CLIMATE CHANGE AND BIOENERGY REPORT

CASE STUDIES OF OYOLA AND WEKESI VILLAGES, NYANDO DISTRICT, NYANZA PROVINCE ,KENYA

THE AFRICAN CENTRE FOR TECHNOLOCY STUDIES (ACTS)

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EXECUTIVE SUMMARY

ACTS – the African Centre for Technology Studies seeks to expound further on linkages relating to the enhancement of adaptation to the impacts of climate change, with particular focus on the use of bioenergy. This is in recognition of the prevailing situation in our world with reports of rising oil prices and the resultant geopolitical undercurrents; of melting glaciers; of catastrophic floods as witnessed in Pakistan and China in July/August 2010 with subsequent mudslides, loss of life and livestock, loss of arable land (especially in countries that are highly dependent on land resources to contribute to household income and food security), destruction of biodiversity, among others; to the obverse conditions of limited water through droughts as in North Africa's consequent desertification,

The significance of bioenergy has of necessity been elevated both nationally and internationally, since it is also a means of alleviating the impact of global warming through efficient energy utilization; and is potentially an ecologically friendly tool for poverty eradication. For Kenya, this efficient use of bioenergy has been encouraged through setting development goals encompassing the provision of sustainable bioenergy to Kenyans.

This *outcome report* is part of a continuing series of fundamental data and information that are being collated and compiled by the DFID funded PISCES Project (led by ACTS) and the IDRC/DFID funded Community Based Adaptation in Africa Project (CBAA). The report provides baseline information on bioenergy consumption, and the relationship to climate change from the village level, using specific variables related to farming, livelihoods and climatic seasonal variations.

This study was conducted in November 2009 in Oyola and Wakesi villages in Kano Plains, Nyalunya Sub-location, Central Kolawa Location, Nyando District. Oyola and Wakesi, two villages which are heavily impacted by the effects of climate change (particularly manifested through frequent floods and prolonged periods of drought), have been the principal sources of data. The study notes how at the village level, Kenyans who reside in areas affected by climate change (evidenced in this case by extensive flooding and drought) have responded to the use of biofuels. It also looks at the relationship between household energy consumption and climate change in the target villages.

Data were collected in the two villages through group discussions and individual interviews using a pre-designed questionnaire (appendix 1). The study population was selected using random sampling techniques. A total of 65 respondents were interviewed. The study has revealed that, with regard to agriculture, more drought tolerant crops and livestocks are being favoured by the local people, in response to the severity of climate change. On the other hand, little is being done to introduce improved crop varieties and livestock breeds, or improved energy-using appliances. It was evident that fuel is becoming scarcer and the community is resorting to using previously less favored fuel types. While in more flooded areas there has been some effort by the communities to shift to more portable cook stoves, such appliances are of low quality and low efficiency. There is need for intervention to introduce cleaner and more efficient stoves.

INTRODUCTION

Bioenergy is an inclusive term for all forms of biomass and biofuels. In the context of this inquiry, only biomass was considered. Biomass is any biological mass derived from plant or animal matter (e.g. timber crops, straw, animal litter and other waste material) which is used as a source of renewable heat. Bioenergy is the most commonly used source of energy in Kenya. Current biomass demand is estimated at 40.5 million tones, against a sustainable supply of 16 million tonnes (NEMA, 2005). This is mainly used by rural households and peri-urban populations. Rural-based cottage industries, including a range of production and processing activities such as brick making, tobacco curing, milk purification, fish smoking, jaggeries, and bakeries, and the service sector, including hotels and restaurants, together consumed 8.3% of the total firewood and 17.3 % of the total charcoal produced.

It is notable that problems relating to environmental degradation, land clearance, overgrazing, deforestation, drought and desertification are placing more and more pressure on dwindling bioenergy resources. Biomass fuels are the largest source of primary energy in Kenya, with woodfuel consumption accounting for over 68% of the total primary energy consumption. In rural areas, people are using wood, agricultural residues and other bioenergy sources for up to 90% of their energy consumption and many remain wholly dependent on such sources. Despite annual forest growth, this volume of wood biomass harvested is unsustainable leading to many negative environmental and economic impacts This has resulted in the continuous clearing of the country's forests and woodlands. Although Kenya is not a net emitter of GHGs, the forests act as carbon sink. Therefore destruction of the natural woodland and forest for woodfuel is a national concern. Approximately 200-300 trees are needed per household per year[1]. In addition, the use of inefficient stoves, especially traditional three stone stoves, is still prevalent in rural areas.. Replacing traditional cooking stoves with more efficient and cleaner stoves and alternative biofuel sources can contribute to both economic and environmental sustainability as well as social well-being.

Climate change poses clear, catastrophic threats. Although its exact extent is debatable, the risk of inaction is unaffordable. The term "climate change" is often used interchangeably with that of "global warming," but according to the National Academy of Sciences, "The phrase 'climate change' is growing in preferred use to 'global warming' because it helps convey that there are [other] changes in addition to rising temperatures." Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or

[1] http://regionalenergy-net.com/index.php?option=com_content&task=view&id=100&Itemid=114

wind) lasting for an extended period (decades or longer). Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns.

