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A Study on Agricultural Residues as a Substitute to Fire Wood in Kenya: a Review on Major Crops

Stephen K. Kimutai (Corresponding author)
Department of Mechanical & Production, Moi University, P.O Box 3900, Eldoret, Kenya
Email: mantuikong@gmail.com

Alex M. Muumbo
Department of Mechanical & Production, Moi University, P.O Box 3900, Eldoret, Kenya
Email: muumboalexis@gmail.com

Zachary O. Siagi
Department of Mechanical & Production, Moi University, P.O Box 3900, Eldoret, Kenya
Email: siagzack@yahoo.com

Ambrose K. Kiprop
Department of chemistry, Moi University, P.O Box 3900, Eldoret, Kenya
Email: ambkiprop@yahoo.ca

Abstract
For Kenya, the use of fire wood is enormous that the exploitation of other energy resources such as biomass from agricultural residues is little known. Therefore, the main aim of this study is to investigate agricultural residues estimates for use as a substitute to fire wood and charcoal in Kenya. This solution is in line to the urgent needs of finding the alternative for the depleting fossil fuels. The study found that Kenya agricultural residue energy potential is about 187,000 TJ which enough to substitute fire wood in most regions if converted with suitable technologies. If all the available agricultural residues are used as substitution fuel for fire wood, Kenya could reinstate the 10% forest cover as recommended from the current 1.7%.

Introduction

Currently, there exists a growing imbalance between supply and demand of wood energy in Kenya. The wood demand stood at 34.3 million tonnes as compared to an estimated sustainable supply of 15 million, thereby indicating a deficit of about 60% (Mugo and Gathui, 2010). This has resulted in heavy depletion of forest resources, severe land degradation, soil erosion and declining agricultural productivity. Consumption of traditional fuels has negative environmental, economic and health impacts. That is, increased use of firewood and charcoal leads to deforestation, ecological imbalance, and increased use of agricultural residues and animal dung, deprives the land of the essential nutrients that are necessary for soil fertility. Furthermore more smoke from the use of fuel wood and dung for cooking contributes to acute respiratory infections. This latter problem is worse in poor countries where households are not equipped with separate living and working places (Gorfu, 2004).The existing burden on biomass resources, the negative impacts on the environment and energy supply problems could be alleviated by undertaking comprehensive alternative energy technologies for decentralized applications (Gorfu, 2004).

Agriculture is a dominant sector in the Kenyan economy accounting for 24% of the country's Gross Domestic Product. The sector is the largest contributor of foreign exchange through export earnings from tea, coffee and horticulture. Agriculture also provides employment and livelihood to a large proportion of the population. An estimated 75% of the population depends on the sector either directly or indirectly. Any changes in the sector, due to its dominance will translate to changes in the whole economy. Hence the depletion of forests can be reduced, if the remains of agricultural products are properly utilized (Ministry of Agriculture, 2013).

Also research by Matiru (2007) found out that significant quantities of agricultural residues are available for conversion into domestic energy sources but are under-utilized due to their handling, transportation, storage and combustion characteristics. Therefore, converting these agricultural residues into environmental friendly form of energy can substitute firewood and charcoal produced in traditional way (Ministry of Energy, Economic Survey 2008). Estimation of the amount this Agricultural residue is the first step in mitigating both energy and environmental problems and hence forms the basis of this paper.

Methodology

The methodology in this study is divided into two parts, namely, (i) Crop production (ii) Agricultural residues estimation using residue-to-product ratio (iii) Energy potential of these residues (iv) Energy recovery option

DISCUSSION

Crop production

The map shown in Figure 1 shows the areas where; maize, wheat, millet, sorghum, cassava, barley and rice are majorly grown in Kenya. Others not shown in the map are sugar cane

