	3	5	5

Appendix VI. Comparison and scores for economics, education (for primary and secondary school completion) and selected natural resources (all regions)

Region	(X1) Under Poverty	**(Y1) Completed Primary**	(W) sScore	X1 Score	Y1 Score	W Score	Final Score
Upper East	88	36.8	13	1	2	1	4
Northern	52.3	33.2	14	3	3	2	8
Upper West	70	39.9	17	2	1	3	6
Greater Accra	11.8	86.3	19	10	10	4	24
Volta	15.1	69.1	20	9	5	5	19
Brong Ahafo	29	65.5	24	5.5	4	6	15.5
Central	20	72.0	28	7	6	7	20
Eastern	31.4	80.9	31	4	9	8	21
Ashanti	20	78.6	32	5.5	8	9	22.5
Western	18	76.7	34	8	7	10	25

Region	(X1) Under Poverty	**(Y2) Completed Secondary**	(W) sScore	X1 Score	Y2 Score	W Score	Final Score
Upper East	88	11.5	13	1	2	1	4
Northern	52.3	12.8	14	3	3	2	8
Upper West	70	11.1	17	2	1	3	6
Greater Accra	11.8	35.3	19	10	10	4	24
Volta	15.1	14.7	20	9	6.5	5	20.5
Brong Ahafo	29	14.0	24	5	5	6	16
Central	20	14.7	28	6.5	6.5	7	20
Eastern	31.4	13.0	31	4	4	8	16
Ashanti	20	17.8	32	6.5	9	9	24.5
Western	18	17.5	34	8	8	10	26

Appendix VII. Comparison and scores for economics, education (for primary and secondary school completion) and selected natural resources (without Greater Accra)

Region	(X1) Under Poverty	**(Y1) Completed Primary**	(W) sScore	X1 Score	Y1 Score	W Score	Final Score
Western	18	76.7	35	9	8	10	27
Ashanti	20	78.6	34	7.5	9	9	25.5
Eastern	31.4	80.9	32	5	10	8	23
Central	20	72.0	29	7.5	7	7	21.5
Brong Ahafo	29	65.5	24	6	5	6	17
Volta	15.1	69.1	21	10	6	5	21
Upper West	70	39.9	18	3	4	4	11
Northern	52.3	33.2	15	4	2	3	9
Upper East	88	36.8	14	2	3	2	7

Region	(X1) Under Poverty	**(Y2) Completed Secondary**	(W) sScore	X1 Score	Y2 Score	W Score	Final Score
Upper East	88	11.5	14	2	3	2	7
Northern	52.3	12.8	15	4	5	3	12
Upper West	70	11.1	18	3	2	4	9
Volta	15.1	14.7	21	10	7.5	5	22.5
Brong Ahafo	29	14.0	24	6	6	6	18
Central	20	14.7	29	7.5	7.5	7	22
Eastern	31.4	13.0	32	5	4	8	17
Ashanti	20	17.8	34	7.5	10	9	26.5
Western	18	17.5	35	9	9	10	28

Appendix VIII. Survey questions handout

1. Where do you live in Tamale?	2. What water source do you drink at home?	3. Are you the purchasing decision maker at home?
1. Rural 2. Peri-urban 3. Urban 4. Others _____	1. Tap Water 2. Dugout Water 3. Others____________ 4. Sachet & Bottled Water 5. Do not have water supply	1. Always 2. Often but not always 3. Sometimes 4. Never, then who_____?