The impacts of climate change, worldwide, tend to be experienced by countries which are least disaster prepared and thus extremely vulnerable. The challenges to these countries tend to be exacerbated by several factors, including great geographical diversity and climatic variations. Thus certain regions might have to deal with rising temperatures, decreased moisture availability and desertification,[i] while other regions, *even within the same country*, must deal with the exact opposites including inundated plains and changing rainfall patterns, all of which affect agriculture. Kenya has had and continues to have it its own experience of the impact of climate change through recurring floods and frequent and prolonged droughts.

Even if the countries of the world agreed to take aggressive steps to stabilize or reduce CO_2 emissions over the next twenty to fifty years, there would still be a strong possibility that the cumulative effects of past greenhouse gas emissions would still have an impact for at least the next several decades, and possibly longer. Given such risks, it is imperative to search for low-cost ways of reducing CO_2 emissions. Collectively, such steps fall under the heading of *mitigation*. There is also a need to reduce the severity of whatever impacts do occur. Such measures generally fall under the heading of *adaptation*. In this context, the importance of bioenergy cannot be gainsaid. Bioenergy is only one part of a many-faceted approach to the problem of climate change, but we must make use of all the measures available to us. Biomass—as a source of heat and electricity—holds significant potential for carbon saving. Of all the available sources of bioenergy it offers the greatest carbon savings per hectare of land cultivated. At the same time, the destruction of forest and woodland for fuel could have the opposite effect of the intended outcome.

Kenya has, since the early 80s, promoted use of energy efficient and relatively clean cooking stoves to replace the traditional use of biomass. However, penetration remains low in the rural populations where the traditional "three stones" are still dominant, with all their disadvantages such as IAP and environmental degradation. Stoves used by households to burn *charcoal* for cooking and heating include 1) traditional charcoal stoves, 2) insulated metal charcoal stoves and 3) the Kenya ceramic *jiko* (KCJ). Although adoption of the KCJ has been high at 85% of *urban* households?? or what??, a significant proportion of the urban population dependent on charcoal for cooking and heating still uses the first two types of stove. The energy delivery efficiency of traditional and insulated metal charcoal stoves is about 25-30%, compared to 33-35% for the

KCJ[2]. This means that a significant amount of charcoal is wasted through use of stoves with low energy conversion efficiencies. If more households move to use the KCJ, consumption of charcoal would also go down, leading to more sustainable management and exploitation of forest biomass for charcoal production. Wide use of more efficient KCJ stoves provides many other benefits. First, household health (especially for women and children) is improved as a result of reduced CO_2, CO and other toxic gas emissions. A study carried out by Practical Action showed that respiratory infections in children and women fall by 60% and 65% respectively when the KCJ is used (reference). The same study showed that conjunctivitis in children under five fell by 70%, while it fell by 67% in women (Practical Action, 2003). Furthermore, use of inefficient cooking stoves by rural households increases consumption of wood fuel; household expenditure on energy is increased and the demand for wood fuel is much higher than would be the case if more efficient stoves were used. Increased household expenditure on energy means that they cannot make savings to move up the energy ladder and eventually invest in more sustainable renewable energy such as biogas production.

Bioenergy has several linkages to climate:

1. Of both national and international significance is the fact that this energy is compliant, in terms of being a means of offsetting emissions through the Clean Development Mechanism with targets offset in the Kyoto Protocol and post-Kyoto, together with COP-15 instruments. Therefore, bioenergy is often regarded as a suitable key driver in development because the replacement of non-renewable types of energy with renewable ones is encompassed within the broad label of "bioenergy" products. Thus bioenergy is a means of harnessing that energy to assist with development, in compliance with targets from the Kyoto and post Kyoto instruments.

2. There is an economic-environmental linkage in supporting and encouraging clean technology in order to mitigate the impacts of pollution on the environment in a cost effective manner using natural materials.

3. The current international status quo on the environment promotes the need for alternative energy that will reduce the adverse impacts of climate change. Its link to climate change is an area of interest to think tanks and civil society and the international community as a whole, an importance which is highlighted by climate change-related catastrophes. Bioenergy, therefore, remains an area of focus; and particularly its uses, which generally include:

i. Burning the biomass directly as fuel;

ii. Fermenting biomass to alcohol which is then dehydrated for useas a transport fuel;

iii. Utilising industrial and municipal wastes in two contexts:-

(a) Regional, involving the national and international community and

(b) Local, involving households and individuals

4. There are several linkages between bioenergy and climate change. These mainly highlight the increase in bioenergy demand as climate change occurs. "Deforestation, agriculture and livestock production systems further accelerate climate change. The expansion of the livestock and biofuels sectors has a major role in deforestation and land degradation."[ii]

5. Bioenergy production is linked to changes in various environmental policies. There is, a great challenge in the development of biofuel plantations, relating to forest cover and burning in order to clear land for bioenergy crop production. Further, the consequent growth of the bioenergy sector may lead to water shortages and contamination. Biofuels development needs to be supported by appropriate policies to ensure environmental, social and economic safeguards.

This report is part of ACTS' ongoing climate and environment themes that specifically focus on energy, particularly the provision of bioenergy as a means of reducing greenhouse gases that increase the adverse effects of climate change. This report details the results from the study of the relationship between various variables related to farming and means of livelihood, in order to draw specific empirical observations that would lead to further knowledge regarding bioenergy and climate change. It makes policy proposals to the national government.

Study Objectives

This study provides baseline information on bioenergy consumption and its relationship to climate change from the village level, using specific variables related to farming, livelihood and climatic seasonal variations. This is a foundation upon which policy can be formulated and implemented, at both national and international levels, and upon which further research can be built.

