Journal of Energy Technologies and Policy
ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online)
Vol.4, No.8, 2014

Climate Change and the Domestic Energy Sector- A Comparative Analysis

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Abstract

Climate change is a global issue that is not evenly distributed in causes and effects. While the industrialized nations are the major causes of climate change, the effects of climate change hardest hit the developing nations. The whole of sub Saharan Africa account for less than 2 percent of global greenhouse gas (GHG) emissions. The developed countries with greater historical responsibility for climate change and a greater capacity to act should take the lead in dealing with climate change. On the other hand, the emerging economies and developing economies should have mitigation measures in place for their own emissions. The domestic energy sector is the largest energy-consuming sector in Nigeria and Uganda with the effects of climate change quite visibly seen in both countries. This paper compares the climate change impacts, policies, governance structures and method of approach to climate change in both countries and puts forth recommendations on how to mitigate and adapt to climate change in the domestic energy sector.

Keywords: Climate change, energy, sustainability, GHG emissions

1. Introduction

Sustainable development refers to the pattern of resource use that meets human needs while preserving the environment so that generations yet unborn can also meet their needs in the future (Sambo 2009). Sustainable energy is essential for sustainable development. Access to affordable, reliable energy advances education, empowers women, and creates economic opportunities. Climate change is a long term threat that is currently affecting every part of the globe. With the resultant disruption of economic activities, climate change is no longer just an environmental issue but also a developmental issue in developing countries. It affects all sectors from energy, agriculture, health and sanitation to forestry, biodiversity, coastal water and fresh water resources and so on. Recent estimates suggest that in the absence of mitigation and adaptation measures, climate change could result in a loss of between 2 percent to 11 percent of Nigeria's GDP by 2020 and rising to between 6 percent and 30 percent in 2050 (NASPA-CCN 2011). The United Nations Framework Convention on Climate Change (UNFCCC) has the main objective of mitigating climate change through the Kyoto Protocol and the purpose of the Clean Development Mechanism is to assist developing countries (Non Annex 1) that are parties to the protocol achieve sustainable development as well as the developed nations (Annex1) comply with their certified quantified emission limitations. Nearly 3 billion people around the world rely on wood, coal, charcoal or animal waste for cooking and heating (United Nations report 2013). Nigeria is richly endowed with conventional energy resources (oil, gas, coal, bitumen and lignite) as well as renewable energy resources such as hydro, wind and solar. Aside hydro, the natural resources are largely untapped. It is the largest oil producer in Africa and has the second largest proven crude oil reserve in Africa exporting most of its crude oil to Europe and the United States. Nigeria is a member of the organization of petroleum exporting countries (OPEC) and relies heavily on the petroleum sector for its economic growth. The sector contributes 76 per cent of the government revenues (Economic Report on Africa, 2013). She has a proven crude oil reserve of 37.14 billion barrels and a daily production of about 2.5 million barrels per day with plans by the government to hit the 40 million barrels mark in reserve by the end of the first decade of the millennium with a daily production of 4 million barrels by the target date. With a proven natural gas reserve of 260 trillion cubic feet, Nigeria gas reserve is triple the crude oil resources and it's rated the world's number 1 in gas flaring because most of the associated gas during the oil production is being flared. Plans are under way to end gas flaring and develop the domestic gas market. Flaring intensity has reduced by 60 per cent between 2003-2012.The domestic sector is the largest energy consuming sector of the economy and accounts for about a quarter of total commercial energy and over 90 per cent of traditional fuels especially fuel wood in the country (Adegbulugbe & Akinbami 1992). Predominant energy sources in this sector are fuelwood, charcoal, kerosene, liquefied petroleum gas (LPG) and electricity. The rural households which constitute 49 percent of the population (according to the world bank data in 2013) depend on unsustainable fuel wood use for their domestic activities. Abundant energy resources including renewables also characterize Uganda having discovered oil in 2006. Proven crude oil reserve in 2014 is 2.5 billion barrels and commercial oil production is expected to start in 2018. The domestic energy sector in Uganda is predominantly dependent on wood fuel and biomass which accounts for up to 93 per cent of the country's total energy needs .The main other sources of energy are petroleum products (6 per cent) and hydro-electricity (1 per cent) (Knofle 2004). The high dependency on wood fuel and charcoal has implications on carbon production through