Thank you very much for doing the survey! **Please answer these following questions. And we have prepared a <u>small gift</u> for you at the end.** **Don't forget to ask me!**	 ***Kosim Classic*** can improve drinking water quality and treat 4-6 Liter of water per hour. It has its safe storage bucket equipped and great for rural family.	 ***CrystalPur*** is a water filter device removes most of the bad bacteria. It is small and does not require a lot of maintenance. It filters 4-5 liter per hour.	 ***PuR*** is chemical powder that disinfects water. Each packet treats 10 liters of water. It is perfect for treating water with less dirt.	 ***Life Straw*** filters 10 liter of dirty water per hour and does not occupy land space at home. It removes bacteria fast without chemical. It is easy for children to use.	 ***Aquatabs*** is a tablet that removes bad bacteria with mixed alum and chlorine. One tablet treats 10 liters of water and is convenient to carry around for treating various type of water.	 ***Kosim Deluxe*** is designed for people require high quality of water and life style. It removes almost 100% dirt and bad bacteria in tap water. It is a great device for offices.
Which one would you prefer to buy? (Please rank Top 1, 2 & 3)						
What concern you <u>the most</u> in this product? (Size, volume, water quality, appearance, maintenance, etc.)						
Is the product enough to treat water you and your family drink per day? (Yes or No)						
The price is listed now. Would you like to buy this product? Please rank Top 1, 2&3 :)	1. Yes! The price is OK. Rank __________ 2. I will <u>NEVER</u> buy. Why __________?	1. Yes! The price is OK. Rank __________ 2. I will <u>NEVER</u> buy. Why __________?	1. Yes! The price is OK. Rank __________ 2. I will <u>NEVER</u> buy. Why __________?	1. Yes! The price is OK. Rank __________ 2. I will <u>NEVER</u> buy. Why __________?	1. Yes! The price is OK. Rank __________ 2. I will <u>NEVER</u> buy. Why __________?	1. Yes! The price is OK. Rank __________ 2. I will <u>NEVER</u> buy. Why __________?
Where would you prefer to buy this product?	1. In fixed location such as this shop 2. Supermarket 3. In shops that I see everywhere (e.g., drink shop) 4. From village volunteers	1. In fixed location such as this shop 2. Supermarket 3. In shops that I see everywhere (e.g., drink shop) 4. From village volunteers	1. In fixed location such as this shop 2. Supermarket 3. In shops that I see everywhere (e.g., drink shop) 4. From village volunteers	1. In fixed location such as this shop 2. Supermarket 3. In shops that I see everywhere (e.g., drink shop) 4. From village volunteers	1. In fixed location such as this shop 2. Supermarket 3. In shops that I see everywhere (e.g., drink shop) 4. From village volunteers	1. In fixed location such as this shop 2. Supermarket 3. In shops that I see everywhere (e.g., drink shop) 4. From village volunteers

Appendix IX a. Raw data collected on *Kosim Classic*

Kosim Classic	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
Respondent 1.	1		1	
2		big		
3	2	big	3	
4				
5	2			
6	2		2	
7		Apearance		
8	3		3	
9	3		3	
10		children	2	
11		Apearance	2	
12	2		2	
13	3		1	expensive
14		big	2	
15	2		2	
16	3		3	
17	3		3	
18	3		3	
19		big		
20	3		2	
21	2		3	
22	3			have to be different than what he's using now
23			1	big
24	2		2	price is ok
25		not necessary		
26	1		1	
27	1		1	
28	3			
29		Apearance		
30	1		1	volume
31	1		1	
32				
33		Apearance		
34	3			
35		Apearance		
36				

Appendix IX a. continued

Kosim Classic	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
37		big		people think that it's just a bucket; not water treatment product
38	2		2	
39		Apearance	3	
40				
41		waste of time		
42		big, might not kill bacteria fast enough	3	
43	2		1	durable and simple
44	3	big	2	
45		might seem slow		
46	2		1	
47	1		3	
48	1		1	
49	2		2	has used a similar product for 5 years!
50				
51				
52	3		3	
53	2		2	big
54		no support at the bottom	2	
55	3		3	
56	1		1	big
57	1		1	big
58	3		3	
59	3	big	3	
60		appearance		
61		appearance		
62				
63	2		2	big
64	3		3	
65				