Specific objectives of this study include:

- To assess the impact of climate change on livelihood systems;
- To evaluate the way in which climate change may influence fuel consumption and the type of fuel used in households
- To evaluate the impact of climate change on bioenergy appliances
- To determine how the use of bioenergy may contribute to adaptation (?)

METHODOLOGY

This study which was conducted in November 2009 in Oyola and Wakesi villages in Kano Plains, Nyalunya Sub-location, Central Kolawa Location, Nyando District. These two villages have been heavily impacted by the effects of climate change (particularly evident in frequent floods and prolonged periods of drought) and have been the principal sources of data. The study notes how at the village level, Kenyans who reside in areas affected by climate change (in this case intensive floods) have responded to the use of bioenergy. It also looks at the household relationship to energy consumption as influenced by continual climate change.

The two sites were selected because they were situated in areas where:

i. The impacts of climate change are extreme because of many factors, among others their geographical location e.g. altitude (low-lying plain) and proximity to higher lying areas.
ii. Areas which owing to historical and social factors already have communities which are able to work together in adapting to the impacts of climate change.
iii. Additionally, ACTS had previously conducted community adaptation studies[iii] related to community based adaptation strategies.

- Data was gathered by interviews using a pre-designed, semi-structured questionnaire as well as focused group discussion.
- Random Sampling techniques were employed to select the farmers that were to be interviewed.
- The pre-designed questionnaire detailed the respondent's main identifiers, nature of housing materials, livelihoods, crops and animal husbandry systems, income sources, impacts of climate on fuel *inter alia* (Appendix 1).
- A total of sixty-five farmers were interviewed, 45.5% of whom were women.

Kano Plains, a low lying wetland region, is an area which magnifies the impacts of climate change especially when it floods. There are several reasons for this, including but not limited to:

(a) *Geographical linkage* magnifying the impacts of climate change through altitude, neighbouring highlands and proximity to a lake; together with the presence of clay soil which has reduced porosity;
(b) Its central location and proximity to a large city (Kisumu) and to rice and sugar farms which permits the study to focus on the villagers' different sources of income, i.e. whether they are small scale farmers, urban workers or seasonal workers.

The two villages are equidistant from the rice growing area of Muhoroni and Kenya's third largest city – Kisumu. Oyola village borders the Kisumu Rabuor Road to the east and the Old Kibos River and lies to the North East of Kamuga village. Its additional water resources include the River Mahenya which cut through the village from the south west to the east and the Kolwanda stream which also runs from the North West and drains into the River Mahenya.