deforestation and carbon dioxide emission through combustion. Developing nations are thus both a contributor to climate change processes and vulnerable to the effects of carbon dioxide accumulation in the atmosphere. Wood fuel is the main source of heating and cooking in rural and urban areas (Uganda Bureau of Statistics 2009). The household sector will remain in the medium term, a developing country's most relevant energy sector in terms of access, energy efficiency, environmental impact, rural livelihoods and lost government revenues. Total household demand for firewood and wood for charcoal is 22.2 million tonnes per year with cottage industries adding a further 5.5 million tonnes of demand for a total of about 27.7 million tonnes for the entire country (Uganda National Report 2010). This leads to a lot of wastage due to the inefficient cooking technologies employed. An estimated 90 per cent of Ugandans live in rural areas with less than 3% electricity access (daily monitor 2013). Both countries are greatly vulnerable to climate change impacts, in respect of climate variability including increasing temperatures, increased frequency and intensity of rainfall, heat waves, droughts, floods and storms. Climate change is being experienced in various forms such as rising temperatures, changing rainfall patterns, increased frequency and intensity of droughts and floods, decline in quantity and quality of water resources, reduced agricultural productivity, spread of vector borne diseases and heavier storms (UNDP 2012). Nigeria's key vulnerabilities to climate change, as stated by Nigeria's First National Communication (FNC) on climate change are Exposure of northern Nigeria to accelerated desertification linked to increasing drought with resulting impacts on the local population and the natural resource base and sensitivity of other sectors of the economy to climate variability such as Nigeria's electrical supply, which is heavily dependent on hydropower and thus is affected by fluctuations in rainfall amongst others. There is evidence that average temperatures have increased by as much as 1.4 degrees Celsius since the 1960s, looking further ahead, up to 4.3 degrees Celsius change in average temperatures by the 2080s is possible in Uganda (Corner 2011). Based on Intergovernmental Panel on Climate Change (IPCC) report for Nigeria, a possible sea level rise from 1990 levels to 0.3m by 2020 and 1m by 2050 with a rise of temperature up to 3.2 degrees Celsius by 2050 is predicted. A temperature rise of that magnitude would have disastrous consequences for both countries.

Nigeria and Uganda have a generally low GHG emissions profile. A GHG emission per capita of 2.25tCO_2e and 2.05tCO_2e respectively (this is less than 10 percent of GHG emission per capita in the United States) however emissions are steadily increasing due to economic and population growth as a result of demand for energy, industrialization and private transport. However, the greatest source of GHG emissions is from land use change through the continued depletion of forest cover and agricultural activities. Climate change-related disasters contribute well over 70 per cent of the natural disasters and destroy annually an average of 800,000 ha of crops, resulting in economic losses of over UGX 120 billion. The annual economic losses resulting from the associated transport damage, accidents, fires are estimated at UGX 50 billion (UNDP/UNEP 2009).

2. Climate change and Energy security

2.1 Impact on Electricity Demand and supply to Households

Both countries have one of the lowest electricity generation and consumption rates in the world. Nigeria's per capita electricity consumption is 4 times less than the African average and about 19 times less than the world average (Sambo 2009). Per capita electricity consumption currently stands at 107kWh for Nigeria. Total electricity generation from hydro and thermal power plants is less than 4,000MW for a population of about 160 million. Per capita electricity consumption in Uganda is 22kWh. Hydropower contributes about 32 per cent of net electricity generation and there exist hydro potential in excess of 11,000MW in Nigeria (Zarma 2006). The present and ever increasing population with the total capacity of the available power stations reveals that Nigeria is not able to meet the energy needs of the people. The rural dwellers still lack electric power (Oyedepo 2012). Model for analysis of energy demand (MAED) was used to model the demand structure of Nigerian energy sector in four scenarios (reference growth, optimistic growth, high growth I and high growth II). With the reference growth scenario (GDP grows at 7 percent per annum), electricity demand in 2020 is 50,820MW as shown in Table 1 (Energy Commission of Nigeria 2006). Electricity supply from hydro in 2020 is 6,619MW as shown in Table 2. This reveals a wide gap between electricity demand and supply from hydro at present and in the future. There would still be a shortfall in energy supply even when all hydro potentials in Nigeria (large and small) have been developed. There is therefore the need to explore other natural resources such as solar. In Uganda, hydro power contributes over 90 percent to net electricity generation (African Union Report 2008). According to IPCC, water resources are more susceptible to global warming. Effects of climate change on water resources manifests as periodic droughts and floods that reduces hydro power generation capacity. A predicted rise of temperature of 3.2 degrees Celsius by 2050 will increase peak energy demand above the baseline scenarios. About 5 million households (85 percent) of the population lack access to electricity, most Ugandan homes use kerosene lanterns and candles in their homes. Currently, domestic power demand exceeds the available supply by as much as 80 MW during peak periods, and is growing at the rate of 8 per cent per year in Uganda (UNDP/UNEP Report 2009). Load shedding is a common similarity and the shortfall in generation

