Viable Alternatives to Unsustainable Household Fuel Supply Sources; the Case of the West Gonja District in Ghana



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Preface

This report is the masters dissertation of Felix Kwabena Donkor, conducted in the spring of 2013 at Aalborg University, Denmark. The study is composed of pages, comprising the core research project, references, lists of acronyms; tables and figures, four appendices and five Microsoft Excel files on a CD ROM. The objective is to provide relevant stakeholders viz; Tertiary Institutions, Government Agencies and local Non-Governmental Organizations (NGO) with concrete information useful for the design of improved cooking technology as a social intervention. The results will also help to design robust public education/awareness creation to influence people's choices for better fuel alternatives. This project concept draws parallels with Millennium development goals of eradicating extreme poverty and hunger (1), promoting gender equality and empowering women (3), ensuring environmental sustainability (7), and developing a global partnership for development (8). Furthermore it echoes themes of the post-2015 Development Agenda of the United Nations and government of Ghana's aim to increase access to clean fuels.

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Abstract

Cooking is a daily activity often based on energy to satisfy man's natural urge for nutrition. Wood fuels (charcoal and fuelwood) are the main source of fuel in rural areas of Ghana, however it comes with detrimental health, environmental and other livelihood effects. The study consequently sought to examine how the current heavy dependence on woodfuels can be reversed with cleaner options using local materials. A combination of qualitative and quantitative methods was used to undertake the research premised in the West Gonja District of Ghana. The case study approach was complemented with Rapid Rural Appraisal (RRA) techniques to gather data from key informants, households and group discussion with school kids. Information was fished from literature such as ; Mole National Park Management Plan; The District Assembly Medium Term development Plan of the West Gonja District Assembly; Ghana Country Policy on Energy; Sustainable Energy Action for All Small is Beautiful by Schumacher, Qualitative Research Methods by Kvale and Brinkmann, Rural Livelihoods and Diversity in developing Countries by Frank Ellis. Meaning condensation was used for data analysis within the context of the sustainable livelihood framework and the appropriate technology theory. The use of woodfuels is having a negative impact on critical rural resources such as labour, land, health and education and thus threatening livelihoods in the case study area. There is a high willingness amongst rural households to shift to modern fuels whilst key informants surmise that the current heavy dependence on woodfuels is reversible. This calls for concerted action at the individual, government and the private sector levels. Education, alternative livelihoods and improved rural infrastructure will serve as catalyst to making the shift to modern fuels a reality. Public private collaboration (PPC) is needed to make clean fuels accessible (financial and physical) to the rural populations and help enhance their livelihoods.

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I am pregnant with gratitude for the love and support of my family, Frank Godwin Donkor, Dina Merley Teitopey and Juliet Donkor.

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Words cannot express my gratitude to God for seeing me through my education successfully. Ebenezer! My appreciation and praise to is encapsulated in Psalm 146!

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List of Acronyms

AAU	Aalborg University
ALRI	Acute lower respiratory infection
BC	Black Carbon
CBD	Convention on Biodiversity
CDM	Clean Development Mechanism
CMS	Convention on Migratory Species
DFID	Department for International Development
GACC	Global Alliance for Clean Cookstoves
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
HDI	Human Development Index
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
IFAD	International Fund for Agricultural Development
IAEE	International Association of Energy Economics
IEA	International Energy Agency
MEA	Millennium Ecosystem Assessment
MDG	Millennium Development Goals
MOFA	Ministry of Food and Agriculture
MPMP	Mole Park Management Plan
NGO	Non Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
PM	Particulate Matter
RRA	Rapid Rural Appraisal
SE4ALL	Sustainable Energy for All
SNEP	Strategic Energy Plan
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan African
RI/EM	Relief International/Enterprise Works
TUHH	Technische Universität Hamburg
UN	United Nations
UNEP	United Nations Environmental Programme
USEPA	United States Environmental Protection Agency

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Chapter 1.0 INTRODUCTION

1.1 Biodiversity, livelihood and wellbeing

Biodiversity is an invaluable resource endowment vital for man's socio-economic progress. The importance of this fragile resource suggests that its biological integrity be preserved for the benefit of posterity; however the pressure on species and ecosystems in contemporary times is such that it calls for urgent redress (CBD, 2012).

Biodiversity is a core ingredient of a healthy environment, providing the basis for ecosystems and the services they offer to promote life on earth (UNEP 2005).The tangible (eg food) and intangible (eg decomposition), roles of biodiversity are so critical, to the extent that people's livelihoods are inextricably reliant on it. Often economically disadvantaged people are at the peril of ecosystem degradation as they bear the brunt of such fluctuations due to their dependence on ecosystem services and living in areas most vulnerable to ecosystem changes (UNEP, 2005).

Furthermore, biodiversity is not limited to supplying material welfare and livelihoods but also embraces security, resilience, social relations, health, freedoms and choices (MEA 2005). Thus biodiversity coupled with its ecosystem services is a core factor in ensuring human well-being. Consequently, biodiversity loss as well as the deterioration in ecosystem services are directly or indirectly associated with ; '— *worsening health, higher food insecurity, increasing vulnerability, lower material wealth, worsening social relations, and less freedom for choice and action.*' (MEA, 2005).

Scientists like Paul Crutzen and Will Steffen suggest the industrial revolution has ushered humanity into the *Anthropocene* epoch. This is where anthropogenic activities have assumed a role as key change agents of the Earth system (Rockström et al.,2009). Such sustained pressure from anthropogenic factors on the planet's biophysical systems may serve as a destabilizing catalyst and result in irreparable damages to the environment. Thus from the perspective of Planetary thresholds and boundaries, the limit value for biodiversity loss has already been crossed by man. One remedial approach is to make conservation alluring from both the cultural and economic perspectives (UNEP 2005; UNEP-CMS,2012).

Global consensus is necessary and important to halting biodiversity loss and consequently ensuring environmental sustainability as exemplified in the Millennium Development Goals (MDG's) and echoed in the post-2015 Development Agenda of the United Nations. However, strengthening individual national institutions and rolling out appropriate robust programmes is equally imperative and has a cumulative impact vis à vis the global agenda (UN,2013).

There is immense pressure on biological resources to satisfy the growing socio-economic needs of man. Energy is one of such pressing needs with its attendant demands on biological resources.

1.2 Biological Resources and Energy

Elementary Physics denotes *Energy* as the ability to do work. However in the socio-economic domain, energy is a unique good vital for individual wellbeing. According to Goldemberg et al (2004), human wellbeing as calculated per the Human Development Index (HDI), rises with increased access to modern energy services. It is notable that the HDI rise is especially high per availability of modern energy to meet fundamental needs such as cooking and heating, for which demand is inelastic as cooking and boiling water are vital for survival (Goldemberg et al,2004).

Consequently,in recent times there has been heightened awareness of the critical role of energy in the life of the world's impoverished- especially the over 2.7 billion people reliant on fuel wood, charcoal,agricultural waste and animal dung to meet their daily needs for cooking (Goldemberg et al,2004). The lack of access to modern energy services is a threat to sustainable development. Thus Energy and Poverty has been a core theme at several fora such as the International Association of Energy Economics (IAEE) and the post 2015 development agenda of the United Nations(ibid).

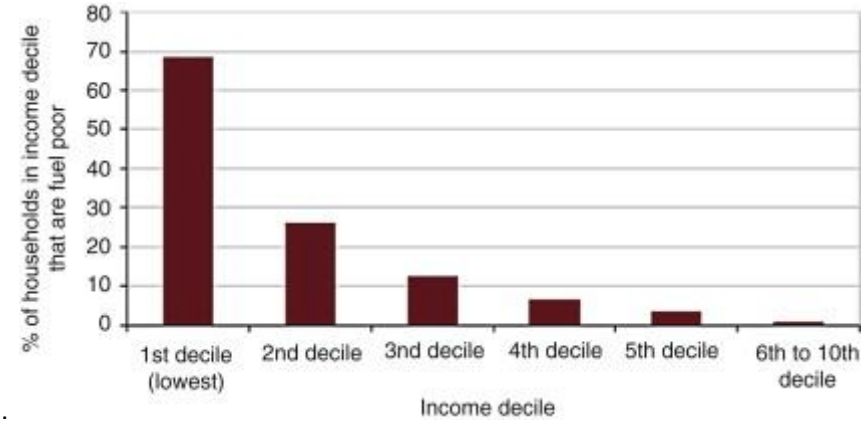
1.3 Energy Poverty

Energy/fuel poverty is the situation whereby a household is unable to pay for all the adequate energy needs on their current income. The low energy efficiency of the home and its energy based devices is the root cause of fuel poverty and also its antidote (Boardman 2012).

Fuel poverty came to the fore as a social concern in many parts of the world following the oil crisis in 1973–74. In the United Kingdom for example it led to The Warm Homes and Energy Conservation Act 2000, which sought to eliminate fuel poverty by 2016 (Boardman 2012). Jan (2012) observes that in the 1970's there was only 15% use of modern energy use in rural areas of developing countries. Consequently, state led programmes were rolled out in countries such as China (Qiu et al,1996), India (Bansal et al,2013) and Brazil (Goldemberg et al,2004) amongst others to address this challenge.

The term fuel poverty connotes causal factors such as high fuel prices and low incomes. Though there is a significant correlation between poverty and fuel poverty (highlighted in Figure 1), the two are not synonymous concepts: financial investments are vital to eradicating the latter, but not the former (Boardman 2012).

Fig.1.1 Income levels and Fuel Poverty



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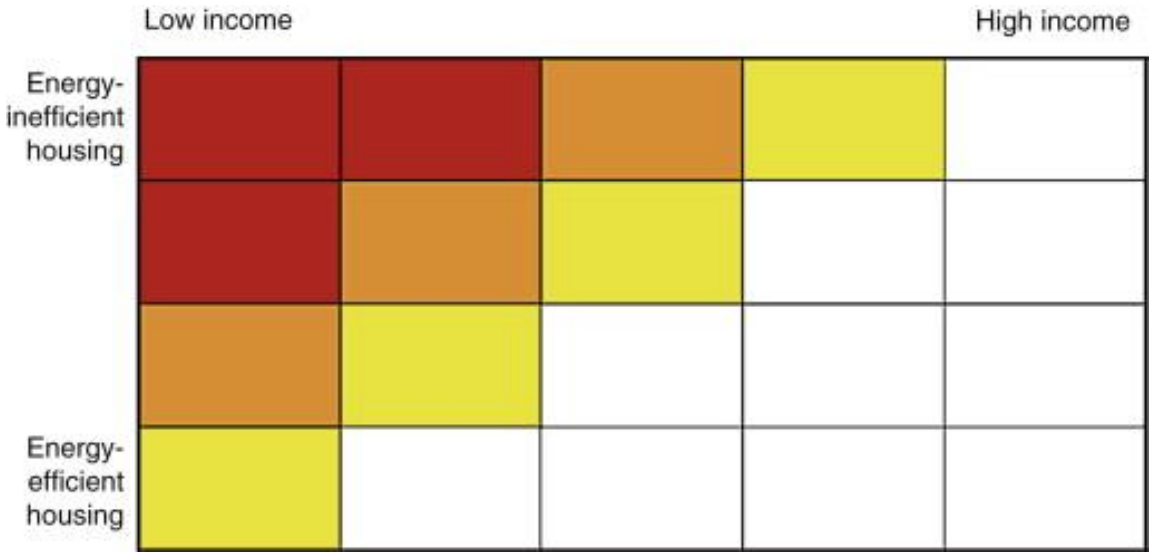
Source : Boardman 2010

Fig.1 highlights the relationship between income levels and the use of fuels. People with low incomes tend to lack adequate fuel resources and vice versa.

The key factor is the low energy efficiency of the household: a household with low income which utilises energy-efficient devices might escape fuel poverty; however a household with a similar income, but using very low efficient devices is prone to fuel poverty as illustrated in Figure 2.

Fig1. 2 Level of income and Use of energy efficient devices



Source: Boardman (2010)

Fig.2 further details the relationship between the use of energy efficient devices in a household and income level. Use of in-efficent energy devices corresponds with low household income levels.

1.3.1 Addressing Fuel Poverty in Ghana

The Ghana Strategic Energy Plan - SNEP (2006 – 2020) is a national energy roadmap which steers the country's energy programme. It provides an overall outlook of the nation's energy options and how to utilise them efficiently for sustainable development. The SNEP also offers opportunities for production of a feasible local industry to provide components and systems locally for the energy sector to enhance savings and ensure long term survival of projects (Ghana Gov.2011).

According to Jan (2012) though the highest need for improved cooking technology is in the rural areas of Africa, improved cooking stoves for example have not registered impressive results (Jan,2012). In addition, the Global Alliance for Clean Cookstoves (2012) opines that cost and versatility may be amongst the prime reasons why people in the rural areas of Ghana still rely on woodfuel despite measures at promoting other options.

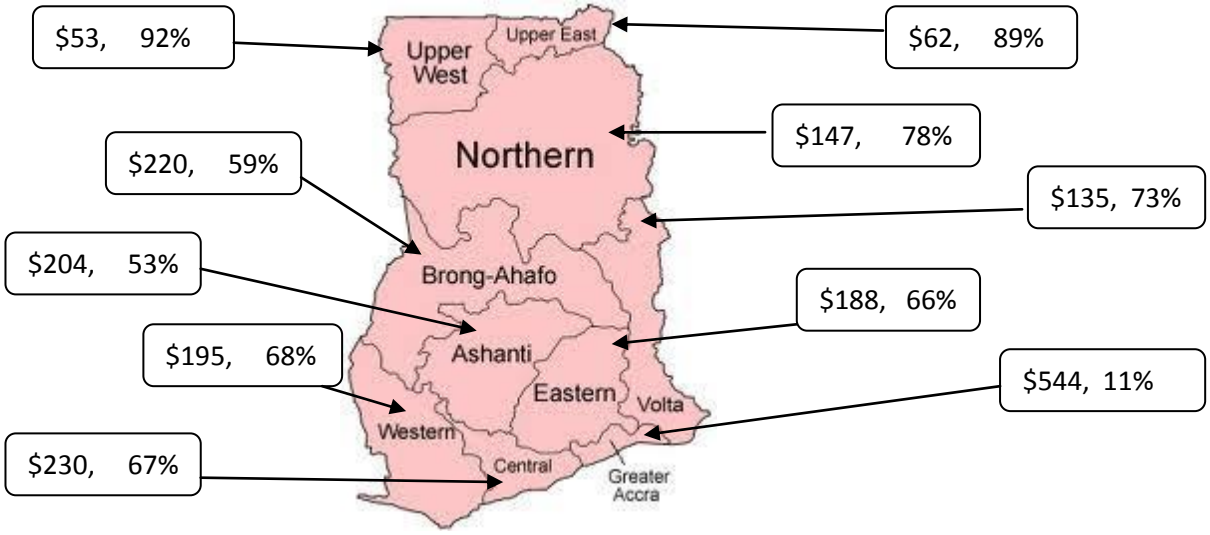
Thus in the West Gonja District for example, the use of woodfuels is very widespread. The Management Plan of the Mole National Park (2011), suggests that high population growth rate coupled with scarce energy sources has fuelled encroachment into the nature reserve for the purpose of harvesting wood for fuel. Poor employment conditions also has led more people to turn to wood harvesting for fuel as a means of livelihood which further aggravates the situation (Management Plan,2011). This is one of the reasons why this project is focused in this area as a *case study*.

The phenomenon of fuel poverty is also partly due to the fact that low-income households are unable to save money to invest in more energy efficient devices (Boardman 2012). This is to say that, there is a high corrrelation between increasing income levels and the adoption of clean energy alternatives by households. Thus when household income rises, then people are more likely to switch to modern substitutes. This forms the basis for the *fuel ladder* concept whereby there is a direct correlation between household income and the adoption of clean cooking technology (Boardman2012).

The Energy Transition Theory: this theory postulates that as the income of a household rises coupled with the economic development of individuals and nations, people's energy preferences will transform '*up an energy ladder from the "inferior" biomass fuels through charcoal – the "transition fuel" – to modern cleaner alternatives including LPG, kerosene, and electricity'* (Zulu and Richardso 2013).

Goldemberg (2004) illustrates it schematically in terms of increasing efficiency as follows:
dung/crop residues→fuelwood→charcoal→kerosene →LPG/natural gas/electricity.

Fig.1.3 Proportion of Rural Residents in Regions and Mean Annual Income in Ghana



Source: Adapted from Clean Cookstoves (2012)

Fig.3 shows that the three northern regions with exception of volta,have high rural populations. In Ghana, rural areas are markedly poorer than urban regions. Regions with high proportions of rural residents have low incomes and are associated with significant use of woodfuels (Zhou et al,2011). Consequently, the northern regions in general depend highly on the use of fuelwood compared to other parts of the country (Energy Commission 2012; GACC, 2012). The idea of people changing their choices of fuel for better ones due to enhanced income also has other background factors at play which influence choice of fuel.

Fuel Preferences**:** firewood has seen the most widespread use for cooking in many African nations inspite of the health impact and poor efficiency. This could be due to it being *free* as it is gathered and not bought. Sometimes the desired taste of a food may be attributed to a type of fuel and thus hamper the acceptance of a new cooking technology which may not meet their customs and preferences. Karekezi and Kithyoma(2002) allude to a village in Sierra Leone, where households are stuck to firewood usage because of '*food tastes, safety and the wider range of cooking methods that are possible with an open fire*'.

