

Full Length Research Paper

Climate change mitigation: Challenges of adopting the green energy option in the Lake Victoria basin

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The search for green/renewable energy such as hydropower, wind power, geothermal power, solar electricity and biomass which are environmentally clean is aimed at diversification of the energy matrix, mitigating against climate change and providing alternatives to the use of fossil fuels (coal, oil and natural gas) which are associated with greenhouse gas emissions that cause global warming, environmental degradation and climate change. Though east Africa (Kenya, Uganda and Tanzania) lie within the tropics and have abundance of strong winds, receive heavy rainfall, abundant sunshine throughout the year and has many hot springs in the Rift Valley, the region has not been able to utilize these energy options due to many challenges. To come up with the challenges of climate change mitigation through green energy use, the study carried a research on energy sources available and used in the Lake Victoria basin and the socio-economic impact of using alternative sources of energy. The study established that: green energy sources were locally available, socially safe, economically affordable and environmentally friendly to all. It was found that 80% of the population use biomass energy. The improved stove and charcoal briquetting technologies were being used in Uganda and Kenya as some of the green energy technologies adopted, viable green energy technologies in rural areas were credited for reducing rural-urban migration, creation of jobs in the sector, and providing a platform for shared social and economic opportunities. It was also established that the following challenges hindered the adoption and utilization of other green energy options; remoteness of the location of hot springs, fluctuating rainfall regimes, lack of technical knowledge and lack of finances in trying to develop and use renewable energy sources as a mitigation to the vagaries of climate change. Charcoal burning contributed to global warming, deforestation of water catchment areas, reduced infiltration and drying of some rivers, for example, river sondu miriu in Kenya.

Key words: Climate change mitigation, green energy, fossil fuels, charcoal briquettes, improved stove.

INTRODUCTION

Green energy is a term used to describe sources of energy which are directly or indirectly linked to the sun and are renewable and can be replenished (Onyango and Ochieng, 2006). Green energy sources include biomass (plants) solar thermal, wind power, hydropower, solar electricity and geothermal energy. Solar energy (sun's radiation) is a free and viable natural resource

particularly in Africa which has 12 h sunshine. Climate change mitigation is the deliberate adoption of possible actions which involve reduction in the concentration of greenhouse gases either by reducing their sources or by increasing their sinks. Mitigation, therefore involves attempts to slow the process of global climate change by lowering the level of greenhouse gases in the atmosphere. Good examples of such deliberate mitigation actions include planting of trees that absorb carbon-dioxide for photosynthesis use, switching to alternative energy sources such as solar, geothermal and bi-fuels

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(green energy options) instead of fossil fuels. Energy in all forms (renewable and non-renewable) is the driving engine of all socio-economic growth for all nations. Many countries in the world still depend on fossil based fuels for energy generation. These fuels are associated with greenhouse gas emissions, environmental degradation and global warming and climate change. Global warming is a major concern world wide leading to formulation of many conventions such as the United Nations Framework Convention on Climate Change (UNFCCC) and several protocols such as the Kyoto Protocol of 1997 and the Clean Development Mechanism (CDM) of 2006 all aimed at reducing greenhouse gas emissions by searching for and providing more environment friendly energy sources. The increased move towards green energy use especially biofuels was spurred by the 1974 to 1979 tenfold oil price increases which threatened the economic stability of oil-dependent countries and the world (Amaral and Pezzo, 2007). The school of thought promoting voluntary and mandatory use of biofuel in diesel and gasoline engines in the transport sector states that it leads to the reduction of greenhouse gas emissions, mitigates against climate change and also generates income for farmers producing diesel and ethanol crops. It is documented that the Lake Victoria region is endowed with abundant renewable energy sources such as biomass, solar, wind and hydropower. Biomass in the form of fuelwood, charcoal, and agricultural residues is the most abundant source of energy in the region. However the cutting down of trees, burning of charcoal and land clearance for cultivation have led to serious fuel shortages which call for the search for other green energy options which will reduce deforestation, land degradation and greenhouse gas emissions.

Hydropower is a major source of energy within East Africa region. Hydropower is however highly vulnerable to fluctuations in rainfall such that too little rainfall leads to droughts while too much leads to floods. The consequence of drought is; low water levels in the dams for electrical power generation leading to huge economic losses and negative economic development of a nation such as power rationing for industries and redundancy of factory employees whose operations are electricity dependent.