capacity is limiting growth in many sectors of the economies. The Council for Renewable Energy of Nigeria estimates that power outages brought about a loss of 126 billion naira (US$ 984.38 million) annually. Although 11 percent of the population in Uganda can access the grid, electricity is mainly for the purpose of lighting. Lake Victoria which is the second largest freshwater lake in the world is the source of power generated by Owen falls dam and Kira dam with a combined generating capacity of 380MW. Low water level in Lake Victoria has caused reduction in electricity generation by over 60 per cent. This has led to increase in electricity tariffs due to additional power generation from thermal sources. The cost of hydroelectricity to every consumer is subsidized by 35 percent of the tariff. This makes it even more difficult for households to afford as taxes on petroleum products are as high as 35- 40 percent.

Table 1 Projected Electricity Demand for Nigeria in MW

Scenario	2005	2010	2015	2020	2025	2030
Reference growth (7%)	5,746	15,730	28,360	50,820	77,450	119,200
High growth (10%)	5,746	15,920	30,210	58,180	107,220	192,000
Optimistic growth (11.5%)	5,746	16,000	31,240	70,760	137,370	250,000
Optimistic growth (13%)	5,746	33,250	64,200	107,600	172,900	297,900

Table 2: Projected Electricity Supply from Hydro in MW

Scenario	2010	2015	2020	2025	2030
Hydro	3,702	4,962	6,479	9,479	11,479
Small Hydro	40	90	140	227	701

2.2 Impact on Fuel wood Demand and Supply to households

In many African communities, women bear the brunt of domestic activities. Charcoal is the predominant source of energy used in urban settings, while firewood is more common in rural areas of Uganda. LPG supply and use in Uganda is very minimal and limited to middle-class town residents, mostly in Kampala (see Tables 3 & 4). When it comes to shortage of fuel wood, women are more helpless because of their responsibility for firewood collection and cooking, and are exposed to diseases associated with smoke during cooking. To address the problem of wood scarcity, women often resort to negative coping mechanisms such as undercooking their meals especially meals that reportedly take a longer time to cook, reducing the number of meals per day, and even selling part of their food ration to buy firewood (Bizzarri 2009). The number of people who live with inadequate calorie consumption – 14 million Ugandans in 2002 – has increased in 2008 to 68 percent of the total population (27 million), due to increased incidence of climate change disasters that continue to disrupt food production and incomes (UNDP, UNEP 2009). The inability to create wealth from Nigeria's flared gas or to develop alternative ways of using it to meet energy needs of households in both rural and urban areas is partly responsible for the increasing fuelwood demand. Nigeria is ranked among the countries with lowest per capita LPG consumption of 0.5kg. The Federal Government spends 222 billion naira monthly on the use of firewood and kerosene for cooking. This economic loss will continue until the government show significant commitment to the use of LPG.