Apkalu et al (2011) also posit that the usage of biomass energy follows a dynamic sequence, because it reacts to factors such as price fluctuation and accessibility to other fuel types. Furthermore though biodiversity and ecosystems service loss due to deforestation has become a matter of urgency, people hardly internalise forest loss externalities at the grassroots (Apkalu et al 2011). Studies on improved cooking technology have shown for example, that upon the introduction of a new stove, it may not be utilised because as opposed to the traditional stove or three stone fire for example, it has low flexibility vis à vis '*size of pot, size of fuel, or type of fuel'* (Bowen & Levine,2012). Moreover, a new stove may be sited wrongly, or its fuel preparation may be cumbersome (Bowen & Levine,2012).

Increasing populations coupled with inaccessibility to modern energy sources have fuelled the increasing demand for wood fuels and help create a ready market for this commodity.

1.3.2 Energy for Livelihood

Energy is important for ensuring a robust and competitive economy (Martinez-Val, 2013). Hence, energy security is a priority of every nation as it helps stimulate economic growth and has implications for sustainable development à la Brundtland Commission, if it is efficiently used and managed (Omer,2008). However woodfuels usage has been environmentally detrimental and unsustainable (Afrane & Ntiamoah,2012).

In Sub-Saharan African (SSA) nations, woodfuel apart from being a primary energy source is also an important contributor to the country's energy balances, a significant source of household income, and able to power economic growth while limiting the reliance of poor developing nations on expensive energy imports (Zulu and Richardso 2013).

Fig1.4 Consumption Rates of Woodfuel

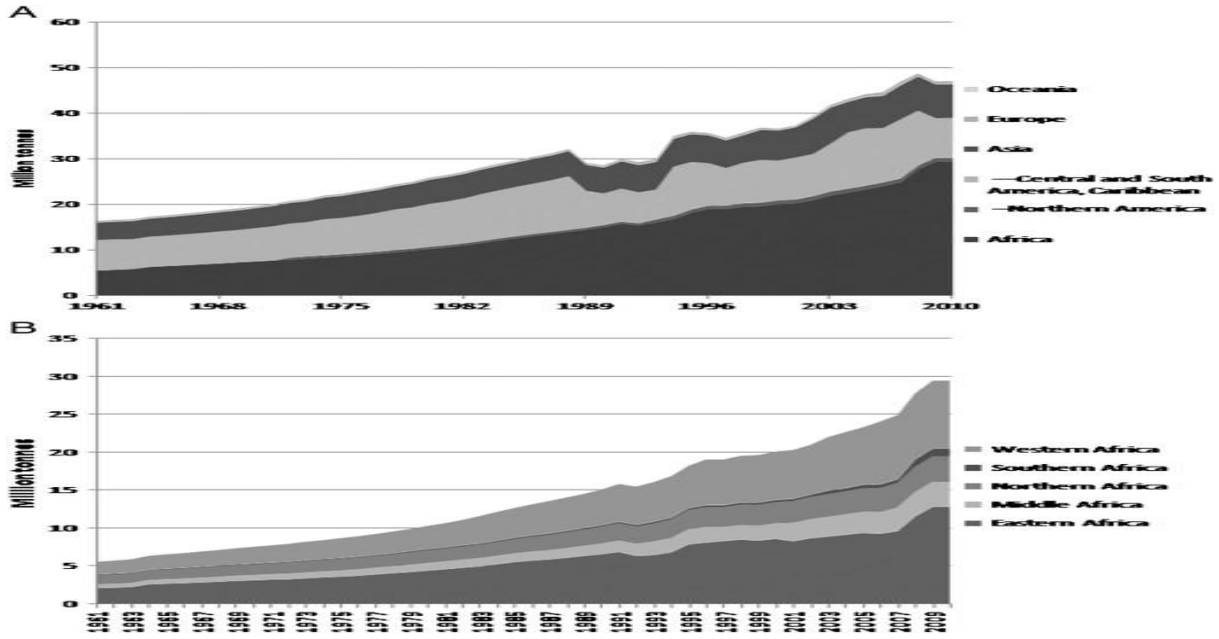


Fig. 1. A. Charcoal production by region of the world: 1961–2010 (millions of tons) B. Charcoal production by region of Africa: 1961–2010 (millions of tons). Source : (Zulu and Richardso 2013)

Woodfuels represent an important productive sector in several economies of SSA countries and help in poverty reduction through national development (eg tax on charcoal), employment, and household income earnings (Zulu and Richardso 2013).

Woodfuels supplied 3.5% of Malawi's Gross Domestic Product (GDP) and 120,000–140,000 in direct employment in 2008. Also charcoal was a single contributor of $650 million to Tanzania's economy, 5.8 times the total worth of coffee and tea production, and the sector supplied income to many

hundred thousands of households in both urban and rural areas (Zulu and Richardso 2013). In 2007, a total of $573,000 worth of charcoal was exported by private Ghanaian ventures to markets in Europe (such as Germany and Turkey) and other parts of the world (Appiah,2013).

The consumption of charcoal in Africa is projected to rise significantly at a faster rate compared to other parts of the world (Fig. 1A), doubling by 2030 versus a 24% rise for firewood. However despite the monetary gains expected to accrue from woodfuel use, the associated negative environmental and health impacts outweigh the benefits in the long run making it unsustainable. The Energy Commission of Ghana thus posits a need to *'ensure sustainable production, marketing and consumption of woodfuels*' (Energy Commission,2006 pg 108).

1.3.3 Energy and Daily Life

Cooking is a daily routine in the life of man to satisfy hunger and enhance wellbeing. Cooking is associated with energy and biomass is a chief source of this energy (WHO,2006). Hence energy is vital to satisfying the most fundamental needs of man be it: cooking, boiling water, lighting and heating. It is also a requisite for good health (WHO,2006). Whilst cooking may represent a pleasurable pastime on an electric oven or a gas stove in some places; it is also a hazardous chore to the lives of many as an open fire in poorly ventilated enclosure. (WHO,2006).

Use of Biomass: it is estimated that 52% of the global population depends on solid fuels to satisfy their vital energy requirements (International Energy Agency (IEA) and Organisation for Economic Cooperation and Development (OECD) 2004). Thus the map of worldwide solid fuel usage is aggregated as follows; from 77% in Sub-Saharan Africa; 74% in Southeast Asia as well as the Western Pacific Region; 74% in the Eastern Mediterranean Region, Latin America and Caribbean / Central/ Eastern Europe have 36% and 16% respectively (Rehfuess et al 2006). Cook et al (2008), infer that the fuel wood condition in developing countries since the 1970s could be described as *desperate* as the usage of wood for fuel has generally been above the recovery rate of the natural forest. Although several interventions to salvage the fuel wood situation have registered unimpressive results; the issue of fuel wood scarcity continues to be a top priority at the household level of several developing countries (Cook et al, 2008).

1.4 The Socio-economic Impacts

Energy though useful, poses several environmental challenges in contemporary society such as heightened number of pollutants, hazards and ecosystem degradation. These represent a challenge to the global sustainable development agenda (Dincer,1999) and therefore, calls for proactive measures to address them.

1.4.1 Human Health

The ineffective combustion of solid fuels on open fire or traditional stove indoors produces a harmful cocktail *of 'pollutants, primarily carbon monoxide and small particles, but also nitrogen oxides, benzene, butadiene, formaldehyde, polyaromatic hydrocarbons and many other health-damaging chemicals' (*WHO,2006).

WHO (2006), indicates that each day, women and their small children inhale smoke volumes equivalent to approximately a double cigarette pack for significant hours. Acute lower respiratory infection (ALRI) and obstructive lung diseases have been observed in children and adults respectively as the product of indoor air pollution in Ghana and Kenya (Ezzati et al., 2000). In addition, projections indicate that about 2.44 million deaths in developing nations are due to the negative impact of biomass indoor particle air pollution. Probably as a consequence of poor ventilation and the incomplete burning of biomass and other fuels utilized to satisfy household cooking demands (Apkalu et al 2011).

The lack of a ready alternative represents a serious dilemma to such households. Furthermore, the incomplete combustion of biomass produces black carbon (BC) which is the most light-absorbing constituent of particulate matter (PM). BC, a chief component of soot; is the most efficient form of PM by mass and is introduced as fine particles ($PM_{2.5}$) into the atmosphere (US EPA,2013).This phenomenon referred to as *particle pollution* includes "fine particles" emanating from smoke which are 2.5 micrometers in diameter and smaller. In Africa, lower respiratory infections (ALRI) are responsible for 11.2% of the overall disease burden on the continent, second only to HIV/AIDS (World Health Organization, 2008, Penisse et al,2009). Unduly exposing oneself to solid fuels increases the of risk of ALRI by 1.8 (Dherani et al., 2008).

1.4.2 Climate Change

Forests help control carbon dioxide levels in the atmosphere as they limit the impact of climate change due to greenhouse gases. BC due to incomplete fuel combustion is also a factor in a number of climate impacts, such as augmented temperatures and ice and snow melt (US EPA, 2013). Though there are other contributing factors to the *greenhouse effect* CO_2 alone is associated with 50% to the anthropogenic greenhouse effect (US EPA,2013). Increasing surface temperatures associated with CO_2 has several implications for human survival and wellbeing such as '*flooding of coastal settlements, a displacement of fertile zones for agriculture and food production toward higher latitudes, and a decreasing availability of fresh water for irrigation and other essential uses'* (Dincer,1999; US EPA,2013).

Realising such equilibrium between economic growth and emissions abatement entails the adoption of robust domestic policies tailored at enhancing the efficiency of energy use and facilitating fuel substitution (Dincer,1999).

1.4.3 Ozone Layer Depletion

Stratospheric ozone serves as a buffer to maintaining suitable temperatures on the planet by, absorbing ultraviolet (UV) radiation and absorbing infrared radiation (US EPA,2003). The destruction of this delicate ozone layer is due to the release of CFCs, halons and NO_x. When the ozone layer is depleted, there is the risk of high levels of dangerous UV radiation having effect on the ground expressed as high levels of skin cancer, eye/sight problems and degradation of ecosystems. Release of NO_x into the atmosphere due to biomass and fossil fuel burning amongst others are key causes of this phenomenon (US EPA, 2003).

1.4.4 Women empowerment

The time and energy invested in searching for fuel is one of urgent concern. These invaluable resources could be better invested in other fruitful ventures which could earn income and thus enhance their livelihoods. Over a billion of the world's females (women and girls) are reliant on solid fuel for satisfying basic home needs. The opportunity to rise above poverty is compromised for such people due to solid fuel dependency. Such women aided by their children use laborious hours each day in search of fuel. Furthermore, after covering long distances to find and gather fuel, they have to carry these heavy loads to cook on crude and inefficient stoves. This situation worsens the fuel collection task (Goldemberg et al,2004). Parikh (2011) observes that in the Himachal Pradesh area of India, women trek 30 km monthly taking 2.7 h per trip to gather fuel wood often navigating very difficult terrain. Furthermore they experience '*stress like stiff-neck, backache, headache and loss of work days*'.

Goldemberg et al (2004), argue that though fuel wood is deemed to be *free*, in reality it is *not free* but rather *non-monetised*. This is due to the reason that no value is given to the labour of the women and children in collecting wood fuel. Furthermore, if the negative health impacts were also internalised, then solid fuel would be extremely expensive.Also the producers and traders (mostly women) are often exploited by middlemen who give them a pittance for their effort but go on to sell their produce at very prices (Zulu and Richardso 2013).

1.4.5 Achieving Universal Child Basic Education

Education is crucial to poverty alleviation. However, often the family requirement of fuelwood collection in poor rural communities depends on school kids.This affects their attendance and performance at school. Therefore, the accessibility to improved cooking technology will relieve such children of the burdens of fuelwood collection so they fully enjoy their right to education. This is an effective avenue for breaking the cycle of poverty (Goldemberg et al,2004).

1.4.6 Environmental Degradation

The search for biomass as fuel has left several green areas naked. Consequently deforestation is a major driver for land degradation and desertification and is facilitated by the harvesting of wood for fuel. Present rate of consumption in Ghana suggest an individual utilizes circa 640 kg of wood fuel annually (Apkalu et al 2011). Wood fuel especially charcoal remains an important aspect of rural life in Ghana and many parts of Africa. Previously most wood supply for charcoal production was from off-reserve sources but increasingly, the forest reserves are also being exploited for illegal charcoal production. Though wood as biomass is deemed a renewable energy source, the rate of forest growth in Ghana is below half of wood fuel demand which means wood fuel is an unsustainable energy option (Apkalu et al 2011). The situation becomes even direr as only 975,000 ha of the forest reserve and off-reserve area are left in Ghana (Mann et al., 2010). The loss of soil cover leads to soil erosion and consequently low agricultural productivity (Zulu and Richardso 2013).

1.4.6 Non-Human Stakeholders

Fauna populations have also been at the brunt of this deforestation. Habitat loss and fragmentation are amongst a litany of challenges confronting the conservation of fauna in recent times due to the onslaught of tree harvest for fuel. Animals with specialised requirements such as migrant species are hence in direr predicaments as the biological integrity of niches are compromised. This situation increases the risk of animal species becoming extinct around the globe (CMS,2011).

A myriad of external factors to the energy sector influence energy production and expenditure in both developed and developing states. Some of these drivers are '*population growth, economic performance, consumer tastes and technological developments'*. These factors coupled with state policies related to the energy sector and developments in the global energy markets shape the dynamics of energy production and consumption (Dincer,1999).

1.5 Problem Formulation

Scarce source of firewood has translated into increased charcoal prices and this situation attracts forest fringe communities into nature reserves. This results in unsustainable levels of tree harvest which degrades biodiversity in these reserves. Consequently, the ecosystem services essential for sustaining the agriculture which more than 60% of the rural population in Ghana and across Africa depend on is destroyed. Ecosystem services such as pollination, soil cover against erosion, disease regulation, pest regulation, natural hazard regulation; are essential for sustaining rural livelihoods (MEA,2005).

The increased demand for fuelwood is due to its low combustion efficiency coupled with population pressure. In a quest to reduce this demand and its resultant pressure on nature, a myriad of efficient cooking technologies suitable to the local environment need to be explored. Consequently, improved

cooking technology has attracted immense attention as a means of doing barter with carbon offsets à la Clean Development Mechanism (CDM) of the Kyoto Protocol (Jan,2012). Novozymes, a Danish biotech company through its *CleanStar Mozambique* programme has substituted traditional cookstoves with gas stoves and supplied *'clean, safe and affordable cooking fuel solution that enables urban families to shift away from deforestation-based charcoal'* (Pederssen,2013). This initiative is inspired by the CDM and helps in preserving Africa's forests which are an important global sink, absorbing 5% of all carbon dioxide emissions(Novozymes,2013).

1.5.1Main Research Question

How can charcoal as a basic source of household fuel be fully or partly replaced; and what materials in the study area are available for developing alternatives?

1.5.2 Sub-questions

Why do people prefer a particular fuel and how could the preferences be directed towards more eco-friendly alternatives?

What can the private sector do to complement Government effort to ensure the supply of eco-friendly alternatives?

1.5.3 Research Delimitation

Due to time and resource constraints, the study focuses on the most salient themes related to the research question. Consequently:

- Though there have been several initiatives from Government and private companies at shifting peoples preferences from woodfuels to modern fuels in Ghana, this study is focused on the views of rural households and key informants on making this shift a reality.
- The research does not go into the technical details of the alternative fuel options mentioned in the study
- Macro and micro policies which have direct bearing on the availability of modern fuels are not treated in detail.

The research design is mainly based on the qualitative approach using the case study approach and complemented with quantitative methods. In addition, the Sustainable Livelihood Approach is combined with the appropriate technology framework to form the theoretical basis of the study. These are explained in detail later in the study.

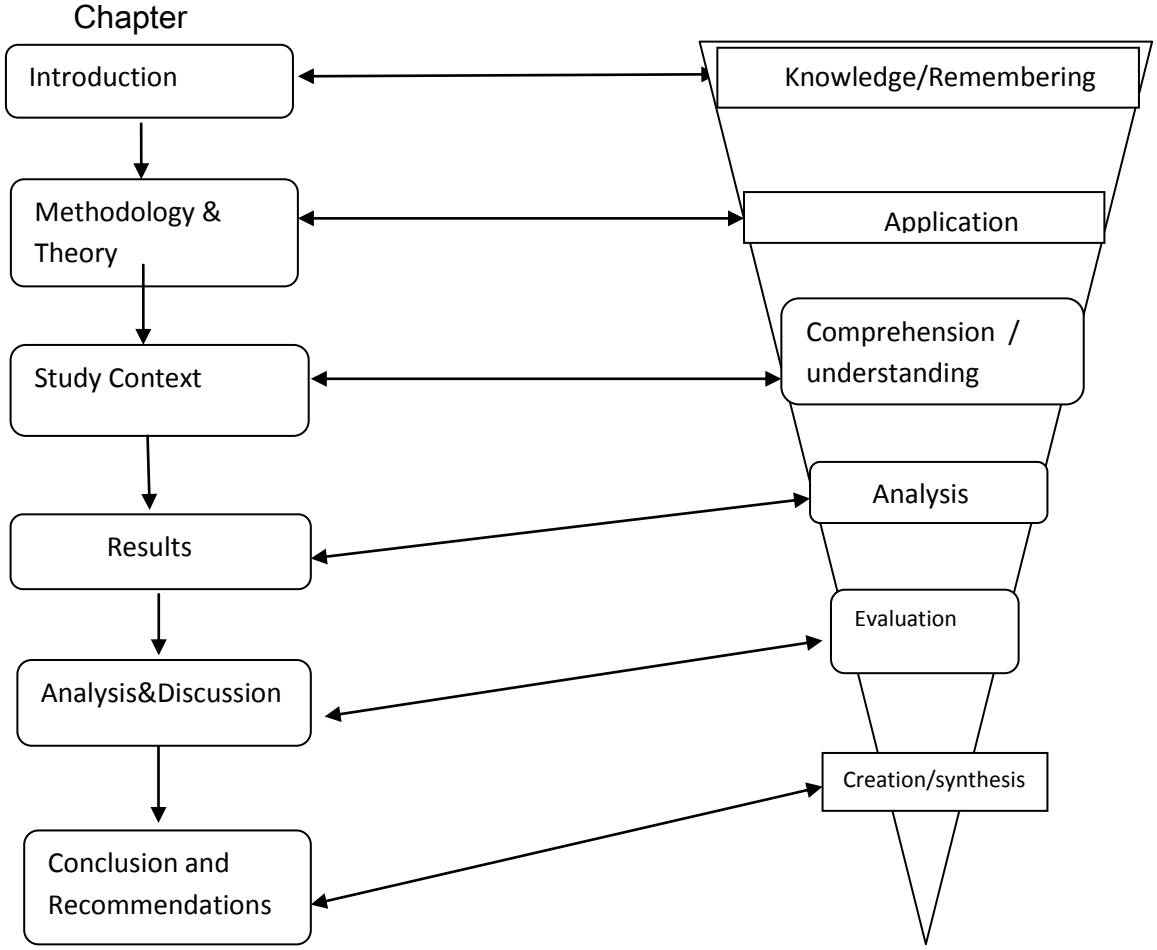
The next chapter illustrates the steps taken prosecute the research objectives. It explains in detail the research design and methodology.