Appendix IX a. continued

Kosim Classic	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
66	2		2	
67		appearance	2	
68		big		
69	1		1	big
70	1	big	1	
71		not necessary		
72				
73	1		1	big
74	2	appearance	3	
75	1	big	1	
76		big		&therefore, might not kill all bacteria
77				*have it at home
78	3		3	
79	1			
80				
81		big		&the mouth is too big
82		big	3	
83		heat the water up	3	All choices are based on whether the filter can cool the water
84	2		2	
85	3		1	the price is most reasonable
86	1		2	
87			3	design and its durable
88	2		1	big and affordable
89	2		2	
90	1		1	
91	1		2	good for large family and it's big
92	2		2	
93	2		1	
94		children		The cover is easy to open by children

Appendix IX a. continued

Kosim Classic	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
95	1		1	
96	1		1	
97	1		1	
98	3		2	family
99			3	Water might not be clean
100	2		2	
101	2		2	
102	3		3	
103	1		1	big for whole family

Appendix IX b. Raw data collected on *CrystalPur™/ Tulip Siphon Water Filter*

CrystalPur™/ Tulip Siphon Water Filter	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
Respondent 1.		handle & small		
2			2	
3	3	no cover		
4				
5		handle		
6		no cover		
7	3		3	
8		small & waste of time		
9				
10		children	2	
11	3			
12		no cover		
13		small	2	
14	3		1	
15		no cover		
16		waste of time		
17		small		
18		small		
19	3		3	
20	2		3	
21		waste of time	3	
22			3	
23	3			
24		complicated		
25		complicated		
26		waste of time		
27		small		
28			2	good for polytank
29			3	
30		small		
31		not appealing		He cannot see inside, he dislike for personal preference
32	1		1	
33		no cover	3	need to look at what is in the pocket
34		small		
35				

Appendix IX b. continued

CrystalPur™/ Tulip Siphon Water Filter	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
36	1		1	can put it in the water tank/drum
37	2			can put it in the water tank/drum
38		hard to use		
39	3			
40				
41				
42		no cover		
43		no cover		
44		small		
45	2			
46	3		2	
47				
48		waste of time		
49		small		
50		hard to use		
51				
52		no cover		
53	3		3	for travel
54				
55		dirts remain in the filter		
56		small		
57	3		3	
58	1			
59		small		
60	3		3	
61		no cover		
62				
63		no cover		&looks like hospital product
64		wont make water pure		
65				
66		no water tank at home		
67		not appealing		
68		appearance		
69		cheap		

Appendix IX b. continued

CrystalPur™/ Tulip Siphon Water Filter	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
70				* can travel with so that children can bring it to boarding school
71	3		1	*changed because the price indicates quality
72				
73		small		&water quality might not be good
74	3			
75	3			
76	3		1	not expensive
77	3		1	
78		maintanence		
79				
80				
81	2		2	tube is small, might remove more dirt
82	2		2	*too cheap, and a little bit concern
83	1			
84	3		3	easier to use than life straw
85			2	
86		waste of time		
87		no cover		
88		small		
89		waste of time		
90		small		
91	3			
92		not appealing		
93		children		
94	1		1	easy to use
95		children		*children will spoil them
96				

Appendix IX b. continued

CrystalPur™/ Tulip Siphon Water Filter	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
97		hard to use		
98		small		*will be great for single family
99				*water might not been clean
100	3		3	
101	3		3	
102		tedious		
103	3		3	

Appendix IX c. Raw data collected on *PUR*

PUR	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
Respondent 1.		wind		
2		powder		
3				
4				
5	1			
6		children & finish		
7	2		2	
8				
9		2	2	alum
10	3			
11		powder & chemical		
12		chemical		
13		dirts not able to remove		
14		chemical		
15		chemical		
16	2		2	
17		chemical		
18	1		1	
19	1		1	Simple and prettier
20		finish & sometimes not availble		
21		finish		
22				
23			2	
24				mention that rural areas are more appropriate
25	2		2	
26		not convenient		
27	3		3	be able to clean dirt
28	1		3	dissolved
29	1			
30		chemical		
31	3	chemical		but since it remove dirt
32		finish		