Table 3: Energy Access Rates for Uganda

Fuel Type	% Access		Consumption per capita
	Rural	Urban	
Firewood	89.4	22.9	680kg
Charcoal	8.2	66.1	21.6kg
Kerosene	0.8	3.5	1.1kg
Electricity	0.1	0.8	22kWh
Other (LPG, biogas, sawdust)	1.6	6.8	-

Table 4: Current Status of Households to Cooking services

Category	Traditional practices	Improved cook stoves	LPG, kerosene etc	Total
Rural	3,626,000	250,000	4,000	3,880,000
Urban	820,000	30,000	60,000	910,000

2.3 Impact on the Economies

Climate change can affect many important sectors of the economy by influencing the supply of and demand for goods and services. Empirical evidence shows that there will be changes in the supply and demand of food commodities as a result of low yields resulting mainly from drought and flooding events. The changes will also affect the profitability of farming and the affordability of food (Chika & Ozor 2010). Climate change and the threat of related extreme conditions have major implications for development particularly in developing countries. Unlike Nigeria with the largest economy in Africa, the economy and the well being of the people of Uganda are tightly bound to climate, especially because over 80 per cent of the population is rural and depending on rain fed agriculture, that is prone to impacts of climate variability. Uganda is the largest coffee producer in Africa and it is Uganda's largest foreign exchange earner and Tourism is the third largest foreign exchange earner. Small variations in weather conditions (temperature and rainfall) affect coffee flavor and hence the value of the product. Coffee production and prices have declined in recent years. A kilogram of Uganda coffee sold at approximately $4 in 2011 dropped to $1.30 in 2013 (UNDP 2014). This hurts the wider Ugandan economy since the industry employs more than 2 million people directly or indirectly and contributing $400 million to the Uganda economy in 2012. Without adaptation strategies, future production losses induced by climate change are estimated to reach tens of millions of dollars annually (Jassogne 2013). Tourism has remained one of the fastest growing sectors of the economy contributing over US$834 million to GDP in 2012, this represented 4% of total Ugandan GDP (www.redpepper.co.ug). The sector alone employs country-wide an estimated 65,000 people with the related transport sector accounting for another 20,000 jobs. Food prices, Tourism and coffee production are the most sensitive and could affect the economy largely while hitting hard on the domestic sector.

3. The Forest Situation

Forests and forest products can play a significant role in mitigation of harmful effects of greenhouse gas emissions. They can act as a "sink" to absorb emissions and store large quantities of carbon for extended periods of time. Forests are also an important component of adaptation strategies needed to address continuing changes in the natural resource base that sustains our livelihoods (Gbadegesin & Olorunfemi 2011). Historically over 35 per cent of Uganda was covered in forest, however rapidly increasing levels of deforestation have cleared over 50 per cent of forests to an extent that at present forests account for less than 15 per cent of Uganda's land cover. The trend in Uganda is one of loss of forest cover and degradation of the remaining forest resource base. A major factor that causes deforestation in Uganda is the need for fuel and timber. With a population of about 35 million, Uganda has over 90 percent of its total energy demand from biomass and trees are still expected to contribute up to 75 percent by 2015 (UNDP/UNEP 2009). The lack of modern and affordable fuels for domestic use has forced both the rural and urban population to rely on charcoal and firewood as their source of heat energy. This has led to massive deforestation due to pressure exerted on the natural forest. Uganda's forest cover is 24 per cent of the land cover and is likely to decrease with increasing population dependent on it. In the Global forest Assessment Report, the Food and Agricultural Organisation (FAO) said the forest cover has reduced from 4,924 million hectares in 1990 to 3,627 million hectares in 2005. Woodlands provide the bulk of firewood and charcoal used in the urban areas. Degradation is more marked in the woodlands as most of the current loss of forest cover occurs in the woodlands (see Table 5). In high tropical forest, about 280,000 hectares is now degraded representing at least a third of the country's valuable high forest (Uganda Forestry Policy 2001). At global level, about 40 percent of all the carbon emitted by human activity has come from cutting forests and increased industrialization. Stopping deforestation is, in principle, cheap and simple (Arthur & Namuteefa 2013). Nigeria is blessed with a large expanse of land and variable vegetation, but this important resource is not sustainably used or managed. The deforestation rate is about 3.5 per cent per year translating to 300,000 – 400,000 ha of forest land per year. Presently, forests occupy only 10 percent of Nigeria's forest land area (Ladipo 2010). Recent studies suggests that present-day forest cover is under pressure as a result of human activities such as agricultural development where vast lands are cleared without conservation considerations, large-scale peri-urban housing project development, fuelwood generation, uncontrolled forest harvesting including poaching for logs and poles, and urbanization (Ladipo 2010). Fuelwood exploitation in both the forest and savanna regions is unsustainable as most fuelwood collectors do not plant trees to replace those removed from the vegetation for fuelwood (Gbadegesin & Olorunfemi 2011).