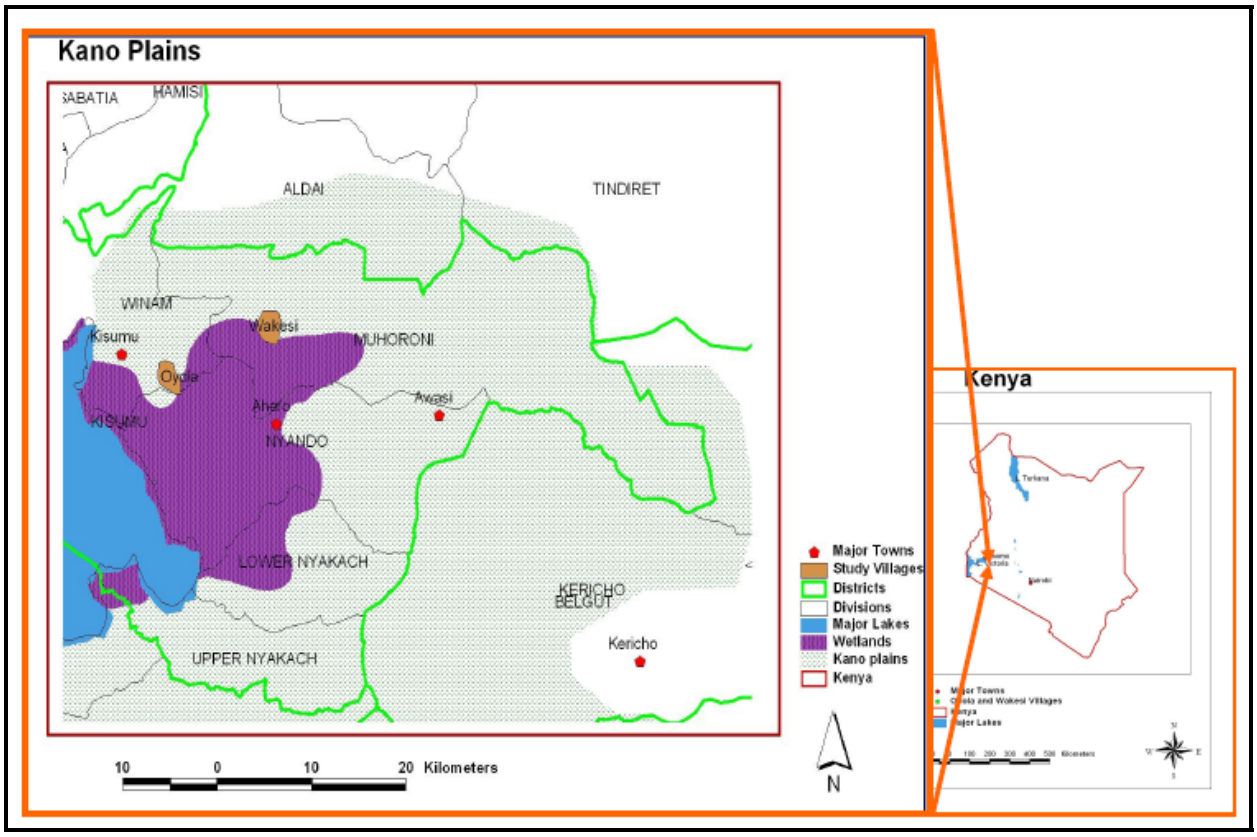

Fig. 1 Map of Oyola and Wakesi villages in Kano Plains, Nyanza District

RESULTS

Livelihood Systems

Interviews were conducted to determine the crop production trends over the last ten years. The results showed that maize, cassava and sweet potatos are the main food crops while sugarcane and rice are the main cash crops (Fig. 2). Based on the number of respondents who indicated that they cultivate the individual crops, it was noted that production of food crops (maize, sorghum, cassava and sweet potatoes) have increased over the past decade with maize and cassava showing the highest increase from 88% to 97% and 65% to 73% respectively. Cash crop production has remained more or less the same with only a slight decline in rice and a slight increase in sugarcane.

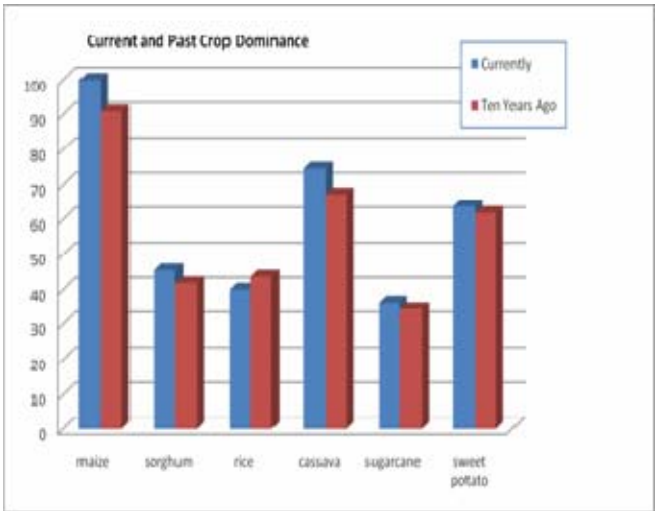

Fig. 2 Ten year cropping pattern

Compassion of the cropping partner of the two villages showed that there was an increase in the number of people involved in crop production over the last ten years (Table 1).

Table 1 Ten years cropping pattern per village

Crop Dominance (%)				
	Wakesi		Oyola	
	Current	10 years ago	Current	10 years ago
Maize	100	94	100	87
Sorghum	41	41	52	43
Rice	63	63	9	17
Cassava	84	78	61	52
Sugarcane	50	47	17	17
Sweet potatoes	78	78	43	39

Fig. 3 Cassava plants in Oyola Village

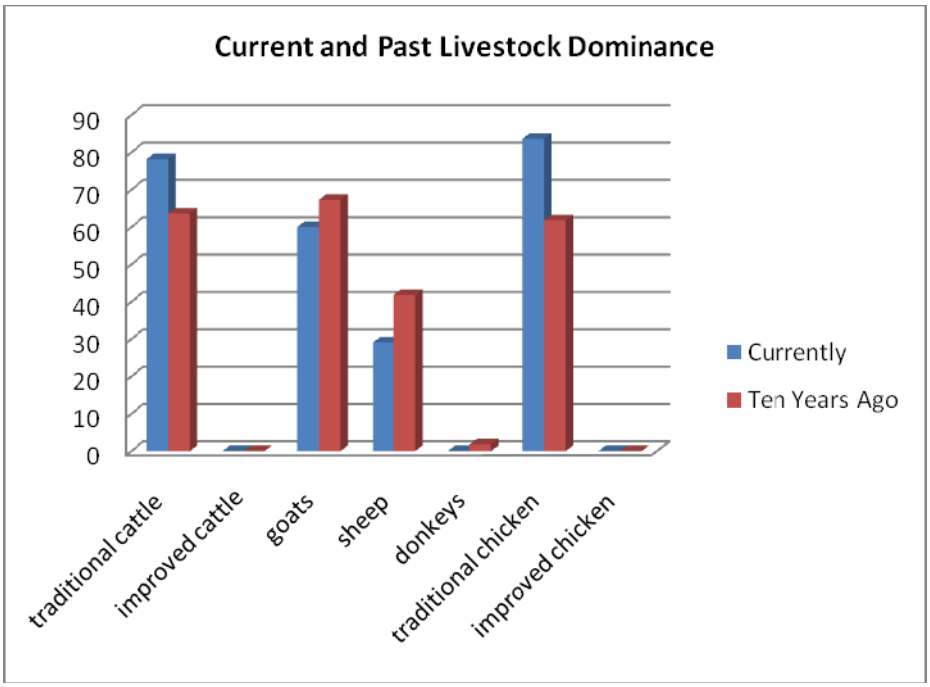

Fig. 4 Livestock production trends

Interviews were conducted to determine the livestock production trends over the last ten years. The results showed that traditional cattle, goats, sheep and traditional chickens are dominant (Fig. 4). Based on the number of respondents who keep the individual livestock types, it was noted that only traditional cattle and chickens have been on the increase while the rest have been declining. For example, the number of farmers keeping traditional cattle increased from 62% to 76% while the number of farmers keeping goats decreased from 65% to about 58% and the percentage rearing sheep decreased even more markedly from 40% to 28%. The study did not record any keeping of *improved* breeds such as improved cattle or chickens.