Appendix IX c. continued

PUR	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
33	1			settled water but expensive
34	1		1	economical
35				
36	3		3	particles is desolved
37	1		1	
38	1		3	
39		expensive		
40				
41	1		2	good for when people travel
42	1			fast
43	1			faster
44	1		1	
45		chemical	3	
46		finish, easy to make measure mistake		
47	3		2	
48	2		2	
49		chemical		has known that the water using has chemicals in it, therefore, no more
50		children		
51				
52		chemical		
53				
54	1			
55	1		1	
56	3		3	most likely she will forget whether she has put it in or not
57		chemical		
58		no filter		
59	2		2	
60				
61	1		3	*outside tank and someone can open it

Appendix IX c. continued

PUR	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
62	1		1	drink tea in the morning, so it is easier to use
63		chemical		
64	2			
65	2		2	have polytank at home so that they can put it into water
66		chemical		
67	2			
68	2		2	
69		chemical		
70		chemical		
71	2			
72	2		2	
73	3		3	
74	1			
75		easy to forget		
76		chemical		&since settled, germs might still be there
77	1			easy to use
78		chemical		
79	2			
80	1			
81		chemical		
82	1		1	
83	2			
84		not necessary		
85	1		3	simple to use
86	3		3	
87	2			
88	1		3	health is more important
89		chemical		
90	2		2	
91		not enough (assume per package for water needed)		
92		chemical		

Appendix IX c. continued

93	3			
94				
95		hard to use		
96	2		2	
97	2		2	
98		finish & expensive		
99	1		2	
100		chemical		
101	1		1	
102		chemical		
103		not necessary in urban		

Appendix IX d. Raw data collected on *Life Straw Family*

Life Straw Family	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
Respondent 1.		wind	3	
2	2		3	
3				
4				
5		hard to use		
6	3		3	
7		children		
8	1	small	1	
9	1		1	
10		hard to use		
11	2		3	money
12	3		3	
13	2		3	
14	2		3	
15	3		3	
16		waste of time		
17	2			
18				
19				
20		small		
21	1		1	continuing coming
22	2		2	
23	2			
24	3		3	
25		complicated		
26				
27		small		
28		small		
29			2	
30	3		3	
31			3	
32	2		2	
33	3		2	
34				
35	2			
36		small		
37	3		3	
38		hard to use	1	based on his own calculation, he thought this has the best quality

Appendix IX d. continued

Life Straw Family	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
39	2		2	
40				
41	3		3	
42	3		2	
43	3		2	
44				
45	1		2	look like machine, seem faster
46	3		3	
47			2	
48	3		3	
49		small		
50	2		3	
51				
52	2		2	
53		small		
54	3	expensive	3	
55				
56				
57		small		can be used when travel
58		dirts remain in the filter	2	
59		small		
60				
61	3		1	
62		hard to use		
63	3		3	
64			2	
65				
66	3		3	
67		small		
68	3			
69	3		2	
70	3		3	* can travel with so that children can bring it to boarding school
71			2	
72				
73				

Appendix IX d. continued

Life Straw Family	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
74		small	2	
75	2		2	
76	1		3	
77				
78	1		1	might have a lot of good filter material inside
79	3			
80				
81	1		1	like the long tube design
82				
83			2	
84				
85		appearance		can only used in the house but not in the office
86				
87	1			
88		small		
89	3	waste of time	3	
90		small		
91		small		&children with play with it
92	3		3	
93		chilren		
94	2		2	
95		small		&children can spoil it
96	3		3	
97	3		3	for self use
98	2		3	easy to use when on bed
99	2		1	the price is more powerful
100		not appealing		
101		waste of time		
102	2	tedious	2	
103		not appealing		