Chapter 2.0 METHODOLOGY

The purpose of this chapter is to afford a comprehensive overview of the research design and methodology, as well as outline procedure adopted in answering the research questions.

Blooms, *Taxonomy of Educational Objectives (1956)* postulates a categorisation of levels of knowledge and a sequential model for addressing topics in a study research towards its conclusion. The diagram below encapsulates the project outline.

Fig.2.1 Report Structure, Correlation of Chapters and Learning Levels



Source: Adapted from (Bloom,1956; Anderson and Krathwohl, 2001)

The opening chapter explains the introductory part of the study, and the guiding research questions within the context of the study site. The research design, mode of prosecuting the research questions as well as guiding concepts are outlined in chapters 2 and 4 respectively. Chapter 3 provides an insight into the background approaches and resources at addressing household energy needs. The report findings are presented in chapter 5,whiles a thorough appraisal of results is afforded by the continuing chapter. Chapter 7 presents the main findings which ultimately filters into the recommendation of chapter 8 thus conclusion and recommendation.

Thus to gain a comprehensive insight of a subject involves a series of stepwise learning starting from the simple rank of *remembering/knowledge* to the complicated rank of *creation/evaluation* (Anderson and Krathwohl, 2001). Consequently, the *knowledge/remembering* component of the taxonomy is covered by the *introductory* chapter whilst the *understanding* aspect is woven around the *study context*. The *methodology* adopted is then *applied* to the case study whilst the *theoretical framework* does an *analyses* of the challenges identified. The *evaluation* of case study results is performed in the discussion and analysis chapter. Ultimately, the study results are employed in the *creation* of recommendations, whereby obtained knowledge is translated into practice.

2.1 Research design

This research is undertaken from the case study approach. Literature and theoretical studies alone are not enough to afford adequate understanding of the subject under investigation. Given the dynamic and urgent nature of the solid fuel challenge, field work was undertaken to afford first hand information. Kvale and Brinkman (2009 pg 108) argue that immersing oneself in the target population will usher the researcher into the socio-cultural life of the people and afford an inkling of what the subjects may articulate. In addition, this was also to help unveil crucial ethicopolitical concerns which need to be considered at both the pre and post interview phases. Furthermore, this field presence enables one to pick situational cues which facilitate the interview process as well as respond to the research questions (Kvale and Brinkman 2009 pg 139).

2.2 Methodological Framework

Karpatschof (2006) surmises that the preference for either qualitative or quantitative methods must be premised on the substantive issue under investigation, a point which Kvale and Brinkman (2009) also concur. Karpatschof (2006) argues further that '*quantitative methods are suitable for investigating serialized phenomena (ie.., those aspects of persons that are salient when they are regarded as parts of a series), and qualitative methods are suitable for investigating contextualised phenomena, where persons are considered as members of social groups'* (Kvale and Brinkman,2008 pg 305).

Consequently this study primarily assumes the qualitative methodology in prosecuting its objectives à la Kvale and Brinkman (2009): *Interviews-Learning the Craft of Qualitative Research Interviewing*. This was combined with some Rapid Rural Appraisal Techniques viz : personal observation, key informant interview, and group discussion to garner data. Qualitative research interviews empower individuals to articulate their views, aspirations, and concerns in their own words (Kvale and Brinkman,2008 pg 311). Since the views of the target population are essential to this study, it was worthy to use this approach.

The qualitative method is then coupled with *quantitative methods* to assess data.

2.2.1 Case Study:

The case study research method is a qualitative research technique employed in this research. Yin (1984, p.23) explains that the case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. Furthermore, Flyvbjerg (2006) argues that universals are the exception rather than the norm in the study of human affairs. This is because human activities are predominantly found in a local context of practice hence, context-dependent information is of more significance than a quest for universal speculation. Kvale and Brinkman (2009 pg 264) also intimate that case studies can help make generalizations when rich contextual cases are strategically chosen to test the validity of a hypothesis. Kennedy (1979) in this vein advises researches to offer sufficient data to support such generalizations however she argues that the responsibility of such clinical generalizations rests with the recipient similar to generalizations in law. Given the above views, the case study method was adopted to get a true understanding of the subject under investigation to afford valid generalizations.

2.2.2 Information gathering

This refers to the various strategies used in generating information for the study.

2.2.2.1Literature reviews

A literature review is a critical assessment of the current state of scholarship of the subject under investigation. In addition a good literature review demonstrates skills in fishing data and critical appraisal. Some of the main documents perused include Park Management Report of the Mole National Park (2011), Millennium Ecosystems Assessment (2005), Rural Livelihoods and Diversity in Developing Countries by Frank Ellis (2000), Small is Beautiful by Schumpeter, Ghana Government Policies on Energy. These documents helped understand the status quo on the various themes of the project.

2.2.3.2 Seminar participation

Some seminars were attended which further gave insights into the topic under investigation as well afforded the opportunity to meet experts in the field. These include a presentation by Claus Stig Pedersen (Director of Sustainability at Novozymes) organised by the department of Planning and Development on the 14th of February 2013. The presentation demonstrated how Novozymes through its sustainability approach à la Clean Star, succeeds in preserving forests, supplying food and generating clean energy devoid of health risks as well as save time in the households.

2.2.3.3 Desk Study/News Articles

News articles were also instrumental in providing up to date information on developments in the energy industry back in Ghana and the roles of some of the players. News articles provided information on the challenges with energy accessibility. For example, knowledge of the solar cooking project at Kumasi Polytechnic was due to a news article.

2.3.4 Data Collection

Rapid Rural Appraisal (RRA) denotes a multiple array of investigation procedures across several disciplines employing 'informal' data collection techniques. Rapid Rural Appraisal (RRA) has evolved as an antidote to the challenges of traditional research approaches such as: time constraints, lofty cost of formal surveys, and the often case of data unreliability stemming from non-sampling errors (FAO, 2009). This is very useful in areas where there is unreliable and often a paucity of baseline data. Some Rapid Rural Techniques adopted embraces the following:

2.3.4.1 Field work and personal observation

In addition to the secondary data studied, primary data was sought by visiting the field. Thus the case study site was visited which enabled interaction with households, school children, and some key informants as a way of *participant observation*.

2.3.4.2 Sampling

Sample space :Kvale and Brinkman (2009 pg 113) advice that in qualitative interviews, the subject numbers tend to be either far less or more which has implications for analysis and consequently the validity of the results. Thus it is best to interview as many subjects as possible. Given resource constraints as per time and funds, interviews were done with 30 households; 5 NGO's with a record of active participation in the rural energy landscape; 3 tertiary institutions which are into household improved cooking technology for the local market; and two government institutions.

2.3.4.3 Choice of Interviewees:

The choice of respondents was carefully chosen and is informed by assessing global and country efforts at addressing the household energy challenge. For example, borrowing from past experiences, the United Nations as part of its post-2015 development agenda, has sought to ensure: the roles of *women* are given prominence; *youth and education* play key roles; multi-sectoral approach is used in addressing energy goals; the *private sector* is involved as a vital player in the delivery of its goals (IISD,2013). Furthermore, the Country Action Plan of Ghana on Sustainable Energy for all identifies the need for collaboration and concerted action between *government, civil society, research community* and the *private sector* (Ghana Government,2012).

2.3.4.4 Sampling method

Purposive /snowball sampling**:** given the time and other resource constraints, a desk study was done to identify key stakeholders who are active in the field of study and were recruited as key informants *(purposive sampling).*

Interview with *elites*: these are influential resource persons connected to the field of study due to their portfolio as traditional leaders or employees of government and community based non-governmental organizations. These served as key informant who apart from sharing their knowledge also divulged their social networks and relevant contacts in the field of study to help facilitate the project *(snowballing or chain referral sampling).*The selected key informants were administered with questionnaires.

Some of the key informants consulted include; a local chief, the district assembly planner (Damongo District Assembly), school teachers at the district level (Damongo LA Primary and Bowena Primary and Junior High School), lecturers at the tertiary institutions dealing with energy/fuel (University of Ghana, Kwame Nkrumah University of Science and Technology, Kumasi Polytechnic), divisional heads of civil society organisations (AROCHA, SIMAVI/New Energy).

2.3.4.5Interviews

Interviews are often applied to case studies as they focus on a particular *person, situation, or institution*. Furthermore interviews may also be employed as an auxiliary method coupled with other methods (Kvale and Brinkman,2009 pg 117). The informed consent of the interviewees was sought in each case before being interviewed. In cases where the interviewer preferred the interview in the local dialect, the interview was conducted with the aid of an interpreter. After getting the consent of the interviewer, a semi-structured interview was conducted as per the objectives of the project. A semi-structured interview seeks to appreciate the daily life of the subject from his/her viewpoint as encapsulated in given information using common language. It resembles normal discussion however due to its research intent; it assumes a particular approach and technique to prosecute data vis a vis relevant themes of the study (Kvale and Brinkman, 2009 pg 27).

2.3.4.5.1 Key informant interview

This is a standard in-depth interrogation technique with persons who are knowledgeable about a community and can be considered community experts. The experts by virtue of their rare insights can shed light on the nature of a problem and offer useful recommendations (USAID, 1996). Key resource persons from several instituitons were interviewed as indicated in table 3.1 above.

2.3.4.5.2 Group interviews

A group interview is composed of several subjects facilitated by a moderator. Its hallmark is its non-

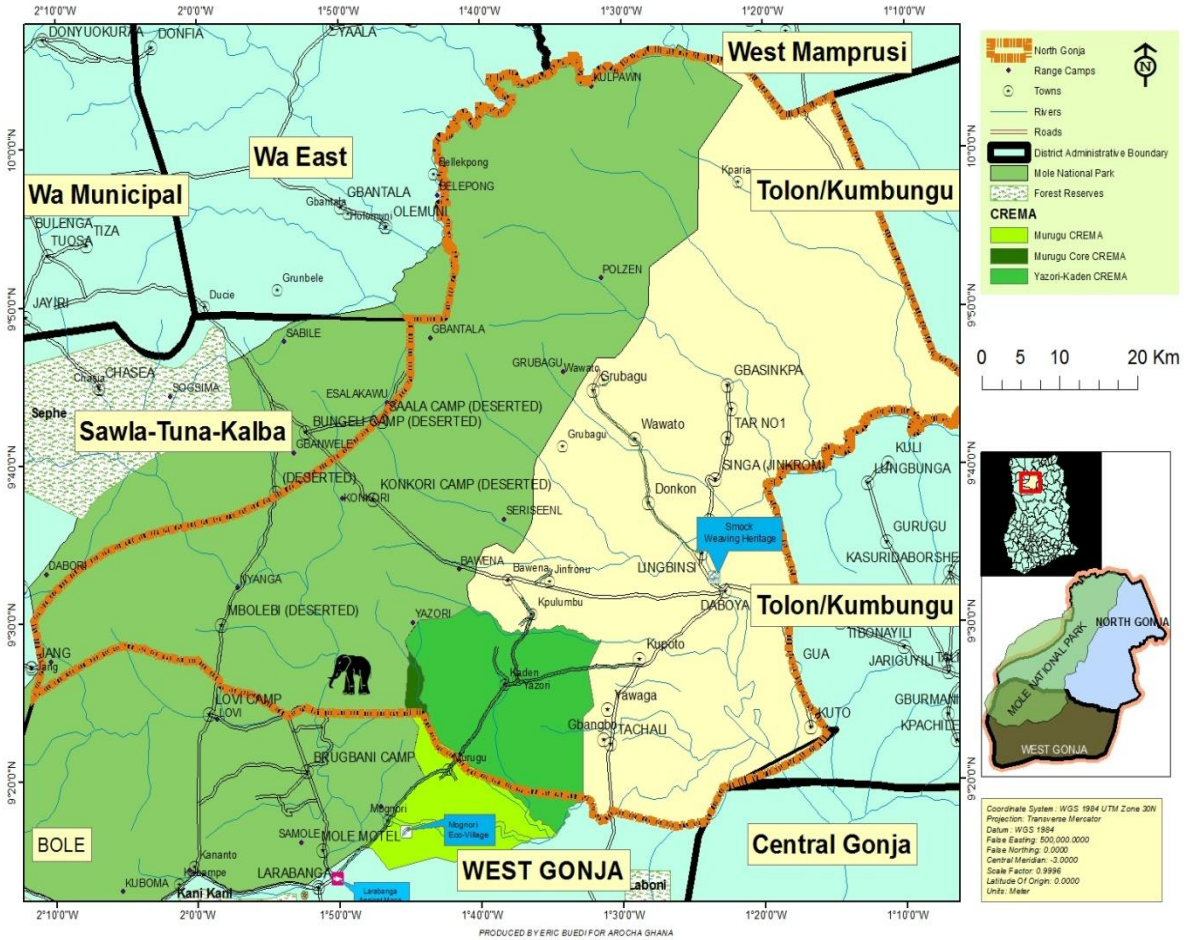
directive style of discussion. Furthermore, the key concern is to promote a myriad of opinions on the subject under discussion rather than arriving at a consensus (Kvale and Brinkman 2009 pg 151).

The group discussions were done with school children and facilitated by their teacher. Difficulties or barriers to effective interaction between adults and children could be overcome when kids are interviewed in natural settings (Kvale and Brinkman 2009 pg 146). Group discussions were conducted with school children at the playground. Consent was sought from the local chief and parents.

2.3.4.5.3Interviews with households

A number of households were visited, observed and interviewed. These households were within communities where the local AROCHA operates (AROCHA communities). A household is a social unit which exhibits coresidency, often having a common catering arrangement and jointly shares resources (Ellis 2000pg 18). The household is also a basic unit of enumeration used by the Ghana Statistical Service for its Housing and Population Census. The 5 communities visited were Yazori, Murugu,Mognori,Bowena, and Damongo.

Fig.2.2 Map of Case Study Area



Source: AROCHA 2013

Fig. 2.2 Highlights the case study area. In general these are largely agrarian rural communities with low rates of formal education and low income. The district capital Damongo on the other hand has relatively higher levels of education and income levels (AROCHA, 2013). Yazori is found on the south-eastern fringe of Mole National Park (MNP) in the West Gonja District (WGD) of northern Ghana. Mognori and Murugu are located approximately 11km and 16km respectively from the Mole National Park (AROCHA, 2006). According to AROCHA as at 2006, Murungu was more than twice the size of Mognori with a population of 1054 in 75 households whilst Mognore had a population of 416 with 62 households.

Ownership of land is communal '*under the custody of the Tendana (Earth-priest), held in trust by the Chief of the community on behalf of the Divisional Chief (Wasipe-wura) with overall custody entrusted to the Yagbon-wura, the Gonja King' (*AROCHA, 2007). The *Tendana* in the community oversees the management of all natural resources within the communities and hence plays a crucial role in the use of resources. Overall, the communities are farm/hunter groups occupied with rain-fed agriculture. In the long dry season, majority of households engage in small – scale off – farm activities viz : *Shea butter* extraction, *Gari* (grated cassava in mash form) processing, which boost household incomes. These activities are mainly household based, seasonal and labour intensive with women as the main players.

Selection of households: Upon entry into a community, a courtesy call was paid to the local chief in line with custom and so as to explain the purpose of the visit. After obtaining permission, the chief's household was thus the first household for interview. Every second household was also selected in a clockwise similar fashion e.g 5, 7, 9, 13. This approach was used for Yazori, Murugu,Mognori and Bowena Fig. 2.3 Schematic Overview of Household Selection in the Villages

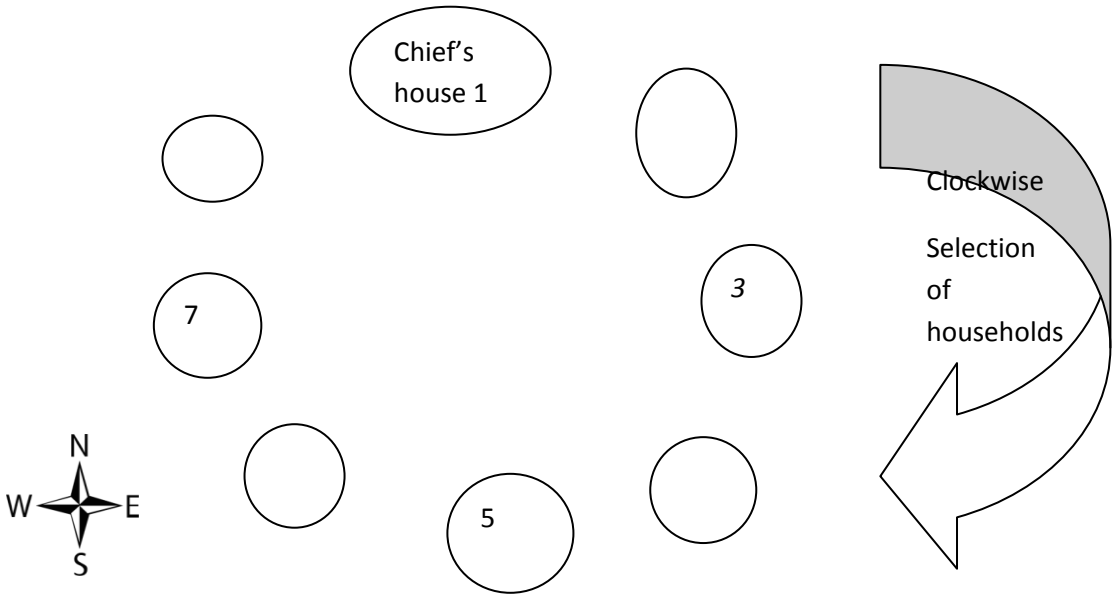


Fig. 2.2 describes the manner of selection of households and the interview procedure in the rural villages.