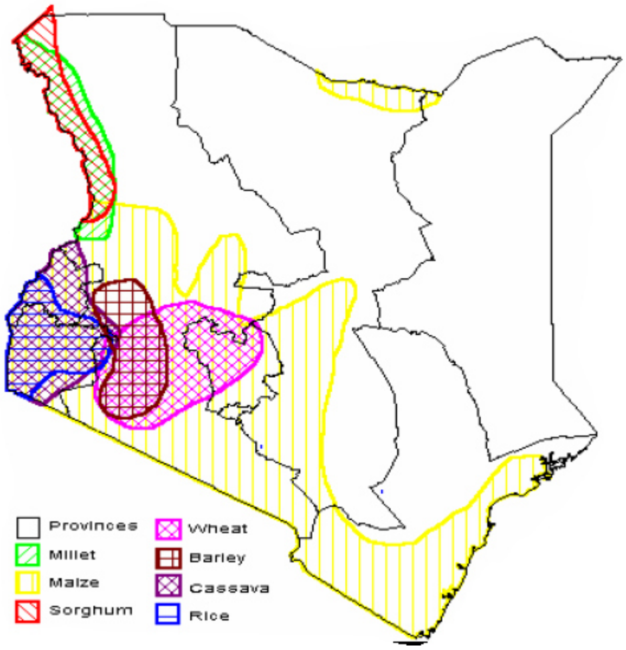

Figure 1: Map showing major growing areas in kenya (Ministry of agriculture report, 2013)

i) Maize

Maize is Kenya's staple food, with area under cultivation estimated at 1.6 million hectares. Maize production in Kenya relies on the small-scale farmers who contribute about 75% of the overall production, with the remaining 25% being contributed by the large-scale farmers. The estimated contribution of regions in terms of area coverage, production and maize residues to national production in the year 2007 as shown in table 1

Table1: Estimates of maize residues by provinces in Kenya

Province	**Estimated maize area (Ha)**	**Maize production(MT)**
Central	112,000	134,312
Coast	64,000	49,975
Eastern	288,000	114,365
Nyanza	208,000	252,361
Rift Valley	688,000	1,085,765
Western	240,000	418,706
Total	**1,600,000**	**2,055,484**

Tegemeo Institute of Agricultural Policy and Development (2009)

With Bumper harvest which was reported in the lower Eastern Province counties- Machakos, Kitui, Makueni, Ministry of agriculture reported Maize production in 2012 to be 3,603,338 tonnes(Ministry of agriculture report, 2013)

ii)Wheat

Wheat is the second most important cereal grain in Kenya after maize. Wheat growing areas include the scenic Rift Valley regions of Uasin Gishu, Narok, Marakwet, Keiyo, Londiani, Molo, Nakuru and Timau. The areas have altitudes ranging between 1200m and 1,500m above sea level with annual rainfall varying between 800mm and 2,000mm, with up to 2,500mm on higher grounds. The area under wheat production in Kenya is more than 150,000 hectares with total production of about 567,000 tonnes.

With the improved weather conditions in the main production regions of Narok, Wheat production increased to 4,908,400 bags (441,756 tonnes) in 2012 as compared to 2,983,130 bags (268, 481 tonnes) in 2011. This value is low compared to the normal production which is due to the farmers in Uasin-Gishu and Marakwet preference for Maize due to its high profitability (Ministry of agriculture report, 2013).

iii) Sugar

In Kenya, sugarcane is grown on fairly flat regions in the Western, Nyanza and Coast Provinces. About 92% of the total cane supply is from about 250,000 small-scale growers whilst the remaining is from the nucleus estates of the sugar factories. The total area under sugar is about 107,622 hectares with total production of about 523, 652 tonnes.

The industry directly and indirectly supports 5 million Kenyans representing about 16% of the entire Kenyan population (Ministry of agriculture report, 2013).

iv) Sorghum

In Kenya the crop is predominantly traditionally grown in Eastern, Western, and Nyanza provinces. Generally sorghum productivity is influenced by rainfall. As an indigenous Kenyan crop, sorghum provides food security and is becoming a suitable alternative in many places where maize crop fails. It is production is estimated at 126,433 tons per annum, with rift valley and nyanza province leading. (Tegemeo Institute of Agricultural Policy and Development, 2009 and Ministry of agriculture report, 2013)

v) Millet

Kenya largely produces the finger millet variety. Production in 2008 was 64,023 tons, which met the domestic requirements. Millet is often used as a substitute to maize incase of the latter's' failure. Millet is mainly produced in Nyanza, Eastern, Rift Valley and Western provinces of Kenya, as illustrated in the table below.

Table 2: Kenya Millet Production Statistics 2007-2008

Province	**Production (metric tons)**	
	2007	**2008**
Central	44	34
Nyanza	12,973	12,139
Western	11,500	8,341
Coast	398	70
Eastern	45,211	33,601
Rift Valley	6,413	9,843
Total	76,539	64,023

Tegemeo Institute of Agricultural Policy and Development (2009)

Cassava

Cassava is grown on approximately 77,502 Ha with an annual production of about 841,196 tons for food and income and has the potential of making Kenya realize its 2030 goals in the marginal and Semi-Arid areas. The majority of small-scale farmers in these areas are women. In the marginal areas of Coast Province, Cassava has potential not only as food for humans, but also as feed for livestock and as a substitute for over exploited forest covers (Kiura *et al*, 2008).