On the other hand, too much rainfall often lead to floods that pose threat to dam breakages and siltation leading to reduced power generation (ICPAC, 2006). There are many rivers with water falls in the region such as Nile, Omo, Nzoia, Athi. Tana and Rufiji; there are hot springs in the rift valley region; strong winds in the lowlands and heavy plant diversity in the varied climatic zones. Biomass is the organic matter in trees, agricultural crops and other living plant material, it is solar energy stored in organic matter. Biomass is a renewable energy source because the growth of new plants and trees replenishes the supply (<http://www.oregon.gov/energy>,

2008).

If these energy resources are appropriately harnessed, they can be vital energy resource for mitigating against global warming and providing alternative to pollutant fossil fuels use. The Fossil fuels such as coal, oil and natural gas are non-renewable sources of energy. They are formed from plants and animals which lived up to 300 million years ago. They are called fossils because they have been formed from the organic remains of prehistoric plants and animals. They were formed during the pre-Cambrian mountain building Era. These energy sources are also exhaustible.

The 1974 to 1979 ten fold increase in oil prices which threatened the economic stability of oil-dependent countries of the world stimulated research into the use of bio diesel (produced from oil seeds and animal fat) and ethanol (produced from starch and sugar) as a potential alternative for gasoline in Europe (Amaral and Pezzo, 2007). The use of biofuels in diesel and gasoline transportation systems contributes to: Reduction of green house gas (GHG) emissions in an effort to mitigate climate change, diversification of the energy matrix. This is important considering the uncertainties of oil supply and the politics of oil producing countries which cause frequent price increases, generation of income for farmers and deployment of agribusiness chains and expansion of agricultural and industrial subsidies and finally, using plants (biomass) rather than oil or coal to produce fuels and chemicals can play an important role in reducing the world's dependence on fossil fuels which are environmental pollutants (Masika and Joeke, 1997).

The technology used to produce green energy is simpler and easily affordable, the technology can be developed by the communities themselves for example, many countries in the world are moving towards gradual and partial replacement of fossil fuels with bio fuel mainly ethanol. The move towards biofuels is caused by global political, economical and environmental challenges especially the rising oil prices and global warming as a result of fossil fuel pollution.

Since green energy sources vary in their availability, abundance and distribution on the globe, different countries adopt different green energy options available in abundance to them (Table 1).

Fossil fuels are not sustainable since the mines can be exhausted for example, coal, petroleum, natural gas, the availability of some fossil fuels is questionable where prospecting can be expensive and time wasting before any discoveries are made (the case of petroleum prospecting in Northern Kenya, where no discoveries have been made since the oil prospecting started in 1996). The technology used to produce energy from fossil fuels is complex, expensive and needs highly skilled experts, petroleum dependent countries are subjected to frequent major oil price swings based on the politics of the oil producing regions.

Burning of fossil fuels produces carbon dioxide which is

Table 1. Green energy options for various countries.

Country	Energy in use	Green energy options adopted
Greater Horn Africa, Lake Victoria Basin	1. Hydro power (HEP) 2. Petroleum products 3. Biomass; firewood, charcoal	Geothermal and Naivasha plant in Kenya Solar - (abundant sunlight) in Africa Wind - (Extreme temperatures) Biomass - (biodiesel), woodlots, planted hedges
European Union	1. Hydro power 2. Petroleum products 3. Gasoline	Biomass (wheat, corn oilseeds) Ethanol (wheat, corn, barley) Biodiesel (oil seeds)
Brazil*	1. Hydro power 2. Petroleum products	Biodiesel (oil seeds) Ethanol (sugar cane)

*Brazil is the only country today which has succeeded in large scale production and use of biodiesel and ethanol (biofuel). Source: Amaral and Pezzo, 2007 and ICPAC, 2006.

a pollutant to the environment and contributes to global warming effects, and in the rural and remote areas of developing countries, transmission, distribution and transportation of energy generated from fossil fuel can be very difficult, expensive, and dangerous for example, the *Sidindi and Sachangwan* transit petrol oil tank explosions which killed over 200 Kenyans in March 2009. Industrial pollution of fossil fuel gases cause acid rain, urban heating and emission of greenhouse gases that lead to global warming.