Comparison of the two villages shows that, except for traditional cattle and traditional chicken, the number of respondents keeping livestock has generally been on the downward trend over the last ten years (Table 2).

Table 2 Livestock production trends per village

Livestock Dominance (%)				
	Wakesi		Oyola	
	Current	10 years ago	Current	10 years ago
Traditional cattle	72	59	87	70
Goats	59	66	61	70
Sheep	25	31	35	57
Donkeys	0	0	0	4
Traditional chickens	88	66	78	57

Fig. 5 A cow grazing under restricted range in Oyola Village

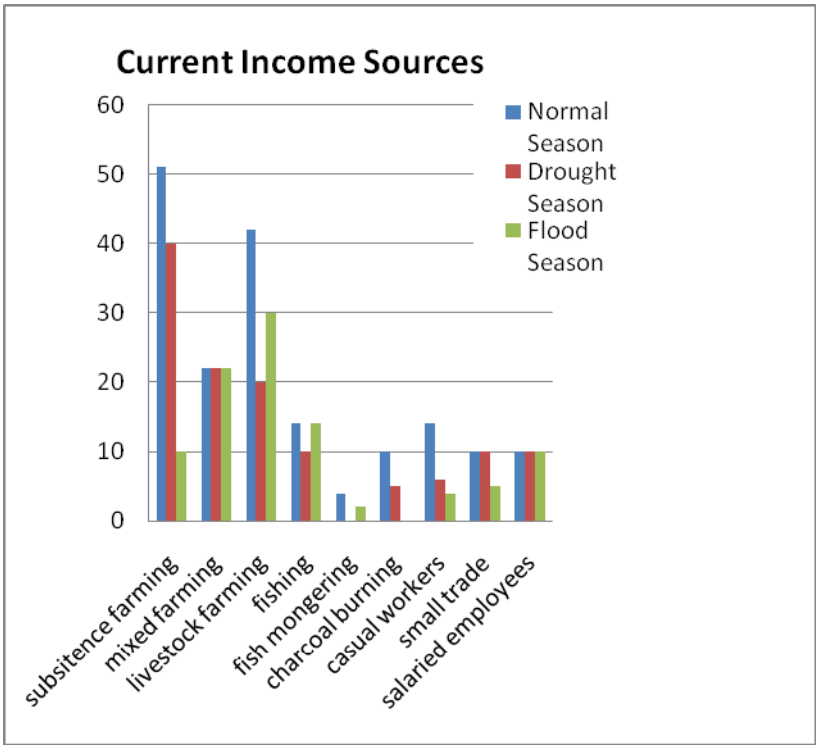

Fig. 6 Current seasonal variation in income sources

For the sake of this study the seasons were categorized into three normal seasons (when there is neither drought nor floods), a flood season and a season of drought. Salaried workers and mixed farming was the only income source that was cushioned from any seasonal variations. Other income sources varied with the three seasons. Sources of income during the normal season were subsistence farming, livestock farming, and casual work. Subsistence farming dropped significantly from about 52% to 10% during floods as compared to a normal season. Livestock farming remained high during the normal season and during floods but dropped during drought. Fish mongering went during a normal season and during floods but experienced a low during drought. Charcoal burning was nonexistent during floods.

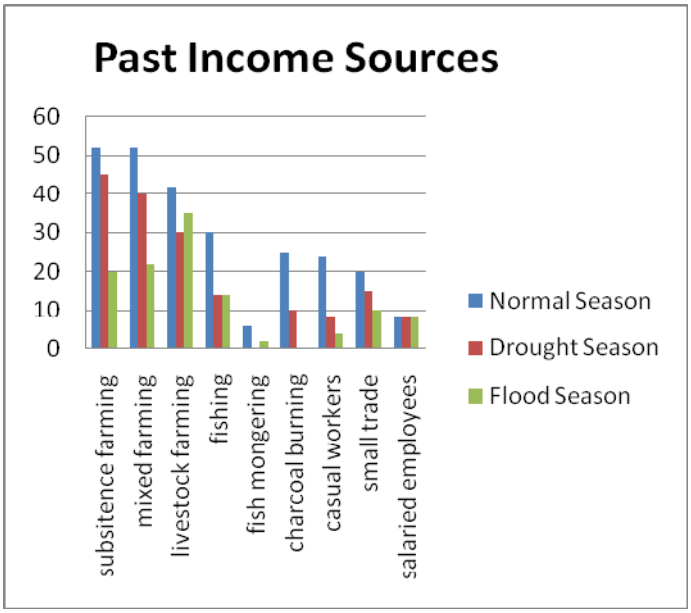

Fig. 7 Seasonal variation in income sources over the past 10 years

From the results noted in figure 7 above, salaried employment is the only steady income source that is not affected by seasonal variations. All the income sources performed better during a normal season as compared to drought or flood seasons (Fig. 7). Farming (livestock, mixed and subsistence) was the predominant income source during floods, followed by fishing. Compared to floods, drought had a lesser impact on income ten years ago as drought tended to reduce the incomes of the households in these areas, significantly.