Appendix IX e. Raw data collected on *Aquatabs*

Aquatabs	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
Respondent 1.	3			
2	1		1	
3	1		1	
4				
5	2		3	
6		finish		
7		children		
8		questionable for chlorine		
9		never heard		no alum in it
10	2	expensive		
11				
12		chemical		
13		settle		
14		chemical		
15		chemical		
16		chemical		
17			2	
18	2		2	
19	2		2	
20		finish		
21		finish		
22		no container		
23		tablet	3	
24		waste of time		
25	1		1	can use it for polytank and drum
26	3		3	
27		settle		
28	2		1	
29	2			
30				
31		settle & chemical		
32				
33		settle		
34	2		2	
35				
36		dissolve		
37				
38		settle		
39				convenient
40				

Appendix IX e. continued

Aquatabs	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
41	2			too cheap
42		dissolve		
43		settle		
44	2			
45		dissolve		
46		finish		
47		dissolve		
48		dissolve		
49		chemical		
50	1		1	easy to use
51				
52		chemical		
53				
54		dissolve		
55	2		2	
56	3		3	
57		chemical		
58				
59	1		1	used it before
60	2		2	affordable
61				suspect that one tablet can kill the bacteria, ways she described was more of a dissolve issue
62	2	dissolve	2	
63				
64		settle		
65	1		1	
66		chemical		
67	2			
68	2		1	cheaper
69		chemical		
70		chemical		
71	1			
72	1		1	use it at home now and wil not consider other products besides chemicals
73		settle		
74		settle		

Appendix IX e. continued

Aquatabs	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
75			3	cheaper
76		chemical		children might take it
77	2		2	
78		chemical		
79				
80	2			
81		chemical		
82		settle		
83		dissolve		
84		not necessary		
85	2			
86		settle		
87		settle		
88		settle		
89		chemical		
90		settle		
91			1	cheap
92		chemical		
93		settle	3	cheaper
94		not necessary		
95	3		3	
96		settle		
97		settle		
98				
99		dissolve		
100		chemical		
101		settle		
102		chemical		
103				

Appendix IX f. Raw data collected on *Kosim Deluxe*

Kosim Deluxe	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
Respondent 1.	2		2	
2	3			expensive
3			2	
4				
5	3		1	
6	1		1	look nice
7	1		1	convenient
8	2	children	2	
9		too fancy		
10	1		1	
11	1		1	
12	1		1	
13	1			expensive
14	1			
15	1		1	
16	1		1	good and must be healthy
17	1		1	
18				Large family!!
19		complicated		
20	1		1	big
21	3			
22	1		1	
23	1			expensive
24	1		1	portable, nice, etc. price should be down
25	3		3	nice design
26	2		2	serve the purpose that I need
27	2		2	
28		small		
29	3		1	presentable
30	2		2	
31	2		2	
32	3		3	
33	2		1	quality better than quantity
34		small		
35	1			
36	2		2	
37			2	

Appendix IX f. continued

Kosim Deluxe	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
38	3			
39	1		1	nice
40				
41			1	price = high quality
42	2		1	price = high quality
43			3	
44			3	
45	3		1	
46	1			simple but too small
47	2		1	** typical price switch case
48	1		1	
49	1		1	reluctant to choose the 3rd choice, and the top choices are both *Kosim*
50	3		2	good quality and she can afford it
51				
52	1	small	1	
53	1		1	
54	2		1	
55				
56	2		2	
57	2		2	price does not matter but health is more important
58	2		1	
59				price is a little bit high
60	1		1	the lid is well closed and easy to use
61	2		2	
62	3		3	price does not matter
63	1		1	quality is good