The village households were adobe structures and roofed with thatch. Each compound consisted of a husband (head of household), his wife/wives and children in a circular compound. In each household, the head of household was consulted when present before conducting the interview with the wife. In some cases where the head of household was not present, the most elderly of his wives acted as head and permission was sought from her. In other cases where the husband was not available, the wives declined to divulge information in the absence of the male head of household and this was respected.

Damongo is the district capital, here the housing pattern is different. People live in self-contained /compound houses. Furthermore unlike the villages in the rural areas where it is easy to predict when people leave and return from their farms, people are relatively busier and quite difficult to find them at home. Consequently a random approach was used in selecting the households and interviewing based on availability of respondent. In Damongo, the houses are built of concrete and roofed with modern products which give an indication of the comparatively wealthier economic profile of the households.

Fig.2.4 Schematic Overview of Household Selection in Damongo

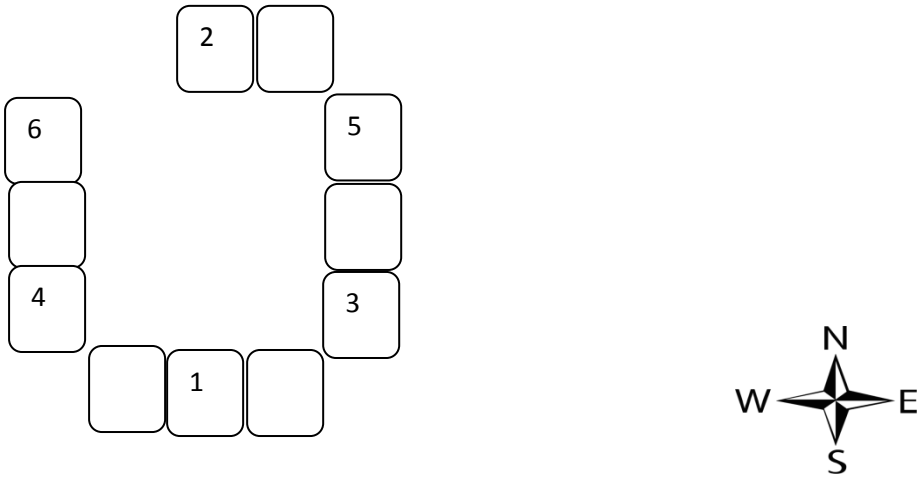


Fig 2.3 describes the random household selection process in the district capital Damongo

Data Validity and Representativeness: the goal of this study is to offer data that ultimately can be used to address parallel issues in other real-life cases. Though the case study approach is usually based on both the qualitative and quantitative methods of data collection (Bryman 2008), this study is predominantly based on *qualitative* methods. Flyvbjerg (2001) posits that in order for case study results to be valid and afford generalisations, it is prudent to select a critical case. The Gonja District

is a critical case as both Management Plan of the Mole National Park (largest nature reserve in Ghana), as well as key national policy documents on energy allude to the negative effect of woodfuels on the study area (Energy Commission,2006).

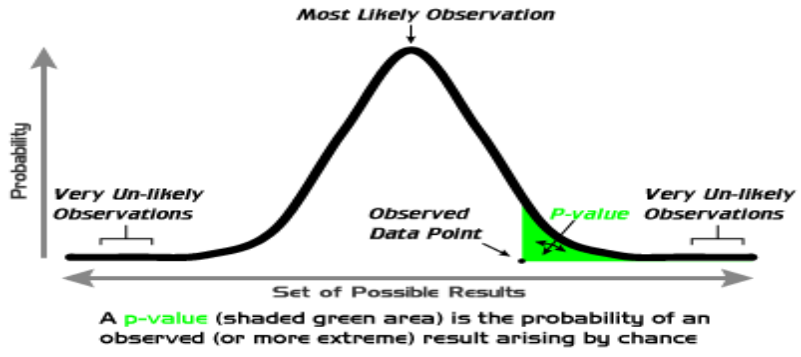
To ensure validity,several approaches to data collection were employed; group discussions, household/key informant interviews, personal observation. In addition, to enhance triangulation, several households from different villages were interviewed. Furthermore, the key informants were selected from different stakeholder groups to afford a comprehensive overview of the energy challenge at the rural household level. Finally, the questionnaires were structured in a manner such that ambiguity is avoided.

2.4.0 Data-Interpretation

During the interview notes relevant to the objectives of the project were made. Interview recordings were made so they could be reflected upon later in the day and cross check where necessary. The relevant themes from the interviews were then stringed into statements à la *meaning condensation*. Meaning condensation connotes a summary of the meanings as articulated by the interview subjects into brief formulations. Lengthy accounts are condensed into succinct statements where the main issue expressed is rephrased more concisely (Kvale and Brinkman,2008 pg 205). The meaning condensation approach to analysis follows five main steps: the whole interview is initially examined to afford a comprehensive overview; the *meaning units* as articulated by the interviewees in the transcript are isolated by the researcher; the predominant thematic areas as per the meaning unit is rephrased concisely; the meaning units as per the study are cross-examined; finally the vital themes of the whole interview are compiled to forge a descriptive statement (Kvale and Brinkman,2008 pg 207).

SPSS Statistics (Statistical Package for the Social Sciences), was used for statistical analysis of case study results and to highlight variances and significant levels. Data trends are showcased with *Microsoft excel* by way of graphs, tables and charts.

Fig. 2.5 Statistical Significance



Source: Min (2012)

A significant value (P) is the probability that a result or relationship is due to a cause other than random chance. Testing a hypothesis statistically is a means of measuring if an outcome is statistically significant or otherwise (Chivers,2011). This produces a "p-value" suggesting the likelihood to which coincidence could explain the result. If there is a vast difference and variance between samples, then the difference may not be significant and vice versa. For example, P values below 0.05 are regarded as statistically significant, and interpreted as enough justification for rejecting the null hypothesis (Cambridge,2013).

The Pearson chi-square test is one of such statistical tests for measuring if the probability of an event occurring is as result of a cause effect or mere random chance. The Pearson chi-square test can be used as part of *SPSS* Statistics in determining the statistical significance of an outcome.

2.5.0 Qualitative research and ethics

The genesis of ethics in research can be traced to The Belmont Report of 1979 which revolves around three cardinal principles. These principles epitomized therein have embraced all disciplines of research and evolved into the cornerstones of international conventions tailored at best practices as per research ethics (OHRP, 2012). The codes of ethics as encapsulated in The Belmont Report includes : *Respect for persons* this dictates that the dignity research participants be valued. Thus it demands that the autonomy of research participants are not compromised and in cases where autonomy is diminished, they be shielded from harm's way. *Beneficence* obliges the researcher not to endanger the wellbeing of research subjects. Thus research should reduce probable risks but heighten the potential benefits. *Justice* stipulates a fair distribution of the threats and opportunities associated with research. Thus those saddled with research participation must also gain from it.

In modern times*, Respect for communities* has surfaced on the research ethics landscape as a fourth principle pioneered by some bioethicists (FHI, 2012). This obliges the researcher to respect the norms and aspirations of the target population in research and, where feasible, shield them from harm's way as a form of social responsibility (BPS, 2010).

2.6.0Work Journal

In consonance with the counsel of Kvale and Brinkman (2008 pg 112) a work journal was created to facilitate judicious use of time and other resources as well as serve as a personal audit. A work journal was kept to record reflections and also help to best navigate the various phases of the project temporarily and spatially.

2.6.1 Research Limitations

Similar to most research works, some challenges were encountered in carrying out the research which inter alia included:

Language barrier,the use of an interpreter may have caused some loss in meaning due to translation. However this possibility limited to the bearest minimum by taking notes and asking for further explanation right in the presence of the interviewee whenever clarification was needed about an issue before proceeding to the next question.

Due to time and resource constraints, the sample size was small however the results afford a comprehensive picture of the experiences and opinions of the relevant key stakeholders.

The following chapter elaborates on the country and case study site scenario on energy. It also offers insight on policies and initiatives towards energy access in Ghana.

Chapter 3.0 STUDY CONTEXT

This chapter delves into the challenge of access to modern fuels. It touches on the global and country context and concludes with local initiatives and options to addressing the challenge. Unlike the introductory chapter, this chapter deals more with the country and case study area context.

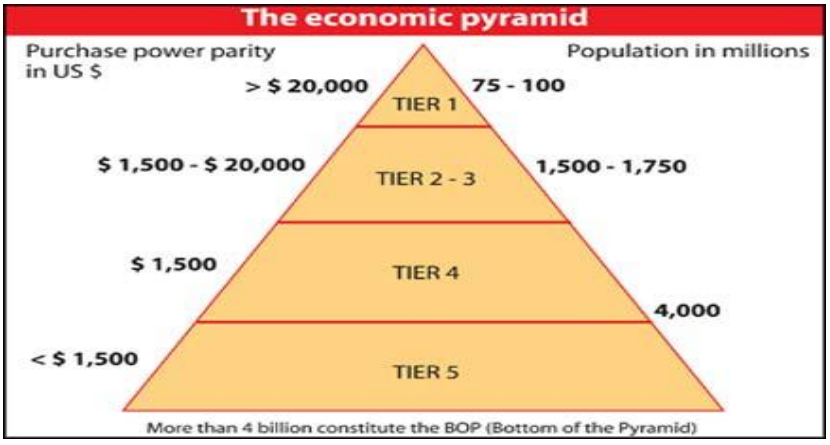
Achieving access to modern energy forms such as improved fuels is crucial to attaining the Millennium Development Goals, especially poverty alleviation, ensuring improved education, health, water accessibility and environmental sustainability (Kemausuor et al,2011).

There is a direct correlation between the lack of adequate energy services and several poverty indicators such as infant mortality, illiteracy, life expectancy and total fertility rate. Low access to energy also worsens rapid urbanisation in developing countries, as it compels people to seek better living conditions (Energy Commission,2012). Thus income levels have an influence on the use of modern energy sources at the household. Consequently people with relatively very low incomes are prone to the use of inefficient fuels as stated earlier. This group falls under the category of bottom of the pyramid in terms of wage levels (Hahn,2009).

3.1 Addressing Needs at the Bottom of the Pyramid

The bottom of the pyramid relates to the lowest tier of the global income pyramid, highlighting the huge proportion of people subsisting in moderate and extreme poverty (Hahn 2009). Kaplinsky (2010) argues that with the onset of the financial crisis in 2008, the numbers of people under this category has swelled between 55 m and 90 m making the needs of this constituency a global concern. Prahalad and Hart (2002) also concur with this assertion. Furthermore, the concept of sustainable development and the millennium development goals (goal 1) are subtle admission of the need to address the challenges of the global poor forming the bottom of the pyramid (Hahn,2009; Kaplinsky,2010). Access to modern energy is one of the prime needs at the bottom of the pyramid.

Fig.3.1 The Income Pyramid



Source: Sarasohn-Kahn (2011)

This notwithstanding, 1.3 billion people have no access to electricity and 2.7 billion people are dependent on traditional biomass for cooking and heating (IEA, 2011). Moreover, with over one-third of a household's budget being spent on fuel in several Sub-Saharan African countries, the region's populace pays a heavy price for fuel (mainly biomass) that is of low quality and ineffective.

3.2 Global efforts at meeting the energy needs at the bottom of the pyramid

In appreciation of the crucial importance of improving global access to sustainable, affordable and environmentally sound energy services and resources, The United Nations General Assembly declared 2012 the International Year of Sustainable Energy for All (SE4ALL),urging Member States and the UN system to heighten sensitisation on the importance of addressing energy issues and to promote action at the local, national, regional and international levels (Energy Commission,2012). As a response, the UN Secretary General rolled out a worldwide programme to achieve "Sustainable Energy for All by the year 2030". The core aims of this initiative are: (1) ensuring universal access to modern energy services; (2) doubling the rate of improvements in energy efficiency; and (3) doubling the share of renewable energy in the global energy mix (Energy Commission,2012).

Furthermore, the Millennium Development Goals (MDGs),implicitly acknowledges that accessibility to reliable, enhanced and sustainable energy services for all could contribute largely to the attainment of all the MDGs. Realizing the MDGs demands several interrelated actions that can be decomposed into nine areas of activity often termed 'investment clusters' (Energy Commission,2012):

- Rural development—increasing food output and rural incomes
- Health systems—ensuring universal access to essential health services
- Education—ensuring universal primary education and expanded post-primary and higher education,
- Gender equality—investing to overcome pervasive gender bias
- Environment—investing in improved resource management
- Science, technology and innovation—building national capacities

Investments in modern energy services are crucial for supporting each individual cluster identified above (Kemausuor et al,2011; Energy Commission,2012). Consequently, the idea of enhancing accessibility to clean energy for the benefit of sustainable development a la Brundtland Commission has filtered into the national development framework of several countries including Ghana (Energy Commission,2012).

Fig. 3.2 COUNTRY OVERVIEW

Source: (GACC,2012)

Ghana covers a total area of 239,000 sq km with a population of 24.9 million (Ghana Government,2011), with an annual growth rate of 2.4%.The country is endowed with a varied and rich resource such as gold, timber, cocoa, diamond, bauxite, and manganese. The discovery of an oilfield in 2007, projected to hold circa 3 billion barrels of light oil led to commercial oil production at Ghana's offshore Jubilee field from mid-December 2010.

The services sector is the backbone of the economy, responsible for approximately 48.5% of goods and services in 2011, then comes industry with 25.9%, and agriculture with 25. 6%.The impressive results of the services, has resulted in a service led economy. The GDP per capita is US$2,500 (2010 estimate). Ghana's labour force consists of an approximate 10.6 million individuals (2010 estimate) with 56% of them found in the agriculture sector, 15% for the industry sector, and the services sector accounting for 29% (2005 estimate).

The countries chief exports include gold, cocoa beans and timber products. Other export materials are tuna, aluminium, manganese ore, diamonds and horticulture. Agriculture is mainly on smallholder, family-operated farms with rudimentary technology which supply about 80% of Ghana's total agricultural output. It is projected that circa 2.74 million households manage a farm or keep livestock (MOFA, 2007). Agricultural production is mainly rain fed. The overall potential area which could be developed for irrigation is approximated at 500,000 ha, however the total area under formal irrigation is below 5%. Notwithstanding successes made in economic growth and reduction in poverty at the national level, regional, occupational and gender disparities persist. Thus the three Northern regions where heightened poverty levels subsist have not registered any improvements in poverty. More than 70 percent of people whose incomes fall under the poverty line reside in the Savannah areas. The

2009 Human Development Report (HDR) suggests Ghana's Human Development Index (HDI) position had fallen and inequality still high. Consequently increased growth rate has not translated into enhanced human development indicators as the country grapples with hurdles in health and other social services.

3.3 Case Study Site

The study is done in the West Gonja Distirct, which is home to the Mole National Park. The Gonja West District of the Northern Ghana is host to two key nature reserves; Mole National Park (which also double as an Important Bird Areas IBA) and Kekeni Forest Reserve. It is defined by longitude 1^0 5^1 and 2^0 58^1 West and Latitude 8^0 32^1 and 10^0 2^1 North (Park Management Plan,2011). The District covers an area of 8,352sq.Km which constitutes approximately 12% of the overall land area of the region. The Northern Region however is one of the poorest areas in Ghana characterised by low fertile soils, poor agro-climatic zone and low employment prospects and has close proximity to the Sahel region(MOFA,2011). Thus there is often conflict between park management and neighbouring communities due to encroachment into the park for trees and killing of animals for various purposes (MPMP,2011). This has become pronounced as there are almost non-existent alternatives to employment and sustainable livelihoods. This is also a major cause of rural migration by the youth of the area for better opportunities (MOFA,2011).

The Mole National Park is the largest of its kind in Ghana, endowed with a rich biodiversity and unique wealth of flora and fauna some of which are endangered species. Knowledge of its resources is limited, thus its full potential is underexploited for education, research and tourism (MPMP,2011). Furthermore deforestation, bush burning, poaching and littering by fringe communities threaten the very existence of this nature reserve. Aside the unsustainable deforestation for charcoal production, the production technique is a source of health concern (MPMP,2011).