Table 5: Area, biomass and growth of forest Resources in Uganda

Land cover	Area (ha)	%	Stock ('000 ton)	%	Yield(t/ha/yr)
Plantations	35,000	0.2	4,000	1	16
Tropical High forest	924,000	5	164,00	35	15
Woodland	3,974,000	19	126,000	27	5
Total Forest	4,933,000	-	-	-	-

Table 6: Nigeria's Forest Cover 1990-2010

Total Forest Cover (1000 ha)			
1990	2000	2005	2010
17234	13137	11089	9041
Annual Change Rate (percent) *Negative number represents deforestation*			
	1990-2000	2000-2005	2005-2010
	-2.68	-3.33	-4.00

4. Challenges in Mitigating Climate Change

Energy policy institutional arrangement is a challenge being faced by developing nations. The government of Nigeria has many broad environmental policies that may not provide a strategic focus in mitigation and adaptation to climate change though the environmental laws which promote sustainable environmental management can influence on the adaptation and mitigation measures on climate change. The Climate Change Unit (CCU) is reliant on global scale models as the analysis tool which only allows for a generalized assessment. There is need for tools for climate change analysis, impact assessment at national and regional levels. Other challenges are:

- Lack of awareness on climate change issues
- Inadequate financial incentives to stimulate the spread of clean energy technologies
- Lack of up to date data on the environment such as the extent of deforestation and volume of renewable and non-renewable biomass. Database on fuelwood and other biomass energy consumption are usually not reliable and in many years not readily available.
- An adequate legislative framework to support and enforce the implementation of energy efficiency and conservation.
- Inadequate data on the current status of forestry resources in general and woody biomass situation in particular.

5. Mitigation and Adaptation Options and the way forward

Both Nigeria and Uganda are parties to the Kyoto protocol which was adopted in December 1997. Both countries do not have an existing climate change policy in place. The need for Nigeria to adopt a more comprehensive and coordinated approach to the issues of climate change within its national development context than what currently obtains is pertinent. Significant national efforts are needed to ensure that climate change concerns are properly integrated into the country's Vision 20:2020, which currently constitutes the country's blueprint for sustainable rapid socio-economic development. In developing a national response to climate change, the governance structure should be fully in place and functional at the various levels of governance. More importantly, Nigeria should develop its government priotized actions aimed at reducing or limiting GHG emissions. This is expected to be the main vehicle for mitigation actions normally referred to as Nationally Appropriate Mitigation Actions (NAMAs). However, the NAMA development in Uganda has made significant achievements. The European commission and the governments of Germany and Austria provided funding and the technical input needed was provided by the climate change unit and the United Nations Development Programme (UNDP) under its Low Emissions Capacity Building (LECB) programme. Uganda has in place active national and international organizations in the energy sector with various programs in energy efficiency and fuel switch that will mitigate the effects of climate change. Also, the East African Community Climate Change Policy (EACCCP) which came into existence in 2011 has the broad objective of creating a sustainable

environment in the East African Region through Mitigation, Adaptation and Climate Change research. Each member state is guided and reinforced to draw up and implement its climate change policies. Uganda recognizes Climate Change as a major risk factor to national development and specifically energy poverty eradication to achieve sustainable development. This guided the preparation of its National Adaptation Plan of Action (NAPA) and Nationally Appropriate Mitigation Actions (NAMAs). In developing mitigation and adaptation measures that can be adequately implemented in the domestic sector, particular focus for both countries should be in the following areas:

5.1 Improve rate of Energy Efficiency

Energy efficiency in domestic activities like cooking and lighting can be increased through the use of more efficient cooking technologies like Improved Cook stoves (ICS), gas burners and Compact Florescent light bulbs (CFL). These are also energy saving measures. Increased savings encourages investments and development. Currently, Uganda has many ICS projects being executed by international organizations, donor agencies and so on in the rural areas which holds about 85 percent of its total population, however most of the ICS project do not have the carbon finance aspect embedded in it to enhance sustainability. Two ICS projects designed to disseminate 100,000 and 40,000 ICS to households in northern Nigeria by 2015 is being implemented. The projects have the carbon finance aspect embedded in it for sustainability. More of such projects should be spread across the length and breadth of Nigeria. Of particular point and urgency to Nigeria is the utilization of the associated gas being flared during oil production for domestic use. Although Nigeria has crude oil and gas resources, the levels of gas and kerosene cookers and cooking stoves adoption are far below the levels that could make any impact (Gbadegesin & Olorunfemi 2011). Results from recent study show that an annual average of 2040 MJ of fuelwood is consumed in Nigeria, 77.3 percent of the sourcing is done by children and the time spent in fuelwood trips is between 4 and 5 hours, at a frequency of three to four times a week. This amount of fuelwood consumed examined alongside 2.5billion standard cubic feet of gas flared per day, revealed the quantity of energy that ought to be saved and related avoidable extreme weather conditions that prevail in Nigeria (Nwanya 2011).

5.2 Identification of issues which require investigation and providing results through advocacy and research

Training and public awareness amongst households on climate change, adaptation and mitigation measures should be encouraged. Technical assistance and financial support from international organizations and donors for capacity building, resource management and risk reduction initiatives should be optimized. In addition, strategic advice with structures in place to report progress should be explored. Particularly, the government of Nigeria needs to fully re-organize and make functional the National Strategic Climate Change Trust Fund as a channel for broadening the scope of national and international interventions on climate change.

5.3 Explore economic benefits of Carbon Finance

For sustainability of projects that improve energy efficiency and save energy in the domestic sector, carbon finance is important. Carbon credits are an immediate answer to reducing the amount of GHG emissions in the atmosphere. The generation and sale of carbon credits funds carbon projects which would not have gone ahead. Carbon credits also help lower the costs of renewable and low carbon technologies as well as assisting in the technology transfer to developing countries. There exist the compliance and voluntary carbon markets. In the compliance market, carbon credits are generated by projects that operate under one of the UNFCCC approved mechanisms such as the CDM. The voluntary carbon markets function outside of the compliance market. They enable businesses, governments, NGOs, and individuals to offset their emissions by purchasing offsets that were created either through the CDM or by the voluntary carbon standards. The latter are called VERs (Verified or Voluntary Emissions Reductions). Compared to the compliance market, trading volumes in the voluntary market are much smaller because demand is created only by voluntary buyers (corporations, institutions and individuals) to buy offsets. The CERs and VERs when converted into cash or any other beneficial form (e.g. development project in the community) encourages the households to get involved in climate change issues and be better informed on the trends, developments and policies as it relates to climate change. It also encourages the use of clean energy technologies such as solar lamps and cookers and energy saving light bulbs.

5.4 Production of Biogas from Animal Waste

Biogas (a mixture of methane and carbon dioxide produced from anaerobic decomposition of animal waste) reduces GHG emissions by replacing the combustion of non renewable biomass thereby reducing carbon dioxide emissions. It can also reduce methane emissions by diverting animal waste that would otherwise decompose in open pits emitting methane. The slurry serves as fertilizer to boost food production. Biogas plants can also earn certified emission reductions (CERs) or VERs provided the appropriate methodologies and monitoring and evaluation procedures laid out by UNFCCC or any other voluntary standard(s) have been followed. The impact