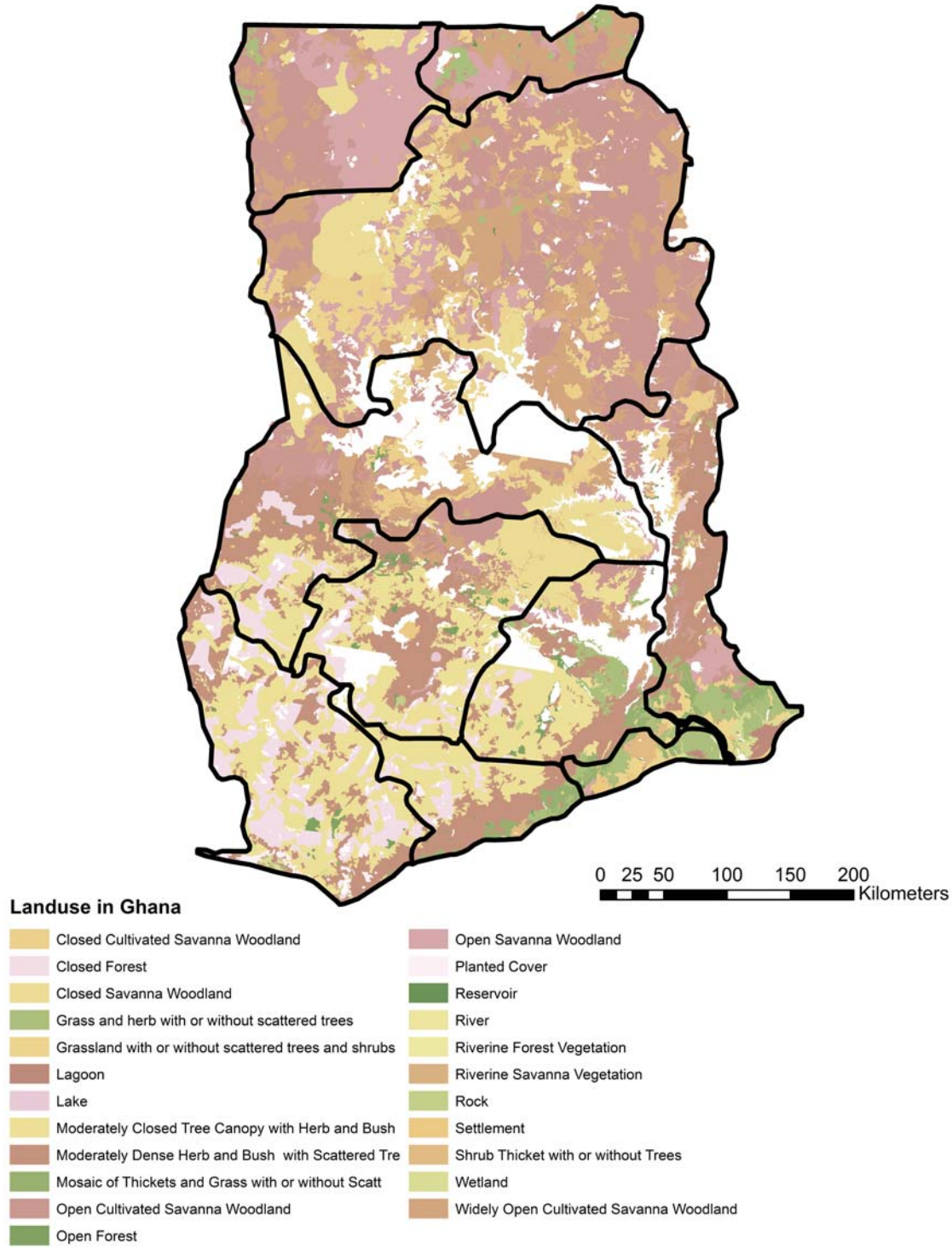
Appendix IX f. continued

Kosim Deluxe	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
64	1		1	price does not matter
65				might feel the taste of clay, so does not like it
66	1		1	price does not matter
67	1		1	
68	1		3	
69	2		3	price is a little bit high
70	2		2	big and price is ok, quality is more important
71		easy to break		price is not more important here
72				
73	2		2	price is not a problem when you can afford
74	2		1	price = quality
75				too expensive
76	2		2	*if have money then it will be a first choice
77			3	quality
78	2		2	
79				
80	3			
81	3		3	
82	3		3	be able to keep more water but it is too expensive
83	3		1	higher price
84	1		1	
85				
86	2		1	
87	3		1	
88	3		2	have the quality but it's too expensive