3.4 Ghana's Development Policy and Energy

The recent medium-term development policy framework, the *Ghana Shared Growth and Development Agenda (GSGDA), 2010-2013*, aims to sustain macro-economic stability and engender increased shared growth to limit socio-economic inequalities, accelerate poverty reduction and the attainment of the Millennium Development Goals. Enhanced job prospects and living standards are envisioned from the success of national and sector development policies (such as energy policy), particularly for the marginalized (Ghana Government, 2012):

The core topical areas pertaining to energy access are: i) accelerated agricultural modernisation and natural resource management; ii) oil and gas development; and infrastructure, energy and human settlements development. For infrastructure, energy and human settlements development, the chief policy focus include : transport infrastructure; energy and energy delivery to shore up '*industries and*

households; science, technology and innovation; information and communication technology development; human settlements development; recreational infrastructure; and water, environmental sanitation and hygiene' (Ghana Government,2012).

Given the vital role of energy as a catalyst for national development, energy accessibility and efficiency cannot be overemphasized.

3.5 The Energy Sector

A myriad of energy resources such as biomass, hydrocarbons, hydropower, solar and wind exist in Ghana (Ghana Government,2012) however at the household level *'electricity, LPG, kerosene, and renewable energy including woodfuels (firewood and charcoal)'* are more important (Kemausuor et al,2011)

3.5.1 Electricity

Electricity is sourced from two hydro power plants at Akosombo and Kpong in addition to some thermal plants. The Ghana Statistical Service suggests that about,4.8% of household budget is spent on electricity, LPG and other fuels. Furthermore it is projected that circa 60% of this expenditure (2.9%) would be used directly on electricity bills(GSS,2008). Access to electricity in Ghana , estimated to be 54% in 2007 and 55% in 2008, places Ghana third place in sub-Saharan Africa, after Mauritius and South Africa (Kemauosuor et al,2011).

3.5.2 Petroleum Fuels

Government efforts at promoting the use of LPG at the household level initially registered positive results. Thus user levels first doubled in 1992 (Kemausuor et al,2011). Furthermore, In 2004 ,household use of LPG was more than 60,000 tonnes/year, which is about ten times greater than initial consumption levels. However, the usage of LPG is mainly in the urban areas, thus in 2005 more than 70% of LPG users were found to be in the Greater Accra and Ashanti regions. Use of LPG in the rural areas on the contrary is estimated at 1.2% of the overall national total (Kemausuor et al,2011)

3.5.3 Renewable Energy

Woodfuels (firewood and charcoal) form the majority of Ghana's energy supply at the household level (Energy Commission,2012). Woodfuels supply circa 63% of the overall energy relative to 27% for petroleum products, and 9% for electricity (Energy Commission,2005; Kemausuor et al,,2011). The household level uses the greatest proportion of energy by virtue of the high dependence on woodfuels to satisfy domestic needs. Kemausuor et al,(2011) suggest the availability of other biomass resources including agricultural and forest wastes, animal wastes, saw-dusts, etc.

Table 3.1 Percentage Share of Woodfuel Consumption in Ghana (2000–2005).

Sector	2000	2001	2002	2003	2004	2005
Residential	72.3	71.8	71.3	70.8	71	71
Agriculture & fisheries	0.1	0.1	0.1	0.1	0.1	0.1
Industry	24.5	25.9	25.4	25.8	25.7	25.7
Commercial & services	3.1	3.2	3.2	3.2	3.2	3.2

Source: Energy Commission (2005)

Improved cookstoves have been promoted to limit woodfuel consumption as well as indoor pollution compared to traditional cooking devices. Improved cooking stoves come with the merits of fuel efficiency and less indoor pollution have been fabricated by the Institute of Industrial Research (of the Council for Scientific and Industrial Research – CSIR-IIR) and New Energy (an NGO

Table 3.3 Overview of Traditional Cookstoves

3 stone Fire	Mudstove	Coalpot	Tire Rim
			
Most common stove in Northern Ghana and rural areas · Used with firewood and other biomass fuels which are collected · Very poor fuel utilization · Easily adaptable Ease of use: medium-high Availability: high	Self-made stoves based on local materials · Used with firewood and other biomass fuels · Adaptable to cooking needs and pots Ease of use: medium-high Availability: medium	Most popular charcoal stove, made of thick scrap metal · Sold by retailers in different sizes based on need, easily available in public markets · Lifetime between 2-4 years Ease of use: medium Availability: medium-high	Charcoal stove made from a used vehicle rim · Very heavy to carry and not easily adaptable · Lifetime between 3-5 years Ease of use: low Availability: medium

Source: Global Alliance for Clean Coostoves (2012)

Enterprise Works (an NGO) and Toyola, two private institutions have also produced different models of firewood stoves. Despite these initiatives, limited success has been recorded particularly in the rural communities, which obtain firewood virtually free. In the early 1990s, the Ministry of Energy after conducting a thorough field and laboratory tests on the *Ahibenso* rolled out a programme to distribute

about 12,000 pre-financed stoves with funding by the World Bank and the government of Ghana (GACC,2012).

Table 3.4 Overview of Improved Cookstoves

Gyapa	Cookmate	Envirofit	LPG
			
Produced locally by RI/EW, Toyola and Man & Man Enterprises · Charcoal stove made of metal casing with ceramic liner · Sold in different sizes · Lifetime between 3-5 years Ease of use:medium-high Availability: high	Charcoal stove made of all galvanized steel · Sold in three different sizes · Fuel savings of up to 50% over traditional stove Ease of use:medium-high Availability: low	CH-2200 Charcoal stove · Currently pilot testing stove in 3 selected districts · Reduction of fuel consumption by up to 60% and smoke emissions by up to 80% · Expected lifetime over 5 years Ease of use: medium Availability:low	LPG stove with a grate placed on top of a gas canister · Cooks faster and burns more efficiently than biomass stoves · Commonly sold in public markets but LPG suffers from supply problems across the country Ease of use: medium Availability:low

Source: Global Alliance for Clean Coostoves (2012)

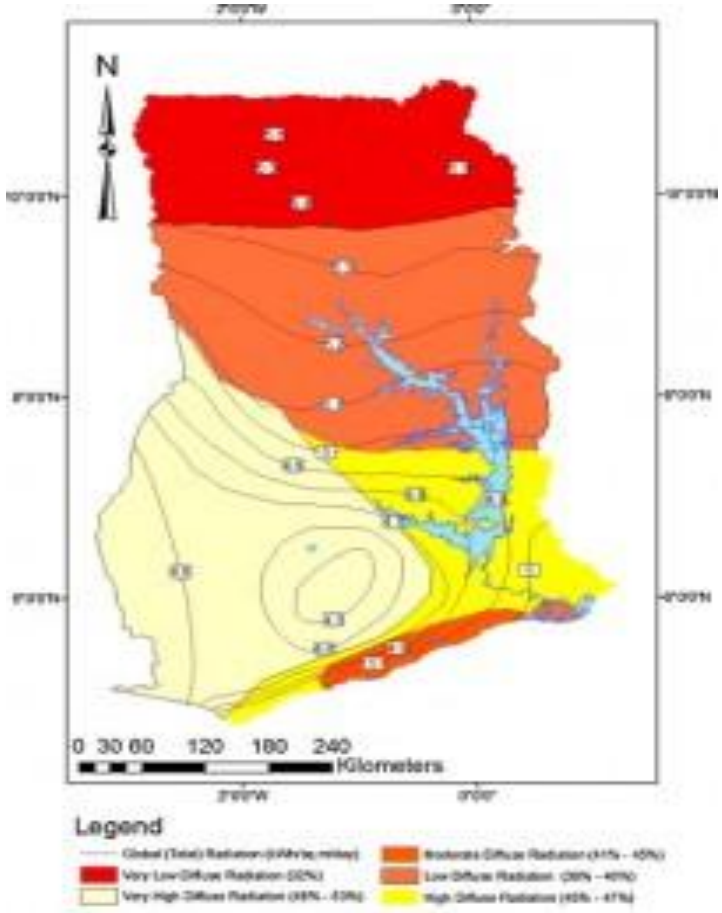
3.5.4 Other forms of bioenergy

The growing of biofuel feed stocks and fabrication of liquid biofuels for export has become widespread in Ghana (Energy Commission,2006). Foreign nations including Brazil, Norway, Israel, China, Germany, Netherlands, Italy and India have indicated desire to farm jatropha and other biofuel crops to produce biodiesel. In addition several community-based, small-scale biofuel programmes have been rolled out countrywide coupled with a Jatropha promotion programme for small farmers by a state agency (Kemausuor et al,2011).

Use of biogas on the contrary has not registered positive results (Energy Commission,2012). According to Kemausuor et al,(2011) the *' high unit cost (50 US cents/kWh) of electricity generated from biogas as compared to 13–20 US cents/kWh for diesel and gasoline is an issue of concern, particularly in the context of access to modern energy services for the poor living in rural and peri-urban communities'.*

Solar Energy: Ghana's tropical location has made solar radiation abundant year round (Kemausuor et al,2011). The Energy Commission (2011) also explains that the mean sunshine availability ranges from 5.3 hours per day in the cloudy semi-deciduous forest areas, to 7.7 hours per day in the dry savannah region. Hence the northern regions and the northern parts of Brong-Ahafo and Volta Regions receive very high radiation levels (Energy Commission,2011). Solar PV is contributing to electricity usage for household lighting, communication, water pumping and rural vaccine storage (Kemausuor et al,2011).

Fig. 3.4 Map of solar irradiation on Ghana



Source: Arrakis Group (2012)

Fig 2.3 describes Ghana's solar endowment and its distribution across the country including the case study site.

The next chapter presents the major concepts of sustainable livelihood and appropriate technology, on which the theoretical framework of this case study is founded on.

Chapter 4. THEORETICAL FRAMEWORK

This chapter further introduces the theoretical presmise of the study and unveils its main concepts.

Livelihood strategies are deeds that ensure household survival. They are dynamic and hence react to fluctuations in socio-economic circumstances and also adapt well (Ellis, 2000pg 40). Cooking and the use of household energy is a means of survival for several households across the globe and fit into this framework. Ellis (2000pg 28) explains that livelihood frameworks look with optimism at peoples possibilities rather than dwell on their dire circumstances. They aim to discover the endowments of the poor rather than their lack and further boost their innovative capacities rather than replace, hamper or compromise them. IFAD (2013) adds that the sustainable livelihood framework puts the rural poor at the heart of development. This explanation by Ellis (2000pg 28) support's the usefulness of this theory as per the project aims. This is because the project seeks to use local resources human and non-human in addressing the household fuel challenge as a cardinal objective.

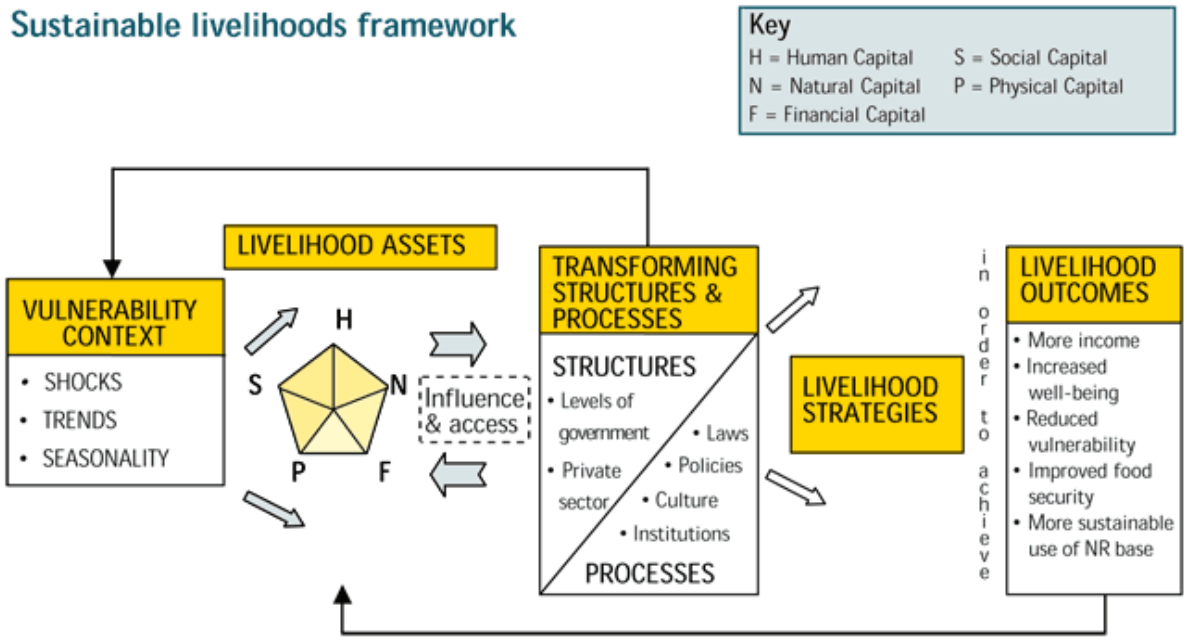
4.1 Sustainable Livelihoods

Ellis (2000pg7) refers to Sustainable Livelihood as the '*capabilities, assets (stores, resources, claims and access) and the activities required for a means of living*'. Furthermore, '*A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base'* explains the Department for International Development (DFID 2007) of the United Kingdom. The guiding principle of the SLA is that people employ a number of livelihood outcomes in their aspiration to enhance their livelihood assets and to decrease their vulnerability (DFID, 2007; Ellis 2000 pg 3). Hence the SLA is cyclical, offering perspectives on the livelihoods of poor people that affords an insight into the several factors that affect livelihoods, their interraction and relative significance as per a locale. The ultimate goal is to find more effective ways to improve livelihoods and decrease poverty (IFAD, 2013).

4.2 The Sustainable Livelihood Framework

The livelihood framework can also be decomposed into the following core components: (1) the asset portfolio which symbolizes the basis of livelihood, (2) the Vulnerability Context and Policy, Institutions and Processes, and (3) the loop connecting livelihood strategies and livelihood outcomes (DFID, 2007; Ellis 2000 pg 30). The Vulnerability Context of livelihoods entails the shocks, trends and seasonality with their probable impact on livelihoods; however Policies, Institutions and Processes consists of the political and institutional agents and influences within state, private and civil sectors that shape livelihoods (DFID, 2007; Ellis 2000 pg 30).

Fig. 4.1 The Sustainable Livelihood Framework



Source: DFID (1999)

The SLA framework is highlighted schematically above and portrays the key elements of SLA and how they are linked.

As per the project site, the poor soil and climatic conditions coupled with scarce fuel sources are an example of the vulnerability context which local institutions can roll out the appropriate policies and measures to address taking advantage of the *assets* such as knowledge, labour, and other natural resources. The extent of vulnerability of a entity is determined by the potency of their livelihoods, the work- related activities they partake in, their ability to access a plethora of resources vital to their livelihoods and the support of their social and institutional capital (DFID,2007; Ellis 2000).Similarly, the success of livelihoods in the project site is a function of the resources at the disposal of the community, and their ability to access them.

4.3 Appropriate Technology

Innovation and technological advancement are catalyst for poverty reduction as they enhance development, with implications for the factors of production, environmental impacts, and social aspects of production and the uniqueness of their products (Kaplinsky, 2010).Cooking and for that matter household energy are areas of life which fall under the core themes being addressed by appropriate technology. The concept of appropriate technology is a marriage of the social and cultural aspects of innovations. It presupposes that the worth of a technology is beyond its technical efficiency

and economic feasibility to its adaptation to the local social and cultural milieu (OECD, 1975; Kaplinsky 2010).

Appropriate technology (AT) denotes equipment/tool that is best tailored to its usage context and hence deemed 'appropriate'. Appropriate technology revolves around some cardinal themes:

- **Sustainable** – projects must have minimal environmental footprints which also have a bearing on the communal harmony as there is less friction in search of resources, thus less probability for communal violence (Schumacher, 1989pg63). The production of improved cooking technology thus stands to succeed when local resources are used efficiently so as not to deplete resources and also keep cost within the means of the target market.

- **People-Centred**: in *Small is Beautiful* Schumacher's proposes that economics charts a new path of people centeredness rather than attention to goods; this he sums as '*production by the masses not the masses for production' (*Schumacher 1989 *pg 79).* Thus the design of improved cooking technology should be such that it promotes grassroots ownership or decentralisation. Consequently, this promotes participation and sense of ownership from the local populace, and enhance people centred development.

- **Appropriate** to the circumstance, embracing the '*environmental, ethical, cultural, social, political, and economical context'*. For an appropriate technology to be efficient in exercise, it should be maintainable with ease; similarly for it to have its intended impact it must be affordable to the target populace. This improves accessibility for the "bottom of the pyramid" due to its simplicity yet ability to fulfil its mission (Kaplinsky 2010).

The genesis of this concept is mirrored in the evolution of three major nations; China, India and the United States of America (USA). In China it is traced to Mao Tse Tung's ideas on technology shaped by the social upheavals of the 1920's as well as its peasant rebellions. In India it is rooted in the rejuvenation and development of village based industries by Mahatama Ghandi as part of a larger goal of weaning the nation of foreign dependence and boosting internal structures (OECD, 1975).These two typologies, suggests appropriate technology can be conceived from the leadership of a country and filter to grassroots programme as a top-down approach.In the United States, its technological history indicates that the present large scale technologies were initially, small scale, low cost and somewhat *appropriate*. This is because it had to import its basic needs like cloths, axes and nails initially from England after independence. This surmises that appropriate technology may also be pioneered from the grassroots as a bottom-up approach (OECD, 1975).

OECD (1975) suggests that, the large scale transfer of technology from industrialized to developing nations have raised question marks from several quarters of the development landscape, as their introduction in poorer nations often do not meet their intended purpose. Furthermore they argue that, these products are often relatively very expensive in comparison to the income levels of the target nations; entail an educational and industrial infrastructure not readily available and may unleash negative social consequences (OECD 1975). Arguably worst of all, they truncate the development of local innovation which is imperative if sustainable development is to occur (OECD 1975).