Fuel Availability

Table 3 below compares current versus former availability of fossil and biofuel. Use of modern fuel types such as electricity and LPG was not recorded in the two villages. The predominant fuel types include firewood, agricultural residue, kerosene (mainly for lighting) and animal dung. Firewood is still by far the dominant fuel type, followed by animal crop residue during normal and dry seasons. During floods, charcoal and kerosene are predominant. While all the fuel types were used during the normal and drought seasons, floods had the greatest impact on chosen fuel types.

Table 3 Fuel types and seasonal availability

Comparison of Fuel Availability, currently and in past years						
	Current			10 years ago		
Fuel Type	**Normal Season (%)**	**Drought Season (%)**	**Flood Season (%)**	**Normal Season (%)**	**Drought Season (%)**	**Flood Season (%)**
Kerosene	64	62	62	64	64	55
Charcoal	55	55	36	64	62	15
Firewood	89	89	9	89	95	13
Animal dung	55	75	4	76	67	0
Crop residue	84	73	7	84	87	11

Fig. 8 A tree being felled for charcoal production

Fig. 9 A woman cooking on a traditional three stone stove

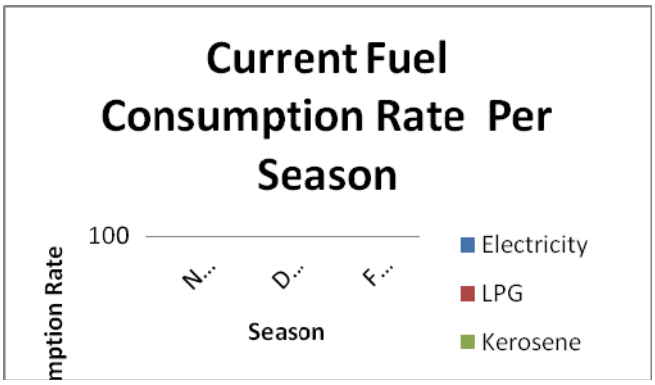

Fig. 10 current fuel consumption rate per season

From the results, it is evident that the pattern of fuel consumption has been changing over the last ten years. In addition, it was observed that this also varied with the season (Fig 10). While ten years ago firewood was the choice fuel type consumed during the normal season, currently agricultural residue has emerged as an important fuel type at the same level as firewood and has even supercede firewood as the choice fuel type during the dry season (Fig 11). As could be expected charcoal, is the choice fuel type

currently during floods though ten years ago there was no clear difference. It is worth noting that except during floods , use of animal dung is becoming increasingly important compared to its use ten years ago.

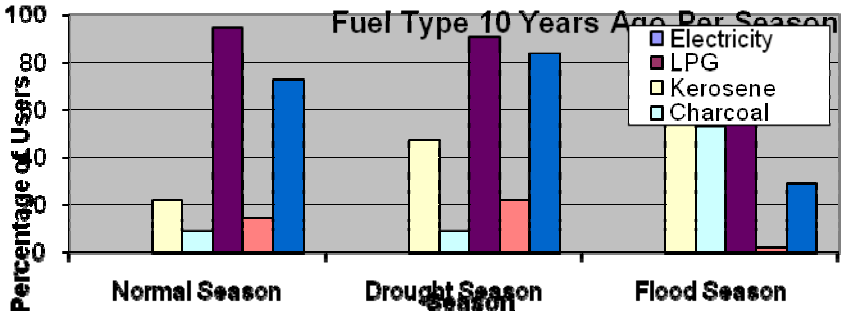

Fig 11 on fuel types 10 years ago per season

Household Cooking Appliances

Table 4 shows that the household cooking appliances of choice are still the traditional three stone and animal dung stoves. In Wakesi village no other type of stove was recorded. In Oyola other types of stoves have been introduced, especially used during floods. These include metalic charcoal stoves, improved, ceramic charcoal stoves and saw dust stoves.

Table 4 Household cooking appliances

Appliance	Current			10 years ago		
	Normal	Drought	Flood	Normal	Drought	Flood
Metalic charcoal stoves	0	0	15	0	0	15
Improved charcoal stoves	0	0	15	0	0	5
Saw dust stoves	20	15	45	0	0	0
Improved wood stoves	0	0	15	0	0	11
Traditional wood stoves	89	89	15	100	100	40
Animal dung stoves	62	62	0	78	78	15

DISCUSSION

The main sources of livelihood in the two study villages have revolved around farming (that is subsistence farming, mixed farming and livestock farming). A few other livelihood sources identified include fishing, charcoal burning and small trade. As was expected climate change has had a great impact on the livelihood options of local residents. This was manifest in the trends of crop and livestock production as well as other income sources. Recorded increase in maize and cassava production could be explained by the fact that quick maturing maize variety is available which can avoid drought. Cassava is known to be drought tolerant thus more suitable for growing in areas such as Oyola and Wakesi which experience frequent drought.

In terms of agricultural trends, the number of people going into food crop production has increased over the years while cash crop production, mainly rice and sugarcane has remained more or less constant. This scenario is an indication of a community ill-equipped for adaptation to the impacts of climate change. In such a poor community more diversification of cash crops would ensure more stable incomes than is the case currently. Greater reliance on food crops is an indication that people are only farming only for subsistence farming just to get day to day food than long term adaptation strategies.