Food and Agricultural Organization (FAO) visualizes a series of effects caused by fuel wood scarcity as in fewer cooked meals, shifts to meals requiring less cooking time, high incident of parasitic diseases caused by drinking of unboiled water and increased workload and economic burden to women who usually collect firewood and cook (Masika and Joekes, 1997). The socio-economic consequences of fuel wood exploitation and consumption cannot be underrated (IUCN, 2004) as related to cooking and taking care of household. It has been argued that the real energy crisis is women's time, for example, in wood scarcity areas such as Kisumu district, women have been forced to cut down on their cooking time and were cooking less nutritious foods due to fuel wood crisis (Heyzer, 2006). Women are the key to development in Africa and Africa's resources, therefore, empowering women to ensure better use, management and control of green energy resources was vital for sustainable natural resource development and mitigation against climate change impacts such as global warming (UN-ESCWA, 2006). International agreements such as the Convention on Elimination of All Forms of Discrimination against Women (CEDAW) do recognize the central role of women as caretakers of the natural world (environment). Most societies and governments have been and are still slow when it comes to integrating women in decision making processes and particularly those dealing with environmental protection. Governments have also

neglected the link between women and the environment when planning for land use, energy use in industries and domestic use (Masika and Joekes, 1997).

The objectives of the study are as follows:

- i. To establish the types of green energy available and utilized in the Lake Victoria Basin.
- ii. To identify the challenges of green energy adoption.
- iii. To identify the biomass technologies (charcoal briquetting) adopted.
- iv. To establish the effects of charcoal burning on the environment within the Lake Victoria Basin.

METHODOLOGY

The research was carried out in east Africa's Lake Victoria Basin (LVB) of Kenya, Uganda and Tanzania between the years 2005 to 2010. The types of energy sources studied were biomass (firewood and charcoal), hydro-electricity and geothermal. The study population consisted of 240 respondents sampled as follows: 120 women firewood users and sellers -to find where they get firewood from. 60 men small scale charcoal sellers- to get technologies of charcoal burning in use. 20 women charcoal users-- to get the effects of using charcoal and suggest alternative clean energy sources. 30 institutions that use both firewood and electricity for cooking and lighting, 10 environmental conservationists from Kisumu Polytechnic, Maseno and Kyambogo Universities and Ministry of Environment from Kisumu and Jinja in Uganda- to establish any adverse effects of biomass energy use on the environment and any recommendations for adoption of other clean energy sources for improved community welfare.

Data collection methods

Questions were administered to all the respondents through a carefully structured questionnaire, photography and participant observation was also used.

Presentation of results

Analyzed data was presented in the form of discussion,



Figure 1. Homestead with planted trees making a fence/hedge in Kisumu, Kenya.

percentages, tables and photographs.

RESULTS

Types of energy sources used

The study established that 80% of the energy used in the institutions and households was from firewood and charcoal collected from natural and planted forests and bushes which were increasingly becoming scarce. About 20% of the people from the middle class (those in formal employment earning a monthly salary) used charcoal. Fuel wood (firewood and charcoal) was the primary source of household energy for the developing world and the LVB in particular. Over 2 billion people used firewood and charcoal to cook and preserve food. Due to increased demand for agricultural land and widespread deforestation, fuel wood was being depleted rapidly. Cow dung, maize cobs, coffee and tea branches were seasonally used by those who practiced small scale coffee and tea farming. 10% of the respondents were aware of the “green energy concept” as an alternative to fossil fuels. 2% used solar energy in institutions where solar panels were installed for provision of lighting in the libraries and hostels. 0.5% used biodiesel, natural gas and Biogas from dry cow dung for cooking and lighting. 20% of housewives aged above 55 years strongly opposed the use of charcoal for cooking. It was established that men of above 60 years old in rural areas ate food cooked on traditional three stone cook stoves using firewood. Wives always cooked food for their

husbands using firewood. Those who used charcoal were termed lazy, proud and “westernized” who could not make good wives. Firewood was seen as an irreplaceable source of energy by all rural households (Sichenga, Personal communication, 2009).

80% of the population in the study area was aware of the adverse effects of tree cutting for firewood and charcoal burning on the environment and community livelihoods. The study established that 70% of rural households had adopted the “fruit, firewood, timber, windbreak (FFTW) concept, where family woodlots consisted of; a fruit tree (mango, avocado) firewood and windbreak tree (Lucerne, Acacia) and a tree for timber (Eucalyptus, Cypress, Blue gum). Woodlots were planted to provide fruits for nutrition, firewood for domestic use and timber for sell to improve family income. The trees also acted as windbreaks from strong winds which are frequent in the region (Ngaira and Migunga, 2008) (Figure 1).