of biogas plants on the domestic sector is to reduce the financial cost expended by households on cooking and lighting and for environmental sustainability. The first phase of the biogas program in Uganda has 12,000 biogas plants installed in rural households within a five year period while the second phase (2014-2017) will install a further 13,100 biogas plants. The biogas project has a carbon finance component to ensure expansion and sustainability. Nigeria is an agricultural nation with 70 per cent of its population involved in different agricultural activities. It is the largest livestock producer in sub Saharan Africa (Ikhatua 2000). Statistical data have been scarce on livestock population, however ruminant domestic population has been put at 13.9 million cattle, 34.5 million goats and 22 million sheep (Ikhatua 2000). Biogas potential has been estimated at 6.8 million m^3 per day (Mshandete & Parawira 2009). Based on a design selection report, a $6m^3$ fixed dome bio digester is the preferred size for most rural households. 3 - 4 non grazing cattle will produce $1.7m^3$ of biogas daily which can sufficiently cook meals up to 4 hours on a single gas burner and can power a lamp for 4-5 hours. With the livestock population, biogas can adequately provide the energy needs for domestic activities in rural households. A lot of awareness and capacity development by government and NGOs is required for the adoption of this technology by rural households in Nigeria.

5.4 Efficient and sustainable Charcoal production and Utilization

The need for fuel wood stems from low electrification rates in both countries. For many urban households, charcoal provides a reliable, convenient and accessible energy source for cooking at a stable cost and majority of households depend on charcoal for their daily energy needs. Continuous urbanization and population growth translates into increasing demand for charcoal and the economic importance of the charcoal sector is substantial (Martijn 2010). Charcoal consumption in Uganda was over 300,000 tonnes per year in the last decade. The ever growing demand for charcoal contributes to sustainability challenges which must be addressed so as to continually meet the energy demands. Reforming the charcoal sector is one of the most important opportunities to not only reduce emissions but also achieve multiple sustainable development outcomes. Sustainable charcoal production has the potential to attract carbon finance. The environmental challenges in the charcoal sector predominantly lie in forest management, production and consumption of charcoal. Deforestation occurs as a result of unsustainable harvesting (forest practices) and pollution of the environment is as a result inefficient kilns during firing and inefficient cooking technologies employed. Economic and societal issues also arise in the value chain such as evasion of licensing fees and taxes and improper value placed on charcoal. The power players are mainly found in transportation and wholesaling dealing in large volumes of charcoal. By controlling the middle of the supply chain, they are able to dictate many aspects of pricing in the value chain leading to lopsided income levels from stage to stage of the entire value chain (Roop 2013). In a NAMA study in Uganda, Basu et al (2013) proposed a twenty year progression in which the traditional earth kilns are replaced by the Cassamance Kilns and ultimately by Adam retort kilns (there are no further changes in years 2026-2030). The former kilns shows higher levels of efficiency and reduction of GHG emission comes from the reduced amount of wood needed to be pyrolized to produce the needed charcoal and the latter kiln also improves efficiency and greatly reduces GHG emissions (see Table 7).

Table 7: Proposed progression and conversion of Kilns in Uganda

Year	Casamance Kiln	Adam Kiln	Year	Casamance Kiln	Adam Kiln	Year	Casamance Kiln	Adam Kiln
2011	0%	0%	2016	100%	0%	2021	70%	30%
2012	0%	0%	2017	100%	0%	2022	50%	50%
2013	0%	0%	2018	95%	5%	2023	25%	75%
2014	100%	0%	2019	90%	10%	2024	10%	90%
2015	100%	0%	2020	80%	20%	2025	0%	100%

5.4 Increase Stakeholder participation in Sustainable Afforestation Programs

Increase stakeholder participation in sustainable afforestation programs and emphasize its economic benefit from carbon finance perspective. Capacity development programs on climate resilient agriculture should be put in place in addition to necessary support for the implementation of the National forestry Policy whose main goal is towards ensuring a sustainable forest management and adopting an integrated approach to forestry development. Trees are a source of fuel wood and income as well as a sink for carbon dioxide released to the atmosphere.

6. Conclusion

Energy efficiency, renewable energy, afforestation/deforestation and finance are pertinent to curbing the effects of climate change in the domestic sector and are focal points to which the government of both countries should

engage meaningfully to achieve economic growth and environmental sustainability. In addition, climate change mitigation through the Clean Development Mechanism and Voluntary Carbon Markets will significantly benefit the countries in the near future. Increasing hydro generation capacity and grid expansion to improve access to electricity are opportunities for Low-carbon energy generation with economic benefits which should be explored. Particularly, the government of Uganda should address the Lake Victoria declining net basin. Finally, a favorable economic environment through public/private partnership is important.

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