The same trend in farming was observed in livestock production where the population of sheep is on the decline while that of goats is increasing. This could be explained by the fact that goats can survive drought better than sheep and as droughts come more frequently most people tend to abandon sheep rearing in favour of keeping goats. As was the case with crops, traditional breeds are dominant and no improved breeds were recorded. Though this could be explained by the fact that the traditional breeds generally tend to be more adapted to the prevailing climatic conditions, in terms of income expected from livestock this is very low and can hardly meet the needs of a typical household. This presents an opportunity when considering adaptation strategies. The introduction of improved breeds could go a long way in diversifying income sources in a more sustainable way than relying on the traditional, low productivity yield.

Looking at the source of income during different seasons, it was clear that with the exception of salaried work and mixed farming which persist, the rest of the income sources fluctuate with seasons. Most significant on this was the observation that income from livestock dropped drastically during

droughts. This was because a long tradition of livestock loaning to relatives and friends living in areas with greener pastures to escape droughts. Adaptation strategies need to consider providing dry season fodder for livestock and providing well or bore holes for watering livestock during the dry season_____

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The CBAA project had reported that the families in Oyola and Wakesi area have a mutual relationship which involves the families in Wakesi permitting the livestock of the Oyola families to graze in their pastures which are relatively higher altitudes, and later the families in Oyola may grant milk, calves or oxen to cultivate the land. This somewhat explains plausible reasons why traditional cattle increased significantly by about 15 percent. Factors favouring this include the fact that the two communities Oyola and Wakesi have entered into some sort of adaptive mechanism agreement between themselves, where the cattle, can be taken to higher altitude during the flood season. Added to this the traditional cattle are already easily adapted to the climatic conditions within this area. It is worth noting that the improved cattle, have not performed well in this area and they are not being kept in the households, neither are the improved chicken. Possible reason to this could be lack or poor facilities needed by improved breeds such as vet services, cattle dip, water and pasture. This would mean thus choice of animals is influenced by effect by the impact of climate change.

Keeping to the trend in the country, fuel type used at household has been changing gradually to low quality fuel types. While firewood was the dominant fuel type 10 years ago, crop residue and animal dung are emerging strongly as the dominant during the normal season and dry season. The explanation of this could be found on the degradation of the natural vegetation in the area for other competitive uses such as poles, timber, fish smoking and also expansion of agricultural activities. Poor quality timber does not only mean that more fuel is used with severe impact on the environment but could also mean increased level of indoor air pollution (IAP). Observation in the area indicated a grim picture. Though the communities unanimously agree that they would prefer species such as *Acacia* spp, *Balanites aegyptiaca* or *Combretum* spp *inter alia* which are known to be of high calorific value and less smoky, these species are currently almost none existed due to over utilization. This is forcing people to use less preferred species such as *Euphorbia tirrucali*, yellow oleander, etc. Some of these species are of the *Euphorbiaceae* familily which are known to produce poisonous smoke thus aggravating incidences of IAP.

Another problem with using animal dung and crop residues is to do with soil fertility. In many of the rural areas majority of farmers cannot afford chemical fertilizers. This means animal manure and decomposing crop residue are the only source fertilizer. Diverting these materials to household energy denies the farms of important or the only source of fertilizer.

The study has noted some relationship between the severity of the impact of climate change and the type of appliances used. In Wakesi village traditional cook stoves are still predominate. While in Oyola village there has been some attempt to use more portable types of cook stoves especially during the time of floods. This can be explained by the fact that Oyala is move vulnerable to flooding being at slightly lower altitude and with flat topography. The traditional three cook stoves cannot be used during floods since they are fixed on the ground. In such condition, therefore, portable stoves that can be moved to raised grounds are more preferable. It was however noted that though preferable, use of improved and portable stoves is still very low in the region. This is a case calling for urgent intervention.

RECOMMENDATIONS AND CONCLUSIONS

The study has shown that there has been a gradual shift in livelihood options as well as the way and manner of use of bioenergy over the past ten years. These changes have been specifically geared towards adapting to the impact of climate change. On the other hand, however there has been little intervention by the government and other development agents to help the communities improve their adaptive capacity.

In light of the aforementioned conclusions, general recommendations ought to include the use of adaptive strategies that interplay with the seasonal strengths or weakness. In this vein for example, using the empirical observation that firewood and crop residue in the normal seasons are the main sources of income, and that animal dung during the drought season increases. This not good for soil health since farm manure are the main source of soil fertility maintenance in the region. The government should help the local communities acquire more modern clean and efficient cook stoves

Introduction of improved animal breeds that are more productive and tolerant to local environmental stresses could offer another avenue of intervention.

General Recommendations

a. Encouraging information dissemination on the importance of growing biofuel crops that can produce high quality charcoal and firewood.
b. Providing at low cost and specific training to make particular cooking appliances like modified traditional stoves i.e. the jikos, since using economics to tie into environmental goals would assist in poverty alleviation influencing normal behavior in a manner conducive to utilization of clean energy. This would however require twin goals like the government encouraging large plantations of appropriate feedstock crops.
c. Improving and using law to mandate specific areas have Forest cover and perhaps encourage plantations of trees like *Eucalyptus* which have the added benefit of providing fuel and draining the water from land during flfod season.
d. Providing clean energy cook stoves, that might use biofuel oils and crop residues
e. Policy at national level should include widespread dissemination of information regarding the benefits of using biofuels and the making available various bioenergy related appliances

Policy Recommendations

a. Incentives will be provided to households that adopt use of efficient and clean cook stoves
b. Though legislation on charcoal has been developed, this does not look at the end user side including appliances to ensure use efficiency
c. Assessment on level of adoption of modern cook stoves will be done from time to time to determine possible impacts on woodlands and tree resources on the farms and implications on climate change.
d. On-farm cultivation of both indigenous and exotic woodlots to sustain the supply of fuelwood in the rural areas while protecting the environment;
e. Support in research and development of appliances and end user technologies such as energy efficient and clean cook stoves
f. Develop of appropriate access and delivery models to ensure that technologies reach the end users including credit facilities for installation of biofuel production plants and acquisition of end user appliances;

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APPENDIX A. CLIMATE CHANGE AND BIOENERGY Questionnaire

1.0 General Information

ID No……Village…… Location……. Division……

District……. GPS …… Date……..