Gender and biomass energy use

It was established that 90% of Women were the primary users and managers of biomass energy use. Women in rural areas spend long hours collecting firewood, cooking and protecting the environment from all forms of pollution. Women were often the leaders in community and National based environmental protection activism such as afforestation programmes, a leading example emulated was Professor Wangari Maathai the leader of the



Figure 2. A planted woodlot and harvested firewood at Kisumu Polytechnic.

Greenbelt movement which had been adopted in Africa and America (Maina and Owino, 2006), however, women had for a long time remained largely absent at all levels of policy formulation and decision making in natural resource management, conservation, protection and rehabilitation in the Lake Victoria Basin.

Institutions in Chulaimbo rural in Kisumu district being aware of firewood shortage due to deforestation for charcoal burning, had decided to plant tree woodlots on their farms for sell and for firewood (Omwayi, 2009). Figure 2 shows an institution with a woodlot.

Challenges of biomass green energy sources

The study established the following challenges faced by communities in the effort to adopt to green energy sources in the region.

i. Some green energy sources such as hot springs were located in very few and remote parts of Kenya and Tanzania where it became difficult to build Geothermal power stations in vacant desolate arid lands. Example given was; the Olkaria hot springs located in Semi-arid Naivasha district.

ii. 70% of the farmers stated that adoption of biofuel plants such as growing of *Jatropha Curcas* plant, oil seeds (biodiesel) starch and sugars (ethanol) was not wise since it impacted negatively on the already strained food insecurity problem caused by persistent droughts. Farmers preferred planting food crops for monetary

values as well. Farmers were not ready to apportion part of their farms for growing of bio fuel crops.

iii. Hydropower which is a major source of energy for most countries in Africa is highly vulnerable to rainfall fluctuation. Too little rain caused droughts whose consequences included low level of water in dams for Hydro Electricity Power generation, leading to economic losses such as the 1999 to 2002 droughts in Eastern Africa which led to power rationing, closure of some industries in Nairobi, Kisumu, Kampala and Jinja, which in turn led to loss of employment for majority of the workers in those industries.

iv. While biomass energy was renewable, available, affordable and mostly used by 90% of households in the study area, it was established that the methods of access which included deforestation for firewood and charcoal burning were major causes of increased carbon dioxide emission leading to global warming and climate change. Figure 3 shows charcoal burning in Musoma rural township in Tanzania. Charcoal burning leads to deforestation and Carbon dioxide emissions, a sure cause of climate change.

Biomass technologies adopted

Since biomass energy in the form of firewood and charcoal were the most dominantly used by 80% of the households in the study area, improved methods of utilization were being innovated by Women groups to; (i) save the energy consumption and reduce on the



Figure 3. Charcoal burning in Musoma township, Tanzania.



Figure 4. The improved stove/upesi jiko with a clay lining and small holes to save energy.

deforestation by using the improved charcoal stove "upesi jiko." The improved stove had a clay lining and small holes that allowed for slow and longer heat

emission from charcoal (Figure 4 shows improved charcoal stove). However, in rural Nyando and Kisumu East districts, the traditional three stone cook stove which



Figure 5. Mixing of charcoal fines, clay and water.



Figure 6. Drying charcoal briquettes in readiness for sale and use.

used firewood was dominant, it had a lot of cultural and social values attached to it. Only 60% of the urban households used the new improved charcoal stove since it was expensive for most households.

The study established that 60% of women in Manyatta slum estate in Kisumu town had innovated a technology of re-cycling charcoal fines into charcoal briquettes using it for cooking. The technology aimed at removing heaps

of charcoal fines/remains from urban charcoal stores, mixing the fines with water and clay, moulding into balls and drying in the sun. The process made the environment clean, at the same time providing energy source for the urban poor since they were the major users of the briquettes (Figures 5 and 6) show steps of briquette preparation (Ngaira and Migunga, 2007). The charcoal briquettes were despised and rejected by the

middle class group who were in formal employment.

Preparation of charcoal briquettes in steps

Step 1: Mixing of charcoal fines, clay and water (Figure 5).