In the coastal lowlands of Kenya, cassava is the second most important staple crop after maize, where 64% of the poor depend on cassava for their livelihoods. Large quantity of leaves is often discarded at the time of cassava harvest, as observed by Jayaprakas et al. (2004) and, the potential of cassava residues remains unexploited and underutilized.

vi) Barley

Kenya's barley growing area is estimated to be 85,000 hectares according to production estimates. However only about 20,000 hectares is under barley production thus 65,000 hectares has not been utilized. The annual production is about 33, 035 tons (Nandwa et al, 2013).

iix) Rice

Rice is Kenya's third staple food after maize and wheat at an estimated growing area of about 23,106 Ha. Its consumption has been growing rapidly and it is likely to overtake wheat. Rice production is estimated at about 64,840 tonnes. In Kenya rice is mainly grown in Mwea, Ahero, Bunyala, West Kano, Yala Swamp (Ministry of agriculture report, 2013).

ix) Coffee

About 70% of Kenyan coffee is produced by small- scale holders. It was estimated in 2012 that there were about 150,000 coffee farmers in Kenya and other estimates are that six million Kenyans are employed directly or indirectly in the coffee industry. The major coffee-growing regions in Kenya are the high plateaus around Mt.

Kenya, the Aberdare Range, Kisii, Nyanza, Bungoma, Nakuru Kericho and to a smaller scale in Machakos and Taita hills in Eastern and coast provinces respectively. Coffee production is estimated at about 23,062 tonnes (Daniel, 2012, Patrick, 2005 and Tim 2013).

Estimation of agricultural residues

Agricultural residues constitute a major part of the total annual production of biomass residues in Kenya and are an important source of energy both for domestic as well as industrial purposes. Little amount of residues are used as fuel, but a large amount is burnt and dumped in the field.

In order to estimate the amount of agricultural residues available in Kenya, residue to product ratio of agricultural residues and productivity of this area were utilized. According to the literature, it was found that the ratios were as shown in table 3. The average values, were chosen for computing as explained below;

i) Sugar cane tops and Bagasse

In Kenya, Bagasse and sugar cane tops and leaves are the residues of which about 50% the former is normally used as an energy source for steam generation while the latter is majorly burnt in the field. Most sugar factories often burnt or dumped bagasse in landfill without recovering energy. Though Mumias and Muhoroni Sugar Companies produce 1,070,000 tonnes of bagasse, only 753,000 tonnes are used annually while the rest are disposed off in landfill (Owino, 2009).

Bagasse: RPR value for bagasse ranges from 0.1 to 0.33 with a moisture content of 50%. Bhattacharya et al. (1993) give an average value of 0.29 with a similar moisture content, which has been used further for calculation purposes.

Tops/leaves: RPR values for sugar tops ranges from 0.1 to 0.125. USAID (1989) reported an RPR value of 0.3 based on actual field experiments in Thailand with a moisture content of 10%. The latter value has been used for calculation purposes.

ii) Maize

Maize stalk: The literature shows widely varying RPR values ranging from 1.0 to 4.328.

Values reported by Barnard et al. (1985) and Desai (1990) are respectively 2.0-2.3, and 2.08 where as Massaquoi (1990) and Ryan et al. (1991) report a value ranging from 1.0 to 2.5. For calculation purposes an RPR value of 2.0 has been assumed (moisture content 15%).

Maize cob: Bhattacharya et al. (1993) reported an RPR of 0.273 (moisture content 7.53%) which can be assumed to be acceptable since the value was obtained from actual field measurements.