Appendix IX f. continued

Kosim Deluxe	Your Top 3 choices?	What concern you the most?	The price is listed now, please re-rank?	Reason of re-rank
89	1		1	depends on the duration but price does not matter
90	3			simple to use but its too expensive
91	2		3	expensive
92	1		1	price is ok & it is simple to use
93	1		2	price
94	3	easy to break	3	price
95	2		2	Easy to use and price is too high
96		small		
97		slow		
98	1		1	the material is nice
99	3			too expensive
100	1		1	
101		waste of time		
102	1		1	price is ok
103	2	small	2	price is ok

Appendix X. Types of vegetation cover in Ghana (Note: areas displayed as white is either water body or the types of vegetation are unknown). Data comes from National Renewable Energy Lab (NREL)[102].



[102] Data is extracted from NREL using QGIS. Online access on June 30th, 2012: http://www.nrel.gov/international/geospatial_toolkits.html

Appendix XI- a. Handouts for *Kosim Classic* and *Kosim Deluxe* promotion

Appendix XI- b. Handouts for *Aquatab* and *CrystalPur™/Tulip Siphon Water Filter* promotion.

OTHER SALES

Sweet Home, Healthy Life, Drink Pure Water

- Convenient for travelers
- Compatible with water tank/buckets

¢20 GHC

- Instant clean water
- Perfect for small family

¢60 GHC

Appendix XII. Brochures for six different products (*Aquatab, PUR, Kosim Classic, Lifestraw Family, CrystalPur™/Tulip Siphon Water Filter* and *Kosim Deluxe)*. Brochure was initially created by Xi Chen (MIT student) and the content was modified by the author.

Aquatabs

Technology Description

Aquatabs are water purification tablets. They are used to self-disinfect water at the point-of-use at the household level. For every 20 liters of clear water, one 67mg Aquatab should be added. When added to water, they release the active ingredient sodium dichloroisocyanurate (NaDCC), which kills most of the microorganisms in water. Aquatabs help prevent diseases such as chlora, typhoid, dysentery and other water-borne disease.

Advantages

- Convenient to carry around
- Reduction of most bacteria and viruses
- Provides a chlorine residual that is easily monitored to indicate success
- 1 tablet = 10 L of clean water
- Suitable to disinfect water during outdoor events, i.e., camping

Contact Information

- Contact Karim: 020 899 0190 (Mobile) alalekarim@yahoo.com (E-mail)
- Address: Pure Home Water - Ghana, PO Box TL2661, Tamale, Ghana

PUR

Technology Description

The PUR packet is a powdered mixture that removes pathogenic microorganisms and large particles. It also removes some metal (arsenic, lead, other), pesticides such as DDT and other organic chemicals. A single sachet of PUR quickly turns 10 liters of dirty, potentially deadly water into clean and drinkable water.

Advantage

- Clinically proven. About equal health protection as chlorine disinfection alone;
- Can precipitate metals and remove some organic chemicals
- Measurable chlorine residual allows and easy way to monitor use
- Simple to use and convenient to carry around
- 1 packet = 10 Liter of clean water
- Applicable for emergency water need

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    - Address: Pure Home Water - Ghana, PO Box TL2661, Tamale, Ghana

Kosim Classic Ceramic Filter

Technology Description

The Kosim filter is a ceramic filter manufactured in Ghana. The filter unit consists of a fired clay pot filter element, a plastic bucket storage unit with a tap, and a cover. The filter allows water to pass through the pores while removing contaminants such as bacteria, protozoa, guinea worm cyclops and large particles. The filter element is also treated with colloidal silver which may act as a bactericide and viricide. The newest *Kosim Classic* can treat 4-6 Liters of water per hour. *Kosim Classic* is an economical choice for rural and peri-urban areas family.