Name of respondent…… Age…… Gender ……

No. of household members…… Amount of land owned…….

Observe house roofing material 1. Grass thatched 2. Iron roofing 3. Tiles 4. Other

Wall of the house 1.Stone 2.Mud 3.Bricks 4.Burned bricks

Floor of the house 1. cement 2.earthen 3.stone

2.0 Livelihood system

2.**1 Which crops do you produce currently?**

1. None 2. Maize 3. Sorghum 4. Rice 5. Cassava 6. Sugar cane 7. Sweet potatoes 8. Others (specify) ……

2.2 Which crops were you producing 10 years ago?

1. None 2. Maize 3. Sorghum 4. Rice 5. Cassava 6. Sugar cane 7. Sweet potatoes 8. Others (specify) ……

2.3 If there is a change, explain why?

…….

……

2.4 What kind of livestock do you keep currently?

1. Traditional cattle 2. Improved breeds 3. Goats 4. Sheep 5. Donkeys 6. Traditional chickens, 7. Improved breeds

2.5 What kind of livestock were you keeping 10 years ago?

1. Traditional cattle 2. Improved breeds 3. Goats 4. Sheep 5. Donkeys 6. Traditional chickens, 7. Improved breeds

2.6 If there is a change, explain why?

……..

……..

2.7 What system of livestock production are you using currently?

1. Free range, 2. Restricted range, 3. zero grazing

2.8 What system of livestock production were you using 10 years ago?

1. Free range, 2. Restricted range, 3. zero grazing

2.9 If there is a change, explain why?

……..

……..

2.10

Impact of climate on income source								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Subsistence farming								
Mixed farming								
Livestock keeping								
Fishing								

Fish mongering								
Charcoal burning								
Casual worker								
Small trades								
Salaried employment								

3.0 Fuel type, consumption rate and temporal variability

3.1

Impact of climate on fuel type*								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Electricity,								
LPG gas,								
Kerosene,								
Charcoal								
Firewood,								
Animal dung								
Crop residues								

*Tick the box as appropriate

3.2

Impact of climate on fuel type availability								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Electricity,								
LPG gas,								
Kerosene,								
Charcoal								
Firewood,								
Animal dung								
Crop residues								

1. Scarce, 2. Abundant, 3. No change

3.3

Impact of climate on fuel access*								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Electricity								
LPG gas								
Kerosene								
Charcoal								
Firewood,								

Animal dung								
Crop residues								

* 1. Collect free within 2 km away from homestead, 2. Collect free more than 2km away from homestead, 3. Buy from the neighbours, 4. Buy from the local markets, 5. Buy from the city, 6. Grid connection

3.4

Impact of climate on fuel type consumption rate*								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Electricity,								
LPG gas,								
Kerosene,								
Charcoal								
Firewood,								
Animal dung								
Crop residues								

*1. Consume less, 2. Consume more, 3. No change

3.5

Impact of climate on plant species used for firewood				
Plant species	Normal season	Drought	Rainy season	Flood

	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Acacia sp.								
Balanites sp								
Sisal								
Combretum sp.								
Papyrus sp								
Crop residue								

4.0 Energy appliances used

Impact of climate on household stoves used								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Electrical hot plates,								
LPG stoves,								
Kerosene								

stoves								
Metallic charcoal stoves								
Improved charcoal stoves								
Improved wood stoves								
Traditional wood stoves								
Animal dung, and residue in traditional stoves								

5.0 Adaptation strategy and bioenergy

Impact of adaptation strategy on bioenergy dependency								
Fuel type	Normal season		Drought		Rainy season		Flood	
	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago	Current	10yrs ago
Subsistence farming								
Mixed farming								
Livestock								

keeping								
Fishing								
Fish mongering								
Charcoal burning								
Brick burning								
Blacksmith								
Pottery								
Basketry								
Small trades								
Casual worker								
Salaried employment								

*1. High dependency, 2. Medium dependency, 3. Low dependency, 4. No energy required

6.0 Ongoing and past initiatives on Bioenergy

6.1 Are there any government, NGO or CBO initiatives on bioernergy in this area?

1. Yes, 2. No.

If yes, what is the name of the initiative/organization? …….

What are the possible interventions?

……

……

[i](Source: *Climate Change, Bioenergy and Land Tenure, Technical Background document,* FAO, http://www.globalbioenergy.org/uploads/media/0805_FAO_-_climate_change_bioenergy_and_land_tenure.pdf)

[ii] Source : http://www.fao.org/ag./agn/agns/files/HLC2_Food_Safety_Bioenergy_Climate_Change.pd

[iii] Wakhungu et al: 2009