Lessons from China, Japan, Europe indicate that innovation alone is not enough to translate into an industrial revolution however the presence of an entrepreneurial class and ' *more important a system of values- cultural, social or religious – which can legitimise and encourage social and economic change'* (OECD,1975). This is because a society often produces the kind of knowledge or science consistent with its values and norms. Institutions such as educational institutions, government and private institutions thus have a pivotal role to build human and infrastructural capacity which will satisfy the innovative and entrepreneurial needs of the society. Despite its plaudits the appropriate technology concept is not embraced across board. Kaplinsky (2010) explains that the march of appropriate technology has met with the resistance of some who deem it as an avenue to further perpetuate the underdevelopment in low income countries through the usage of *'low productivity, undynamic and inefficient techniques'.*

4.4 Analytical Framework

As indicated earlier the theoretical frameworks herein will be the premise for the case study results analysis. With respect to the sustainable livelihood framework it will be from three sub-thematic areas viz: individual, government and private sector.

At the national level, fiscal and policy choices (*transforming process*) influence livelihood options and decisions at the grassroots. In the same way livelihood patterns at the rural level also have an impact at the national level which reflects in national goals either being successfully achieved or otherwise (Jamal,1995). Macro policies are policy objectives which aim to impact variables which have far reaching effect on the entire society, hence influencing the pace and course of economic and social change. These policies include the economic and the socio-political spheres (Ellis 2000,pg 160). In the economic domain, indices such as the country's '*exchange rate, interest rate, taxation pattern, government budget and country's debt burden* '(Ellis 2000,pg 160) come to the fore. However in the socio-political domain the key issues include share of economic activities between the state and the

private sector, role of markets, level of centralization of government power, state agencies being accountable and respect for the rule of law (Ellis 2000,pg 160).

Micro policies unlike macro policies aim to influence the working environment of productive ventures and household incomes at the local level. Fertilizer subsidies or micro-credit (*influence and access*) aimed at increasing yields and increasing the income (*livelihood outcome*) potential of rural women respectively are examples of micro policies. In the same vein, subsidies and other incentives which make modern fuels affordable to enable the rural households make the needed shift falls into the category of micro-policies. In reality, it is the individual/household livelihood decisions that connect macro and micro policy levels (Ellis 2000,pg 160). Consequently, when macro policies are unfavourable to rural livelihoods, they further increase poverty and widen inequality levels (*increased vulnerability*), farm families resort to subsistence (*coping strategy*), risk heightens and rural families become highly prone to disaster and stress (*increased vulnerability*). On the reverse, macro policies can stimulate rural livelihoods, reduce risks, enhance options and lessen vulnerability (Ellis 2000,pg 160).

Individual: the livelihood framework has a hallmark of laying emphasis on individuals, their assets, activities and access instead of segments and their output which is normally the entry point of policy. At the individual level the study will explore these aspects related to the individual.
Government and private level: the framework thus affords the assemblage of *livelihood criteria* which can be used to assess the pros and cons of proposed projects as well as enhance the poverty alleviation content of such policies and projects (Ellis 2000,pg 237). These benchmarks of remoteness, substitutions,assets,options and knowledge are a criteria which refer equally to both government and the private sector. Thus the study will use these benchmark criteria to assess the role of government and the private sector in the framework of the sustainable livelihood framework.

The appropriate technology also lays emphasis on local human reosurces and knowledge systems in designing projects and social interventions. Consequently, the study will consider the *software* component of appropriate technology which has to do with the local human resources and knowledge systems as well as the *hardware* component which has to do with machines/devices being designed to satisfy the peculiar needs of a locale.

The next chapter outlines the outcomes of the case study.

Chapter 5 CASE STUDY RESULTS

This chapter outlines the results of the case study. The results embrace demographic and socioeconomic background of respondents. The results are presented and discussed in the following sections.

Results from Key Informants Interview

In answer to the question *Can wood fuel/charcoal be replaced in Ghana?*

Out of 13 key informants interviewed 10 (78%) answered in the affirmative and were optimistic that the heavy dependence on woodfuel can be reversed.

Fig. 5.1 Perception on substitutability of woodfuels

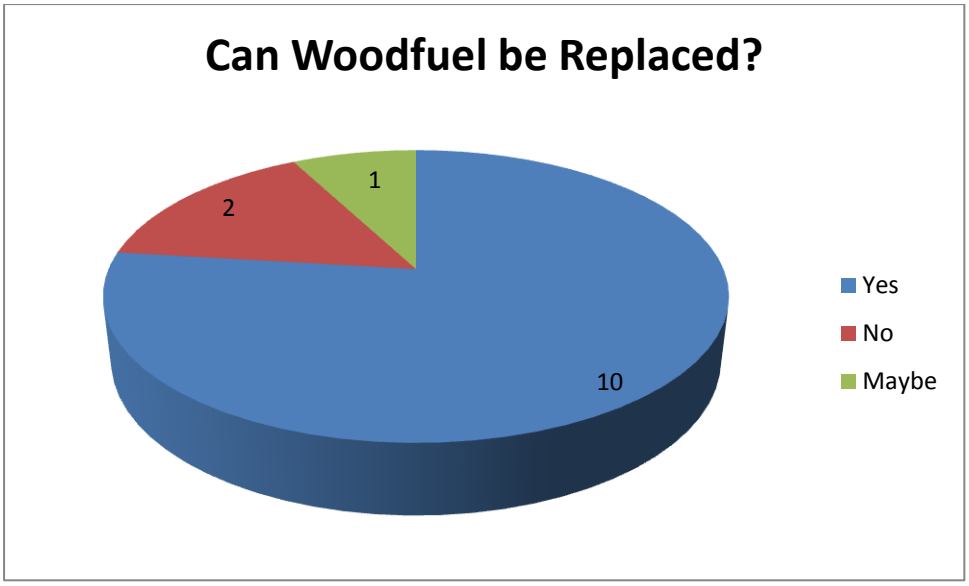


Fig. 5.1 Demonstrates the level to which the key informants view the substitutability of woodfuels.

However, 2 (15%) answered in the negative indicating this is not possible whilst one respondent (8%) was indifferent. Thus there is an overwhelmingly constituency, within key informants community which see it feasible to substitute the heavy dependence on woodfuels.

A.Household Interview

Table 5.1 Educational level of respondent and fuel used

Educational level of respondent	Per%	Fuel used	
No formal education	72.7	Fuelwood	81.8 %
At least basic education	27.3	charcoal	18.2 %

Table 5.1 indicates there is a low level of formal education in the case study area. Meanwhile there is a high correlation between the level of education (amonsgt other factors) and the choice of fuel used.

As part of the questionnaire, respondnets were asked to indicate their level of education. Of the total number of households interviewed 72.7% had no form of education and this combines with another 9.1% out of the population with at least basic education to represent 81.8% dependency on fuelwood. Also 18.2 % of the 27.3% respondents with at least basic education rely mainly on charcoal.

Fig. 5.2 Relationship between educational level and fuel used

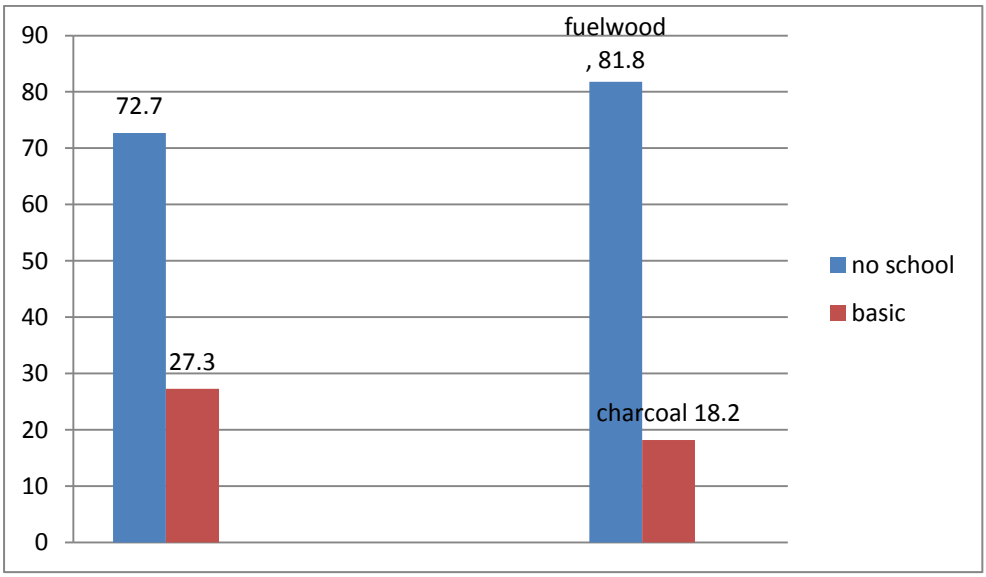


Fig. 5.2 depicts the correlation between the educational level of respondents and the fuel type used.

The educated people used relatively advanced fuel (charcoal,gas) as per the *fuel ladder* in comparison to the respondents with no formal education (fuelwood). This suggests that educated respondents due to their attainment of knowledge and employment, have better income and could afford more expensive fuels in contrast to respondents without formal education.

In a quest to gain insight into factors influencing respondents' choice of fuel, they were asked their *What is/are your reason(s) for preference for choice of fuel?*

Fig. 5.3 Reason for Respondent's Choice of Fuel

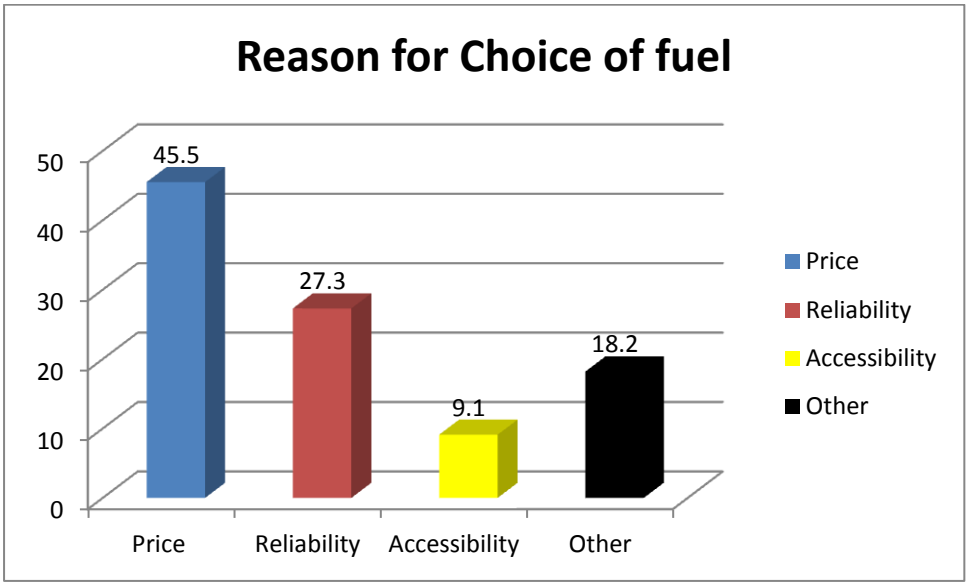


Fig 5.3 portrays the different reasons informing the choice of fuel used by the respondents. Cost of fuel was the main reason for the decision to adopt a particular fuel (45.5%), followed by reliability of the fuel type (27.3), other reasons relating to issues such as the safety of the fuel, ease of use represent 18.2% whislt accessibility was the concern of 9.1% of the respondents.

In the face of these factors, it was imperative to assess the willingness of respondents to adopt modern cooking technology. Thus *Would you embrace a different cooking device?* was a lead question to appraise participants readiness to substitute for improved cooking technology. This was closely followed by *Which cooking device would you prefer if you could afford?*

In general, respondents indicated their willingness to adopt modern cooking technologies should they be in a situation to afford it. Hence 72.7% of respondents registered their desire to shift to cleaner cooking options whilst 27.3 suggested they preferred their current choice and would not be willing to make a substitute for other options.

Fig. 5.4 Willingness to Adopt New Technology

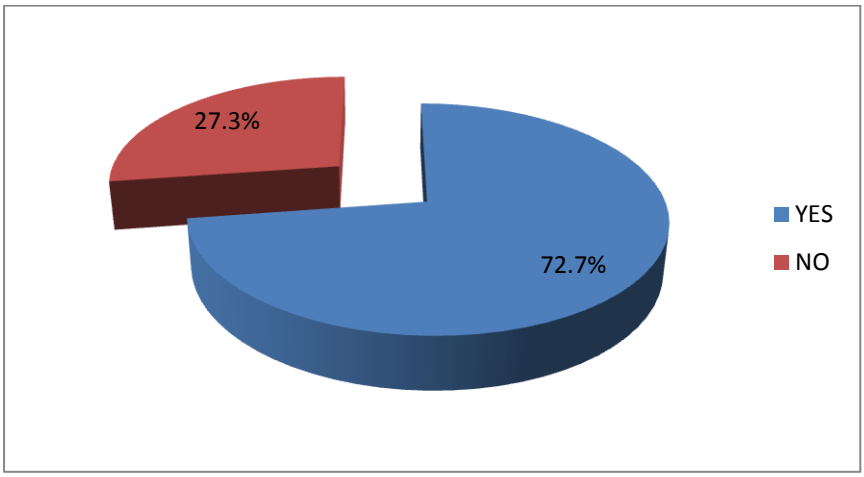


Fig 5.4 Showcases respondent's willingness to shift to cleaner fuels. The general goodwill for modern fuels suggests respondents will be receptive to cleaner fuel options. This *willingness* however is shaped by factors such as *price,reliability, accessibility* which must be made bearable by the mediating institutions.

Respondents were also asked to indicate their primary fuel used and the size of their households.

Table 5.2 Main source of fuel of respondent and household size

		Range of household size					
		<5	5-10	11-15	16-20	>20	Total
Main source of fuel of respondent	Fuelwood	2	16	2	2	1	23
	Charcoal	4	1	0	0	0	5
	Gas	1	1	0	0	0	2
Total		7	18	2	2	1	30

Table 5.2 describes the relationship between household sizes and the type of fuel used.

Families using fuelwood have big family sizes, majority of them (16) within the 5-10 range, 2 within the 11-15 range, another 2 belonging to the 16-20 range, one household with members over 20 and 2 other households with members less than 5. On the otherhand families using charcoal were mostly with members within a range of 5 with only one house within the 5-10 range.

Of the two families using gas as a fuel source, one was within the 5 range and the other fell within the 5-10 size range.

Though Ellis (2000),argues that, *labour* is one of the main assets in the rural livelihood context, the families with larger households will require greater fuel quantities to prepare meals which will demand more income unlike the smaller households. The increased expenditure on fuels will further strain their income. Thus reliance on free fuelwood is a *coping strategy* which helps reduce their *vulnerability*. As different villages were involved in the case study with different populations and level of development, it was interesting to know if there were any significant variances in the use of fuel as per dwelling area of respondent.

Table 5.3 Main source of fuel and location of respondent

		Name of village of respondent					
		Bowena	Damango	Mognori	Murungu	Yazori	Total
Main source of fuel of respondent	Fuelwood	9	0	4	5	5	23
	Charcoal	0	4	1	0	0	5
	Gas	0	2	0	0	0	2
Total		9	6	5	5	5	30

Table 5.3 describes the use of fuel based on the location of the respondent. Statistical analysis produces a Pearson Chi-square significance value of 0.001 ($P<0.05$). This result is highly significant and indicates the use of fuel per location is not by coincidence. Thus there is a very high correlation between the location of the respondent and the type of fuel use. The use of fuelwood is predominant in the rural areas such as Bowena(9), Mognori(4), Murungu(5) and Yazori (5). In contrast, the use of charcoal is more prevalent in Damongo the district capital which also records the only households using LPG gas as household fuel.

Several of the literature consulted (eg MPMP,2011 pg 44) also suggested that fringe communities turn to the park to meet their fuel needs due to shortage of woodfuel sources beyond the borders of the park. Thus the case study also afforded the chance to inquire how proximity of a locale to the National Park may affect the number of hours spent searching for fuel which would in turn give an indication as to how prevalent this phenomenon is within the fringe comunities as depicted in table 5.4. Furthermore, the time spent in searching for fuel is an opportunity cost as it could have been used in more productive ventures which would help improve their livelihoods. Consequently *How much time do you spend in searching for fuel?* was a question posed to respondents to gauge this view.

Table 5.4 Number of hours spent searching for fuelwood

Table 5.4 denotes the number of hours invested in the search of woodfuel by respondents from various locations. An SPSS statistical analysis produces a Pearson chi-square significance value of

		1	2	2.5	3	3.5	4	4.5	5	Total
Fuelsource	Fuelwood	2	6	2	6	1	2	1	3	23
	charcoal	0	3	0	2	0	0	0	0	5
	gas	0	2	0	0	0	0	0	0	2
Total		2	11	2	8	1	2	1	1	30

7.850 (P>0.05), which is insignificant. This outcome suggests there is no correlation between the location of a household and the number of hours spent in search of fuel.

This indicates that the time invested to find fuel in a fringe community such as Mognori (o km from the park),does not differ from Bawena (5 km from Park) ,Murungu (8 km from park), nor Yazori (14 km from park) bordering the Mole National Park.

Thus respondents generally spend between 2-3 hours in search of wood irrespective of location. This infers people in the fringe communities avoid the park and gather woodfuel at a different location which is good for the purpose of conserving the park's resources. The Table also posits that conservation education by organisations like AROCHA (MPMP 2011,pg 74) has made positive impact amongst fringe communities or that park managment has beefed up security and law enforcement to deter abuse of the park since 2011 when the last Park Management Plan published. The law/policies, Park Managment and other organisations like AROCHA, belong to the *mediating institutions* which are building on rural human resource *asset* to improve conservation. It is encouraging to note that respndents referred to the park as a *'protected area'*, *'restricted area'* where they are thus forbidden to harvest wood.