Advantages

- Clarifies turbid water and makes it look clear and clean
- Water is collected directly from the safe storage receptacle (for free!) for use
- Equipped with a spigot to prevent recontamination
- Replacement for parts are available locally
- 1 *Kosim Classic* filter = 3 years of clean drinking water

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- Address: Pure Home Water - Ghana, PO Box TL2661, Tamale, Ghana

Lifestraw® Family

Technology Description

Lifestraw® Family is a microbiological purifier that allows people to have stable and reliable source of water for home consumption. The capillary membrane within the purifier contains millions of micro pores which allow clean and safe water to pass through, while trapping contaminants in the membranes. It effectively removes particles, bacteria, viruses and parasites. The flow rate of Lifestraw® Family is about 10 liters/hour. Each unit is capable of filtering up to 18,000 liters of water, which is enough to provide a typical family of five up to three years worth of clean and safe water.

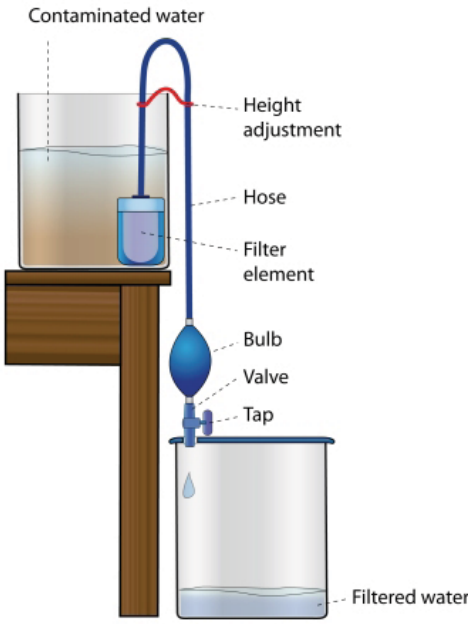
Advantages

- Simple to use and easy to maintain
- Water looks and tastes good
- Long life requiring minimum spare parts
- Easier for children to use
- No chemical needs to be added to the filter to make it work effectively
- Easy to maintain and clean

Contact Information

- Contact Karim: 020 899 0190 (Mobile) alalekarim@yahoo.com (E-mail)
- Address: Pure Home Water - Ghana, PO Box TL2661, Tamale, Ghana

CrystalPur/Tulip Siphon Water Filter



Technology Description
The Tulip Siphon Water Filter is a unique ceramic filter used to remove sediments, bacteria and protozoa to purify water. Place the filter element in a container with contaminated water and squeeze the siphon. The siphon pressure forces water through a high-quality ceramic filter element. The flow rate of the filter is 4 -5 liters/hour.

Advantages

- User friendly, easy to maintain with patented backwash system
- Small, light weight, portable
- Sensor included to show when the filter element should be replaced
- Clean water directly in storage pot

Contact Information

- Contact Karim: 020 899 0190 (Mobile) alalekarim@yahoo.com (E-mail)
- Address: Pure Home Water - Ghana, PO Box TL2661, Tamale, Ghana

Kosim Deluxe Ceramic Pot Filter

Technology Description
The *Kosim Deluxe* filter consists of a fired clay pot filter element, a plastic bucket storage unit with a tap, and a cover. The filter allows water to pass through the pores while removing contaminants such as bacteria, protozoa, guinea worm cyclops and large particles. The filter element is also treated with colloidal silver which may act as a bactericide and viricide. The newest *Kosim Deluxe* can treat 4-6 Liters of water per hour and it is effective to filter any dirt and bad microorganisms in municipal water. Following the U.S. drinking water standard, *Kosim Deluxe* is designed specifically for people who pursue high water quality and life style.

Advantages

- Water is clear, clean and tastes great
- Further improve municipal water quality by physical water treatment
- Equipped with a spigot to prevent recontamination
- *Kosim Deluxe* series provides high-end filters for urban settings, i.e., offices, etc.
- Ideal for filtering Ghana Water Company tap water
- 1 *Kosim Deluxe* filter = 3 years of clean drinking water

Contact Information
- Contact Karim: 020 899 0190 (Mobile) alalekarim@yahoo.com (E-mail)
- Address: Pure Home Water - Ghana, PO Box TL2661, Tamale, Ghana