Step 2: Drying charcoal briquettes in readiness for sale and use (Figure 6).

Effects of charcoal burning on the environment

100% of those interviewed were aware of the adverse effects of charcoal burning. The following adverse effects were listed; cutting down of trees for charcoal burning left the soil unprotected and exposed to both water and wind erosion, important medicinal trees were cut down for burning charcoal, cutting trees in the water catchment areas for charcoal burning caused decreased infiltration, increased runoff and drying up of rivers. A good example of water catchment destruction and effects on water was the Mau forest degradation which caused reduction in the volume of water in rivers Mau and Sondu Miriu. It was established that deforestation and charcoal burning caused the soil to lose important mineral nutrients such as potassium. It also caused desertification in both high potential and low potential agricultural areas, which in turn caused low crop yields and food insecurity in the LVB where agriculture is rain fed dependent. Charcoal burning used as a source of income affected the youth in rural Kisumu because young people from poor households dropped out of school and went to burn and sell charcoal for monetary gains (Dan – personal communication, 2009). With the current sensitization and awareness about deforestation and its negative impacts on rainfall and rivers, charcoal burning was a very risky business for those who depended on the activity for their livelihoods (Manyatta Charcoal seller- Personal communication, 2009).

DISCUSSION

The study established that 80% of the respondents supported the adoption of green energy such as solar energy, use of wind mill power, hydro power, biomass and use of biodiesel. Green energy was renewable, available, clean, none polluting and environmental friendly as opposed to energy from fossil fuels which were non renewable, environmental pollutants and unhealthy and caused global warming. The sun, which is green energy fuel source, was free and without limits, therefore, green energy could be replenished naturally within a short period of time. The sun was abundant in the Lake Victoria Basin of East Africa which received 12 h of sunshine daily all the year round. Green energy such

as solar and wind had less negative impacts on the environment since they did not produce harmful gases, their use limited the production of greenhouse gases. That would ensure a friendly climate. Green energy was more affordable (pocket friendly) and available especially for the poor since it was mainly derived from the sun, wind, water and plants (biomass). Communities could drill down hot spots of the earth and use steam to drive engines. Green energy could economically empower rural communities by creating local industries and businesses for job creation to reduce rural-urban migration because it allowed for decentralization of industries. The green jobs report 2008 noted that some 2.3 million men and women had been employed in the renewable/green energy sector worldwide. Using green energy would definitely reduce the Nation bills on imported fossil fuels and act as a strategy against deforestation and mitigation against climate change impacts in East Africa. Green energy products especially from biomass energy decomposed fully whereas those from fossil fuels such as plastics (hydro carbons) did not decompose and therefore polluted the environment (there was debate against plastic paper bag use as shopping baskets in super-markers in Kenya). The possibility of having small scale decentralized solar, wind or biodiesel energy installations which are run and maintained by the local people (men and women) could improve the quality of life for people in rural areas and act as a starting point in the fight against greenhouse gas emissions (Onyango and Ochieng, 2006). Access to green electricity or green gas would contribute to gender equity with regard to domestic work. The study established that men were sometimes willing to do some domestic duties such as washing clothes, cooking and ironing if those tasks were facilitated by energy-dependent household appliances (UN-ESCWA, 2006). Access to green-energy such as solar energy would impact positively on women's health since they would not be exposed to smoke and charcoal (carbon-monoxide) while cooking. Many people in the study area had found jobs in charcoal briquette sector and a forestation programmes in the deforested Mau and Aberdare forests in Kenya.

Conclusion

90% of the respondents stated that in order to preserve the existing vegetation (trees) for sustainable utilization, only branches of big trees should be cut to provide firewood, the governments should put policies which punitively punished wanton tree cutting for charcoal burning, finally farmers and households should be encouraged to practice agro-forestry, plant quick maturing trees such as *lurcerne* and adopt alternative sources of energy. Developing countries, Lake Victoria Basin included needed to encourage investments by independent power producers who opted to develop

renewable energy plants to supply energy to rural areas where majority of the people lived. This could lead to improved quality of life, reduction in deforestation and charcoal burning, reduction in rural-urban migration and finally reduced greenhouse gas emissions. Adoption of green energy use in the region may appear an elusive attempt because; food insecurity problem is more acute and needs to be urgently addressed before energy issues. Put food in the kitchen, then look for energy to cook it.

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