Maize husk: A value of 0.2 with an assumed moisture content 11.11%, as reported by Vimal (1979) has been used for calculation purposes.

iii) Wheat, millet, sorghum and barley

RPR values for wheat straw, as reported by different authors, range from 0.7-1.8. The value reported by Bhattacharya et al. (1993), i.e. 1.75 has been used since the moisture content (moisture content 15%) has been indicated. Since reported RPR values for millet and barley do not show wide variations from that of wheat, the same RPR value has been used. An exception is straw from sorghum where Bhattacharya et al. give an RPR value of 1.25 at a moisture content of 15%

iv) Cassava

Stalks: Cassava is harvested about 12 months after planting. At harvest the plants are first topped before being uprooted. Part of the stalk is retained for replanting while part is discarded. Tops (leaves) and the discarded part are sometimes left in the field and sometimes used as a domestic fuel. Research by Ryan et al. (1991) found RPR values for cassava stalks to range from 0.167 to 2.0. Assuming a yield of about 37.5 tons of tubers per ha. This would result in a residue base of about 6.5 tons per hectare.

v) Rice

Rice straw: RPR values in the range of 0.416 to 3.96 have been cited in various references.

The lowest among the RPR values 0.416, reported by AIT-EEC (1983) and 0.452 by Bhattacharya et al. (1990) are based on the practice of harvesting rice in parts of Thailand and other Southeast Asian countries, For calculation purposes an RPR value of 1.757 has been used which is based on actual measurements in Thailand as reported by Bhattacharya et al.1993.

Rice husk: RPR values for rice husk range from 0.2-0.33. For calculation purposes an RPR value of 0.267 (moisture content 2.37%) has been used as reported by Bhattacharya et. al. (1993).

vi) Coffee
Coffee is a staple cash crop throughout the Kenyan highlands above 1,800 m. The processing of coffee generates two types of waste. The first is a pulp produced during the separation of the cherry from the bean. The second waste is the coffee husk that is separated during the milling process. Koopmans and Koppejan, 1998 found RPR for coffee husk to be 21. Coffee husk is fibrous, low in moisture, uniform in size and low in ash. This makes it well suited to carbonised fuel production (Chardust Ltd. and Spectrum Technical Services, 2004)

Table 3: The relationship between Crop production, Residues generated and the Energy potentials in Kenya

Crop residue	Crop production	RPR	Residue estimate (tonnes)	Heating value(Mj/Kg)	Energy potential (GJ)
Maize stalks	3603338	2	7,206,676	12.5	90,083,450
Maize cobs	3603338	0.273	983,711.274	15.5	15,247,524.75
Maize husk	3603338	0.6	2,162,002.8	12	25,944,033.6
Wheat straw	441756	1.75	773,073	16.4	12,678,397.2
Millet straw	64023	1.75	112,040.25	12.39	1,388,178.698
Sorghum straw	126433	1.75	221,257.75	12.38	2,739,170.945
Cane bagasse	523652	0.29	151,859.08	13	1,974,168.04
Cane tops	523652	0.3	157,095.6	16.6	2,607,786.96
Cassava stalks	841196	1.75	1,472,093	17.5	25,761,627.5
Rice straw	64840	1.75	113,470	13.45	1,526,171.5
Rice husk	64840	0.275	1,7831	16	285,296
Coffee husk	23062	21	484,302	12.38	5,995,658.76
Barley	33035	1.75	57,811.25	19.2	1,109,976
Total			**13,913,223**		**187,341,439.9**

RPR = Residue-to-product ratio (for each tonne of produce, the RPR indicates the amount of residue that becomes available)
H V= Heating value
Residue estimation =Production by multiplying t by its RPR
Energy Potential = Residue estimates multiply by LVH

Energy recovery option for Kenya

i) Briquetting

There are no statistics for briquette use in Kenya; however the percentage of the population using briquettes is thought to be very low. It is a matter of debate how far charcoal dust briquettes can be considered sustainable, since they rely on the existence of a charcoal industry that most agree is currently operating unsustainably. Briquettes produced from alternative raw materials as urged by Mugo (1997) which otherwise have no other use, such as bagasse, coffee and maize residues or wheat straws can provide a more sustainable alternative to wood and charcoal.

Considerable amount of research on briquetting technology has been conducted on these agricultural residues. Examples of biomass studied are wheat straw (Goldembing, 2000; Klass, 1998), hazelnut shell (EREDPC, 2003), woods (Gorfu, 2004), grass (Hadgu, 2004), cotton (Berglund, 2006), olive refuse, rice straw and husk (Marchaim, 1992, Chirchir et al, 2013), maize cob (Kebede, 2004), as well as bagasse (Chirchir et al, 2013). But Little has been done on harnessing energy through briquetting(densification) using agricultural residues such maize stalks, rice husk, bagasse, sorghum, millet, wheat straw to save the diminishing forest cover in Kenya.