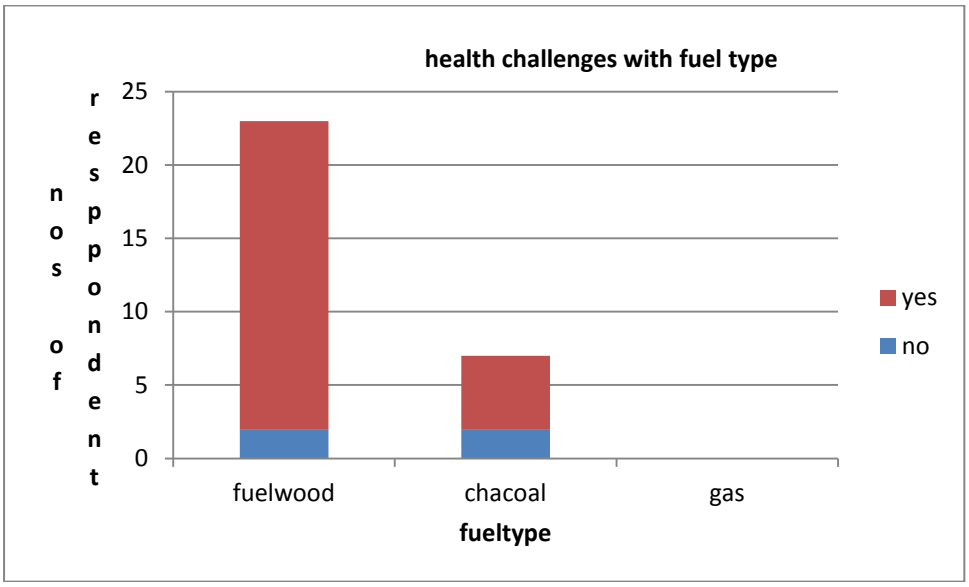
What do you detest about your choice of fuel? Was a lead question which attempted to capture respondents' challenges with their current use of fuel as in Table 5.5. The table indicates that excessive smoke is the main problem respondents have with woodfuels.

Table 5.5 What respondent detest about the use of fuel

		What respondent detest about the use of fuel				
			0	Smoke	Others	Total
Main source of fuel of respondent	Fuelwood	0	1	15	7	23
	Charcoal	1	0	2	2	5
	Gas	0	0	1	1	2
Total		1	1	18	10	30

Other concerns they mentioned include teary eyes due to smoke, catarrh, pots getting blackened, walls being defaced. The key concerns captured in the above table emphasized the fact most of the respondents had suffered a health challenge due to the use of fuelwood and charcoal as showcased in Fig.5.5 below in response to the question *Have you had any health challenge related to this method of cooking?*

.Fig. 5.5 Health Challenges with choice of fuel



Of 23 respondents using fuelwood, 21(90%) respondents reported health challenges. Also 5 (71%) respondents out of 7 charcoal users indicated they have had health challenges with use of charcoal. Only gas users reported no health challenge. This suggests charcoal is comparatively cleaner than

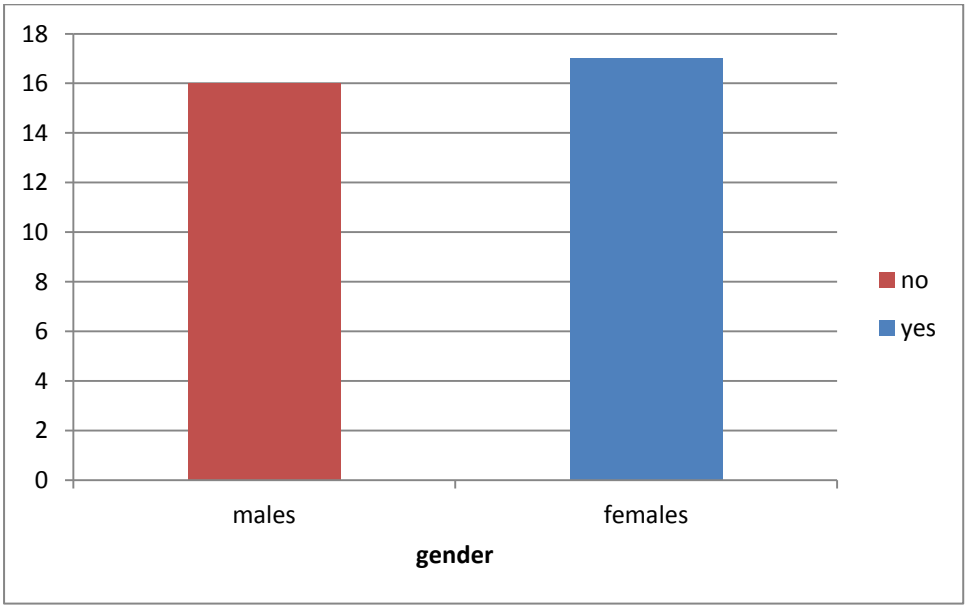
fuelwood and thus poses less threat to the health of respondents and therefore will be less detrimental to their livelihood.

In a quest to find if there were peculiar traditional dishes which required particular fuels as alluded to in some villages in Sierra Leone, respondents largely indicated that scenario does not exist.

C. Group discussions

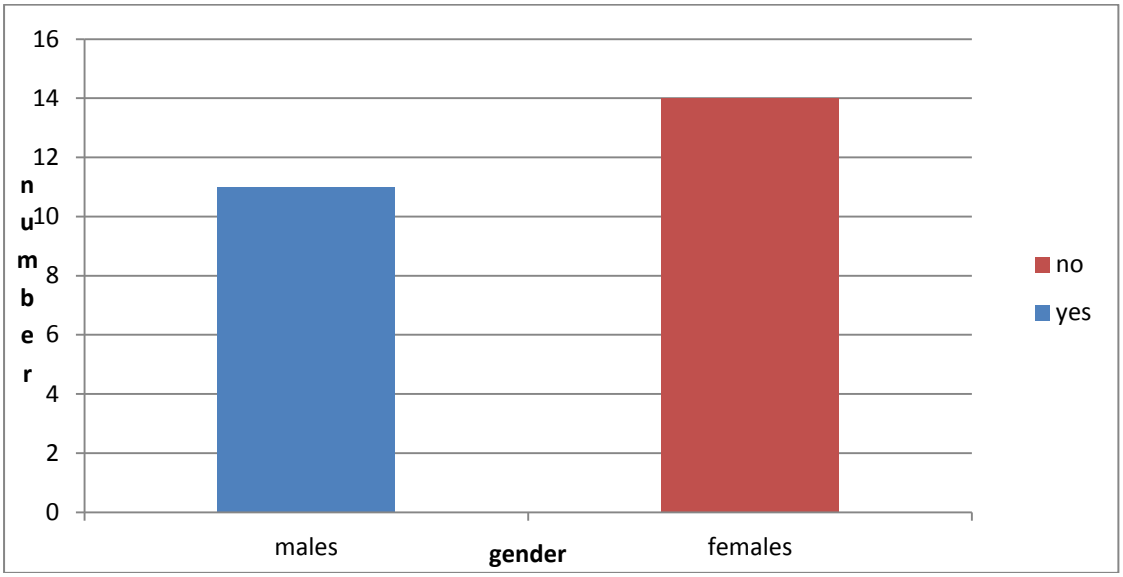
Children are one of the major stakeholders in the household fuel dynamics as they are often sent to harvest and port fuel as well as help with its preparation but gender roles are highlihted below in Fig 5.6. The shool kids in the group discussion were asked to indicate their role in household as per woodfuels.

Fig. 5.6 Relationship between Gender and Fuel Collection



In Mognori, out of the total 33 respondents, all 16 males (100%) indicated they are not sent to fetch firewood. They rather assist their parents on the farm. All the females 17(100%) on the other hand reported that they are sent to collect firewood for the house.The same scenario was recorded in Bowena where out of 25 respondents, all 11 males revealed they do not search for fuelwood in contrast to the 14 females who admitted being sent to collect firewood.

Fig 5.6 Relationship between Gender and Charcoal Production



The focused group discussion at Bowena also revealed that charcoal production is a task of the males. Thus out of 25 school going kids, all 11 males are into charcoal production whilst all the females(14) are not.

The results highlighted herein will be filtered within the framework of the main theories in the following chapter to address the research questions.

Chapter 6 ANALYSIS & DISCUSSION

This section will perform an analysis of the case study results from the previous chapter 6 and lead to the research conclusions. The discussion of the results will be premised on the analytical framework described in the Theory chapter; mainly the *sustainable livelihood framework* and supplemented with the *appropriate technology concept*. In addressing the main research question; ***How can charcoal as a basic source of household fuel be fully or partly replaced; and what materials in the study area are available for developing alternatives?***

The individual level:

Change in Attitudes: Erik van de Giessen a senior programme officer for Africa dealing with water, sanitation and health at the Dutch NGO, SIMAVI states that a lot of awareness needs to be done to sensitise people on the harm of woodfuels. This is an important remark given that people have been used to collecting fuel free of charge and thus making the shift will involve a lot of education (Giessen,2013). The importance of awareness cannot be overemphasized, respondents who indicated a likeness for clean fuels like LPG had been exposed to it at a different location.For example a respondent in Murugu used charcoal always because she was once married in the southern part of Ghana, where charcoal use is more popular. Upon return to the North, though all the other respondents use firewood, she sticks to charcoal because she is used to it. Other respondents who opted for LPG had seen their relatives use it in urban towns and thus preferred it. The positive exposure of the respondents to modern fuels in this case is an *asset* whiles the mode of cooking fuel they witnessed in other locales is in the *transforming process* category and enhanced their receptivity to adopting modern fuels compared to their neighbours. This goes to underline the crucial role of sensitisation.

In the context of appropriate technology, Giessen (2013) indicates change is a gradual process thus to make it more attractive it must be incremental. Thus SIMAVI is introducing propane bottles which can be used like gas cylinders. The propane bottles are smaller than the gas cylinders and cost less to fill. Given that people in rural areas gather fuelwood for free this would be more attractive to them in terms of cost compared to relatively bigger and more expensive gas cylinders (Giessen,2013). Similarly Frederik Appiah of Ghana's Energy commission indicates reducing cylinder sizes into bottles in the near future. He adds that the commission is designing a adistribution plan where for example a consumer takes an old bottle and send to retailer in return for a new one. This is parallel to the practice of *bottle picking* whereby people pick old bottles for the breweries in return for money in many parts of the country. Furthermore, the government will provide the bottles free of charge whiles consumers only pay for the content (Giessen,2013).

Closely tied with awareness creation is the role of education.

Formal education: discrimination against girl education manifests in women with less educational levels compared to men,causing gender disparity in human capital. The result is that women are unable to adequately take advantage of opportunities which demand prior educational qualifications. Hence women are more prone to engage in unskilled labour markets related with poor wages and job security (Ellis 2000,pg 158). The high correlation between educational level and type of fuel used also indicates that, improving educational levels in the rural areas will go a long way to help change people's preference towards use of cleaner fuels. Daryl Bosu of AROCHA infers that when the locals (especially girls) have good education (*livelihood asset*) it enhances their employment prospects (*livelihood strategy*) and consequently income levels *(livelihood outcome).* Thus they will be able to afford and make a switch to modern fuels as evidenced in the Damongo. (Bosu,2013). Two school teachers at the district level,Nicholas Tikah and Martha Subia (Damongo LA Primary and Bowena Primary/Junior High School respectively) also highlited the negative effect of woodfuel collection on the school children. The children spend labourious hours searching for fuel and do not do their homework nor pay full attention to their education. Some get cutlass wounds, allergies, burns from charcoal production and other health challnges which makes them absent from school for some time. Furthermore, in times of shortage, some parents have prevented their children from going to school to search for fuel, whilst others come to the school and request their kid quit class to help find fuel for the home (Tikah,2013:Subia,2013). Moreover, it is common place to find students sleeping in class due to the effect of the woodfuel collection.

Bosu (2013) adds that given the fact these rural areas are without electricity, taking advantage of the sunlight to study would help the pupils, however as they have to go searching for fuelwood, they then struggle at night with poor light from lanterns and lamps (including strret lamps), which does not augur well for their health and education (see appendix). Documents from the District Assembly Medium Term Development Plan (DAMTDP) indicate that at the nursery levels there is a higher enrolment of girls than boys. However at the senior high school level there is a reversal such that male enrolment is twice that of females(DAMTDP, 2010-2013 pg 53). Given the crucial roles of women at the household (*livelihood asset*) level vis à vis the use of fuel, their education (*transforming process*) will greatly enhance a shift towards modern energy choices (*increased wellbeing*).

Appropriate technology makes use of local human resources in developing and managing technology. Thus Michael Kweku Commey of the Technology,Consultancy Centre of the Kwame Nkrumah University of Sceince and Technology (KNUST) suggests that education of the girlchild will help them

provide positive feedback which can feed into design of cooking technology as they use it most. In the broader context formal education will ensure that there is always available human resources which can manage and constantly develop technology to meet the needs of rural households. Furthermore, the adoption of curricular in renewable energy or clean energy by educational institutions will further boost knowledge and skill. Students can be encouraged to take internships in the rural areas and be rewarded with credits or other incentives developed with corporate institutions. This practical experience will all go a long way to developing human and institutional capital for developing and managing cleaner fuel options (Commey,2013).

Alternative livelihoods: in sub-Saharan Africa, household dependence on agriculture (*livelihood strategy*) reduces with increases in income levels (*livelihood outcome*). Thus households with more varied income sources are relatively economically sound (Ellis 2000 pg 233). However , the domestic obligations of women leaves little room for diversification (*high vulnerability*) into non-farm activities(Ellis 2000 pg 149). The marked difference between households in Damongo and the rural areas posits that alternative livelihoods (*livelihood strategy*) are needed to serve as catalysts towards cleaner fuels. Consequently the planner at the District Assembly explains that most of the women due to lack of formal education are unemployed (*high vulnerability*), and resort to fuelwood collection (*coping strategy*) to make money and supplement household (*improved livelihood*) needs (Sampson 2013).

Well designed and managed alternative livelihood strategies have successfully enhanced the living standards of the rural poor (AROCHA,2007). Thus both the Park Management Plan (2011) and the West Gonja District Assembly Medium Term Development Plan (2010-2013) point to alternative livelihood as a possible solution to engaging the women folk in gainful emplyment so as to improve their livelihoods. Nti (2013) adds that women's enhanced income (*livelihood outcome*) is also beneficial for household food security and child nutrition (*improved livelihood*). Furthermore it greatly improves family health indicators (*reduced vulnerability*), (Nti,2013;Ellis 2000 pg 146). Currently, case study results indicates women spend about 2-3 hrs in search of fuelwood (*coping strategy*) in a day. This time could have been invested in more productive ventures (*livelihood strategy*) such as bee keeping, dress making, grass cutter rearing (MPMP,2011pg75). A shift to modern energy options will enable women to add value to their time and consequently improve their livelihood.

Given that all respondents complain of health problems (*high vulnerability*) related to the use of woodfuel, it is not surprising that acute respiratory infection (*shocks*) is the second leading cause of disease(*shocks*) in the area after malaria (DAMTDP, 2010-2013 pg 56). However access to cleaner

energy options will thus greatly reduce susceptibility to acute respiratory infections(*reduced vulnerability*) and consequently help reverse the negative health indicators (*improved livelihood*) in the district (Sampson,2013;Bosu,2013).

Male and female livelihoods in the rural setting is interwoven, premised on gender relations (*transforming process*) which include the division of labour(*transforming process*). These labour divisions are constantly evolving as circumstances change (AROCHA,2012). The resultant effect of these labour division is *occupational segregation* and *wage differentials*. Thus jobs deemed 'female jobs' are associated with feminine characteristics such as 'dexterity,docility,patience,caring,ability to cook'(Pearson,1998). Consequently women gravitate towards jobs in the 'service industries,caring professions,secretarial and clerical occupations as well as domestic service' (Pearson,1998). In contrast men are often engaged in the 'manufacturing,self employment, construction,skilled labour' (DAMTDP,2011)). Rural women seldom find employment in the formal sector, however opportunities abound in the informal sector in areas such as dressmaking,food preparation, textile production,beekeeping etc (MPMP 2011,pg 75).

Diversification due to the adoption of alternative livelihoods will also have a positive impact on *conservation* as it will reduce pressure on natural resources due to the abundance of options. The heavy reliance on woodfuel is having a negative impact on rural agriculture which is the main income source of the rural community. The cutting and felling of tree cover has led to rampant erosion of topsoil and loss of soil fertility. The habitate of wild animals have also been negatively affected (MPMP,2011; SNEP 2012). A survey conducted within the fringe communities of the Mole National Park indicates that communities attest to the drastic loss in animal populations and vegetation cover (*increased vulnerability*) over the years. Consequently animals that used to be commonly sighted are seldom spotted in recent times,whilst areas that used to be carpeted with thick vegetation are now bare (AROCHA,2007). Diversification will however limit the pressure on environmental resources (*reduced vulnerability*) due to *collection and gathering* by rural dwellers(*coping strategy*) and hence boost conservation efforts (Park Management Plan,2011;Ellis 2000;SNEP,2012). This phenomenon of collection and gathering embraces '*firewood collection ,charcoal production, gathering wild fruits and vegetables,and hunting wild animals'* which represent the least return activities as per the rural economy (Ellis 2000 pg 137). The adoption of alternative livelihoods with their attendant increased income (*livelihood outcome*) per labour will be an incentive for switching labour time from these activities. Furthermore, enhanced income may facilitate switching in consumption patterns such as

kerosene substituting firewood, or LPG gas replacing charcoal as per the fuel ladder (*improved livelihood*)etc (Appiah,2013;Giessen,2013;Kemesuor,2013).