If Kenya's dependency upon unsustainable charcoal and wood is to be reduced in line with the energy act 2006, a paradigm shift in cooking habits is required. Additionally a wider programme of awareness –raising and dissemination of energy-efficient cooking equipment will assist with uptake of briquettes as an alternative or supplementary fuel to charcoal and lead to a reduction in deforestation.

ii) Bio-digestion

One possible alternative to firewood especially for farmers is the installation of a biogas unit using the tubular Polythene (plastic) Biogas Digester. It is an efficient and a cost-effective technology. The costs for a biogas digester made from polythene tube vary, but for a 2-cow unit, one can spend between Ksh 5,000 and Ksh 8,000.

It lasts for about four to five years, if well maintained. Findings at KARI-Embu have shown that the Polythene Biogas Digester fed with dung from two dairy cows can supply 30 to 50% of the total energy needs of a typical rural household of about 5 to 8 people, with up to 60% saving on wood fuel, which is a substantial saving on cost (Biovision, 2009).

Agricultural residues have high C/N ratio and helps in enhancing biogas production. Ash additions also which are waste if used might release alkali, heavy and trace metals resulting to the potentially beneficial or detrimental effects on the anaerobic digestion (Lo et al., 2009; Lo, 2005). Both use of agricultural waste and ash for pretreatments are the options for Kenya to increase biogas production and hence improve saving on wood fuel.

Conclusion

With the current forest cover of 1.7% and annual population growth rate of about 3%, the demand for wood-based biomass is expected to increase (Matiru, 2007). And with significant quantities of agricultural residues of about 13,913,223 tonnes annually available in Kenya and distributed among the seven provinces, it can substantially supplement the existing traditional energy sources if fully utilized.

Densification of agricultural residues using available binders such as clay, cowdung and molasses (Chirchir et al, 2013) into fuel briquettes can provide a relatively high- quality alternative source of fuel, especially where fuel wood resources are scarce. The fermentation of animal dung and agricultural by-products in domestic biogas digester is another aspect of converting waste into useful form of renewable energy. Therefore there is need to study the characteristics of briquettes from the different agricultural residues and how to enhance biogas production by use of agricultural residues.

Recommendations

It should be noted that the paper refers only to fuel use, not including non- energy use of the residues. The following need to be investigated:

- The roles agricultural Residues play in soil fertility because the total removal of all above ground residues could lead to soil degradation. However, the issue of soil fertility and recycling of residues is not well understood.
- The roles agricultural Residues play in maintaining the quality of the soil by keeping up its organic content when plough back.
- The importance of burning residues in the fields. Burning may plays an important role in supplying trace elements. While burning the residues in the field is simple and easy to do, ploughing uncomposted agricultural residues into the soil is not also easy.

References

AIT-EEC (1983), Evaluation and Selection of Ligno-Cellulose Wastes which can be converted into Substitute Fuels, Project report submitted to EEC, Belgium.

Barnard, G. and Kristoferson, L. (1985), Agricultural residues as fuel in the third world, The Beijer Institute, Energy Information Programme, Earthscan.

Berglund, M. (2006), Biogas production form systems analytical perspective.Doctoral dissertation. Lund University, Sweden.

Bhattacharya, S.C. and Shrestha, R.M. (1990), Biocoal Technology and Economics, RERIC, Bangkok, Thailand

Bhattacharya, S.C., Pham, H.L., Shrestha, R.M. and Vu, Q.V. (1993), CO2 emissions due to fossil and traditional fuels, residues and wastes in Asia, AIT Workshop on Global Warming Issues in Asia, 8-10 September 1992, AIT, Bangkok, Thailand.

Biovision (2009), the organic farmer, the magazine for sustainable agriculture in Kenya

Daniel. H. (2012), Kenya's coffee wars The Independent, Retrieved 27 March 2014

Ethiopian rural energy development and promotion center (EREDPC) (2003): Charcoal briquette for Ethiopia project No. 823.

Desai, A.V. (1990), Patterns of Energy Use in Developing Countries, UNU, Tokyo, Japan.

Chardust Ltd. and Spectrum Technical Services (2004),The use of biomass wastes to fabricate charcoal substitutes in Kenya, Feasibility Study forming part of the Shell Foundation-supported project on charcoal briquetting in Kenya, a Nairobi-consulting firm.