Accounting for Tastes and preferences; meeting the taste and preferences of consumers is vital to keeping their loyalty for a product. Thus the Clean Cookstoves Initiative (2012) suggests *'Cookstoves will need to accommodate round-bottom pots and specific stove models need to be created for each fuel type'.* Frederick Appiah of Ghana's Energy Commission is thus skeptical of woodfuels being replaced by modern energy options. He adds that aside the cooking habits and food types which differ across the nation, people have developed preferences for tastes associated with certain fuels (*influences and access*). He explains further that some people prefer charcoal-grilled fish to gas-grill due to the flavour the charcoal adds to the fish which makes it a delicacy (Appiah,2013). This view is opposed by the head of the Consumer Sciences Department of the University of Ghana, Professor Christina Nti who explains that the flavour attributed to charcoal grilling are due to deposits resulting from chemical reactions of substances in the wood. Furthermore, this has no added nutritional value but can have negative health implications (*increased vulnerability*) when the deposits are too much over time (Nti,2013).

Moreover those flavours can be extracted by food scientists and applied artificially during gas grilling to produce same result (Nti,2013). Experience from domestic grasscutter rearing for example (part of my undergrad thesis), suggests that people consider wild grasscutter as a delicacy compared to the farmed breeds due to their lean size and peculiar taste. Thus though grasscutter rearing has become popular in Ghana and produced positive results as a way of reducing pressure on wild populations so as to conserve them, there is still widespread hunting for wild game. If results from grasscutter farming are anything to go by, then the suggestion by Nti (2013) though valid and plausible, may help reduce use of woodfuels but will not be embraced across board. During the interactions with households the closest I came to specific fuels being used in cooking particular foods was the preference for cooking rice with charcoal instead of firewood due to the fact that the smoke from firewood spoils the taste of the rice. Also respondents indicated they prefer cooking *Tuo Zaafi* which is the main staple in the case study area on firewood because of their large household sizes, which necessitates cooking in very large pots. This suggests that the issue of specific fuels being used for particular dishes is not major issue thus far in the case study area.

On the issue of design of cooking stoves and the type of pots used in Ghanaian households as per appropriate technology, Commey(2013), explains that gas stoves can be fitted into the hearth or three stone cookstoves so people can still cook their preferred dishes despite the shape of their pots

(Commey,2013). In Damongo, a respondent confirmed her usage of LPG to cook *Tuo Zaafi* , a local delicacy which lends credence to the assertion by Commey (2013).

Thus far, the case study results indicate that the usage of woodfuels has detrimental effects on household assets. These assets; labour, health, local knowledge and practices are invaluable to rural livelihoods and form the asset base of the sustainable livelihood framework at the micro level. This asset base forms the fundamental building blocks upon which the other dimensions of the framework are built.

Plate .6.1 Design of Pots and Cookstove design:

Woman cooking with a round bottom pot

Source: (CleanCookStoves,2012)

Source: Fieldwork

Moreover, application of the livelihood framework indicates that encouraging the rural poor to seize opportunities or create their own opportunities is far more cost effective for poverty alleviation than targeting peculiar sectors of rural economic activity. This goes to underscore the crucial role of *access* in the framework of rural livelihoods (Ellis 2000pg 233). In the livelihood framework, the assets and their possible uses are mediated by social factors (like government institutions, private organisations) and shocks (such as personal misfortune and disease) . Thus besides the asset base where individuals fall, institutions and organisations also have a role to play. The following outlines the role of such bodies in enhancing rural livelihoods as per their energy needs.

B. Government level:

Remoteness is related with increased poverty and less livelihood opportunities, thus it is plausible to target remote locales when devising policies and projects for addressing the rural energy challenge.

The case study area is largely remote, settlements are mainly dispersed and inaccessible especially during the rainy season. In addition, out of the overall 432.5km road network, majority of the roads are in a bad state and immotorable in the rainy season. Hence not more than 0.03% of the district roads are motorable year round except in the Damongo Township. Apart from the Damongo town roads, there is no single tarred road in the district. Most of the roads in the district are feeder roads and are often flooded and impassable during the rainy season (District Assembly Medium Term Development Plan,2013).

Roads in the area constitute the *physical capital* component of sustainable livelihood framework which require improvement by government as a *mediating institution* to facilitate access and thus enhance the rural energy needs. Tarring of the roads will open up the district to investors and tourists. Giessen (2013) posits that the poor nature of roads (*physical capital*) has prevented many energy companies from venturing into the rural areas due to the added cost and low output on returns (*influence and access*). Commey (2013) concurs and adds that improvement in the road sector will greatly change the cost of doing business in the case study area. Price and reliability were some of the main concerns of respondents. Improved roads will ensure that prices of modern fuels are affordable for the rural poor and afford timely delivery of energy services to guarantee the reliability of such services. Case study results indicates the relationship between location of respondent and type of fuel used was also significant. Respondents from the rural areas used mainly firewood whilst in Damongo (District Capital) there was a marked shift towards use of charcoal and LPG.

Assets the possession or lack of assets is crucial to livelihood strategies, thus policies and projects must target people with a poor asset profile to enhance their income as they represent the more vulnerable group of society. The health of the rural folk, labour, knowledge systems all fall under the *asset component* of the sustainable livelihood framework. Ellis, (2000) refers to labour as a crucial ingredient in the rural livelihood patterns. The use of woodfuels however is destroying these assets. Acute respiratory infection associated with woodfuels is impacting negatively on the health of the respondents and this translates into poor labour output and shortages (*increased vulnerability*). Consequently there is a high mortality rate (*shocks*) amongst the vulnerable societal groups directly involved in the use of woodfuels; women and children (DAMTDP,2013 pg 60). The use of modern fuels will therefore help to reverse this situation so that the labour of the rural areas will be developed for the benefit of sustainable development. In addition, the high sunlight radiation, agric waste are other assets which can be developed to meet the energy needs of the area (Bosu,2013).

Substitution Francis Kumausuor of the Energy Centre of the KNUST, the option of shifting between assets and activities is a vital component of feasible and resilient livelihoods. The presence of a diverse asset portfolio and markets afford the transfer of assets and boosts their substitutability. Thus the ability to shift between activities enhances the resilience of livelihoods in the face of shocks (Kumausuor,2013.)

Poverty varies with respect to the total assets a household has at its disposal. Hence a household may have abundant human capital for example but deficient in another such as land. The chance to convert one type of resource into another may differ remarkably. For instance if an energy resource such as firewood can be converted into another asset such as land, then dependence on the former resource will lessen with time. However, if no such chance for substitution exists then dependence on the original resource will rather intensify (Kumausuor, 2013). The abundance of modern fuel options in the rural energy mix will therefore help reduce dependence on woodfuels and make it much easier for rural households to make the needed shift (Kantara,2013). Furthermore, there is a high willingness to substitute to cleaner fuels (72.7%) at the household level which is beneficial for the purpose of shifting to modern fuels. However this positive indication by respondents must be assessed in the context of their reasons for choice of fuel viz: price, reliability,accessibility etc. Some respondents indicated they had to shift from LPG gas to the use of charcoal because they had to travel long distances (*influences and access*) to get gas, this coupled with frequent gas shortages (*shocks*) made charcoal more attractive.

Options are vital; poverty often ensnares people such that they have no alternatives, thus poverty reduction demands enlarging the array of choices and options available. This can be realized by initiatives to enhance information flow, mobility and limit regulatory restrictions on viable courses of action. Edward Antwi and Joseph Francesco Raviera of the Mechanical Department of the Kumasi Polytechnic both indicate that currently there are too many bottlenecks in the energy sector which makes the cost of doing business too high. They opine that government relaxing import demands on renewable energy components will greatly encourage the private sector as well encourage more people to go into renewable energy options. This will increase energy options and address the rural energy challenge and improve livelihoods (Antwi & Riviera,2013). When the import duty on renewable enrgy components are reduced, then the private sector can adapt technology to local use at lower cost which increase energy options at the rural level.

Antwi & Riviera (2013) also explain that with apprpriate technology,they are producing a fuel known as *gel fuel* . The gel fuel looks like the that of a toothpaste which can be used in place of charcoal,by

putting a bit on a cookstove and lighting it to cook, however the cost makes it beyond the reach of most rural popualtions.

Knowledge of the livelihood patterns of a constituency to which a project is tailored is another important factor. This is one purpose of this project as afforded by the visit to the case study site (Kantara,2013). Understanding the norms and values of a people enhances success and resilience of livelihood enhancement programmes (Kantara,2013). Furthermore it reduces hostility of local peoples to social interventions as it takes into account their peculiar culture and lifestyles (UNESCO,2002). A local chief surmises that trees, such as shear tree (*vitellaria paradoxa)* and dawadawa (*Parkia biglobosa*) are prohibited for woodfuel due to the economic value attached to them by the local authority. Infringement comes with a corresponding penalty to deter its use. Gender roles in energy use, local traditions and prohibitions related to fuel as highlighted by this project for example, should be taken into account in the design of policies targeted to such rural areas (Kantara,2013).

The thematic areas of remoteness, substitutions,assets,options and knowledge refer equally to both government and the private sector. The next section will touch briefly on peculiar roles of the private sector.

C Private Sector:

Giessen (2013) postulates that in sub-Saharan African countries there is a relatively less proportion of local risk-taking entrepreneurs (*human capital*) to take over medium and large scale industry(*physical capital*). This scenario has led to a situation where business ownership is concentrated in the hands of a few domestic elites which has stifled competition (*transforming process*). Both Commey (2013) and Kemausour (2013) concur with this assertion.

The private sector will thus have to be less risk averse and venture into the energy sector. When conditions are favourable such as good roads and policies, the private sector will automatically move into energy production (Giessen, 2013; Commey 2013). The Energy Commission suggests private organizations involved in the energy sector have united (*social capital*) to form an organization to help shape policy and also enhance streamlining of standards (*transforming process*) in the energy sector (Appiah,2013). This will ensure high quality fuel is delivered to the rural communities and facilitate the adoption of clean production techniques. Though the private sector is making progress in attempting to satisfy the household energy demand with, clean-efficient fuels (solar, briquettes, gas) there is still a gap between demand and supply (Energy Commission,2012). This gap will be effectively bridged through effective collaboration between the key mediating institutions such as government and the private sector.

The following section looks at some of the materials (*natural capital*) in the local area which can be used to produce modern fuel alternatives to satisfy the energy needs of the rural households.

D.Local Materials That can be Developed into Producing Fuel Alternatives

Forest Plantations: land, a physical asset in the case study area can be used for forest plantations which will help reduce pressure on forest reserves (*natural capital*). Wood species which reproduce faster and produce much denser and efficient fuel (such as bamboo) can be planted to improve house energy in the rural communities (Appiah,2013).

With regards to appropriate technology,he adds that the Energy Commission is promoting sustainable woodlot cultivation with a pilot project at Egyirapa. Moreover the production technology is being enhanced. The traditiaonal *carbonisation technology* using the earth mound is inefficient thus it wastes a lot of wood to produce little charcoal. Consequently, the Energy Commission is promoting the use use improved technology like the cylindrical metal kiln, brick kiln which produce much denser fuel and are more efficient in their wood to energy conversion (Appiah,2013).

Plate 6.2.Bamboo Charcoal **Plate 6.3. Briquettes**

Source: field work (2013)

Waste to energy: not all parts of the felled tree are used for charcoal production; for every tree felled about 20 - 30 percent goes into 'waste' (Energy Commission,2006). The abundance of agricultural wastes such as corn husks, millet husks, animal dung points to usage of briquettes. These briquettes are much denser and the production is efficient. The briquettes produce little pollution and make use of abundant waste materials (Kemausuor 2013, Commey 2013). This is in line with appropriate technology concept of using readily available local materials to limit production costs.

Plate6.4 Saw dust **Plate 6.5. Corn Husks** **Plate 6.6.Waste to energy cookstove**



Source: field work (2013)

Solar energy: Solar energy has been ustilised for electricity generation, drying of crops and water heating, however not on a large scale (Energy Commission,2012). The Kumasi Polytechnic currently has produced a solar cooking stove and oven. However the challenge with this device is that ,it can only be used with good solar radiation. Thus on cloudy days, or other parts of the day with low solar radiation this is not possible. This device can therefore be used as a complement to other stoves (Raviera,2013; Antwi,2013). The abundant solar energy is *natural capital* as per the sustainable livelihood framework which mediating institutions like the Government and Research Institutions can transform via appropriate technology into modern fuel options as is being done by the Kumasi Polytecnic.

On the whole there are varied possibilities for reversing the present heavy dependency on woodfuels, however the main challenge is with making these alternatives accessible to the rural households. This is one vital role of the mediating institutions like government, companies and organisations of the private sector.

The proceeding chapter deals with the main findings of the project and suggested areas for further research.

Chapter 7 Conclusions and Recommendations

This chapter sums up the discussions in the preceding chapters of the study. It presents a summary of the object and results as well as presents the recommendations made from the results.

7.1 Conclusions

Accessibility to energy is vital to enhancing people's living conditions, and important for economic and human development. Energy supplies services to satisfy several essential basic human needs (cooking, heating, light). Trade, commerce and public services viz ; modern healthcare, education and communication are also highly reliant on access to energy services. Hence there is a high correlation between the lack of energy services and key poverty indicators. Access to energy has therefore assumed priority in the post-2015 development agenda of the United Nations as a means of sustainable development filtering to the bottom of the pyramid. Majority of Ghana's energy is obtained from biomass; hence more than 80% of households use biomass as their primary cooking fuel. The country is home to several improved cookstove devices as well as clean energies such as gas and electricity. In addition,alternative energy options have been developed whilst others are at an advanced stage of development such as briquettes, bamboo charcoal,propane gas bottles,solar cookers,waste to energy amongst others, however they are not yet accessible to the rural populace. Moreover,these are beyond the financial means of rural households where woodfuels usage is predominant. Hence in Northern Ghana and rural areas, traditional wood stoves, like the three-stone fires and mud stoves, are most common.

The study sought to investigate how the current unsustainable dependency on woodfuels could be reversed as well as explore the materials in the local area which could be used to develop alternatives. Results indicate that reversing the current levels of woodfuel use is possible to the bearest minimum. This will involve change in attitudes, massive education/awareness creation, alternative livelihoods as well as taking account of the tastes and preferences of individuals. Government and private sector must adopt proactive policies bordering on remoteness,assets,substitution,options,knowledge. However the private sector in particular needs to take more risks in the energy sector order to make inroads in providing modern energy services to the rural populace.

Improved rural infrastructure will greatly reduce cost of operations and improve accessibility to clean energy sources in the rural areas. Woodfuel usage is having a detrimental effect on critical rural

sources such as labour,land,health and education and thus development of human resources. Alternative livelihoods will help to diversify the asset portfolio of rural households and increase incomes to facilitate shift to cleaner fuels. Education has a positive effect women's employment as well as their choice and use of fuels. Awareness creation will greatly help sensitize people on the negative effect of woodfuels and help them make the shift to clean fuels.

Contribution to knowledge

Goldemberg (2004) as well as Zulu and Richardso (2013) suggest the fuel ladder to proceed schematically in terms of increasing efficiency as follows: dung/crop residues→fuelwood→charcoal→kerosene →LPG/natural gas/electricity but in the case study area the fuel ladder will be ; dung/crop residues→fuelwood→charcoal→kerosene →***solar***

Karekezi and Kithyoma (2002) allude to local customs influencing peoples use of fuelwood as in a village in Sierra Leone, however in the study area this scenario did not exist.

Gender roles of children: though children are key stakeholders their roles have not been highlighted, this study indicates male kids are into charcoal production whilst female kids are into harvesting.

Though the Park Management Plan (2011 pg44) suggests fringe communities rely on the park for fuel due to shortage of supply sources, case study results opines this may not be the case and not across board.

Jan (2012) reveals Pakistani women spend up to 6 h/day collecting fuelwood; Karekezi et al (2006), similarly indicate 3.3 h in Botswana, here in the case study area they spend between 2-3 hours.

Woodfuel and nutrition; vulnerable groups (the elderly and physically challenged) are in dire conditions in times of fuel scarcity.

7.2 Recommendations

The private sector needs to play more active role in energy sector and this will enhance competition.

Government needs to improve rural infrastructure and also roll out favourable policies such as tax exemptions which will encourage private sector participation.

There is the need for joint concerted effort between government and the private sector.

Educational institutions need to be proactive and develop curricular that responds to the energy needs of the country.

7.3 Suggestions for further research:

The impact of fuel scarcity on nutrition is one area which offered results with serious implications. One respondent was a physically challenged man with a wife and a little girl. His response indicates in times of fuel scarcity the entire family only drinks water and eats nothing. Another respondent, an elderly woman opines in times of fuel scarcity, she is at the mercy of neighbours and extended family members. The District Assembly Medium Term Development plan indicates these two respondents fall into the vulnerable groups category, whose population is increasing. Further research will help understand how this vulnerable group copes with rising fuel prices or fuel scarcity and what interventions can improve their plight.

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Chapter 8 Appendices

Appendix A : Questionnaires

Appendix B: Audio Interviews

Appendix C: SPSS Statistical Analysis and Excel files

Appendix D: Literature/ Documents

Appendix E: Field Work Photos

Appendix F: List of Resource Persons /Key Informants

Appendix E

Focused Group Interview

Household Interview

Three stone cookstoves

A hearth for cooking

Storage of fuelwood

Effect of woodfuel on cooking pots and buildings Courtesy call on a village chief

Effect of woodfuel collection time on education: student studying under street light

Briquettes students working on cook fuels saw dust for waste to energy

Saw dust for waste to energy

Solar Cookers