Gorfu, E. (2004): Introduction on renewable energies in Ethiopia. Symposium on renewable Energies in Ethiopia, Addis Ababa, EREDPC, GTZ.

Goldembing, D. (2000): World energy Assessment, world Energy and the challenge of sustainability, UNDP/UN_DESA/, pp 31-37.

Ministry of Energy (2008) Economic Survey, Nairobi: Government Printer, Kenya

Hadgu, A. (2004): The perspective of renewable energy development in Ethiopia. symposium on renewable

energy in Ethiopia (pp.65-75) Addis Ababa: Ethiopian Rural Energy Development and Promotion Center, GTZ.
Kebede, D. (2004): Biomass energy for sustainable energy development.Symposium on renewable energies in Ethiopia (p .79), Addis Ababa: Ethiopianrural energy development and promotion center, GTZ.
Kituyi, E., (2002). Towards Sustainable Charcoal Production and Use: A Systems approach.In: Proceedings of Regional Workshop on Wood fuel Policy and Legislation in Eastern and Southern Africa.Ed. Mugo, F., RELMA Nairobi.
Kiura, J.N., A. Ramadhan, S. Bimbuzi and D. Mwakina (2008), Production of cassava forage for livestock feeding in coastal Kenya, Kenya Agricultural Research Institute (KARI), Mtwapa, A paper prepared for the 11th KARI Biennial Scientific Conference, 10-14 November 2008 at KARI Headquarters
Klass, D. L. (1998): Biomass for renewable energy, fuels and chemicals, Entechinternatinal,Inc,Barrinton,illionis,USA.
Koopmans, Auke and Koppejan, Jaap (1998), Agricultural and Forest Residues - Generation, Utilization and Availability, paper presented at the regional consultation on modern applications of biomass energy, 6-10 january 1997, kuala lumpur, malaysia.
Lo, H.M., 2005. Metals behaviors of MSWI bottom ash co-digested anaerobically with MSW. Resour. Conserv. Recycl. 43, 263–280.
Lo, H.M., Liu, M.H., Pai, T.Y., Liu, W.F., Lin, C.Y., Wang, S.C., Banks, C.J., Hung, C.H., Chiang, C.F., Lin, K.C., Chen, P.H., Chen, J.K., Chiu, H.Y., Su, M.H., Kurniawan, T.A., Wu, K.C., Hsieh, C.Y., Hsu, H.H., 2009. Biostabilization assessment of MSW codisposed with MSWI fly ash in anaerobic bioreactors. J. Hazard. Mater. 162, 1233–1242.
Jayaprakas, C.A., Abhilash, B., Pillai, R.R. and Palaniswami, M.S. (2004). Cassava Leaf – a Potential Source of Bioinsecticide Agent *Sitophilus oryzae* (L). In: Abstracts, Sixth
International Scientific Meeting of the Cassava Biotechnology Network, 8-14 March 2004, CIAT, Cali, Colombia.pp.76.
Marchaim, U. (1992): Biogas process for sustainable development. MIGAL Galilee Technological Center.Kiryatghmona Israel, FAO.
Massaquoi, J.G.M. (1990), Agricultural residues as Energy Source, In: 'Energy for Rural Development', Edited by Bhagvan, M.R. and Karekezi, S.
Matiru V (2007), Forest Cover and Forest Reserve Cover in Kenya Policy and Practises, Oxford Press, Nairobi, Kenya.
Ministry of Agriculture (2013) Food Security Assessment Report, Department of crop management
Mugo, F. W. (1997). Factors contributing to wood fuel scarcity and the consequent use of crop residues for domestic energy in rural Kenya. MS Thesis .Cornell University New York, USA
Mugo, F. and Gathui, T. (2010) Biomass energy use in Kenya. A background paper prepared for the International Institute for Environment and Development (IIED) for an international ESPA workshop on biomass energy, 19-21 October 2010, Parliament House Hotel, Edinburgh. Practical Action, Nairobi, Kenya.
Nandwa, O.O. , Manohar, R. and .Wanyony A.W,(2013), Malted sorghum as a possible alternative to barley in beer industry , Journal of the Kenya Chemical Society Vol.7 No.1 .
Owino J (2009), "Bagasse Cogeneration Project", *Climate Care, JP Morgan Environmental Market Team Global Overview*.
Patrick, K. (2005), Kenya Coffee , Royal News June 2005, Retrieved 27 March 2014
Ryan, P. and Openshaw, K. (1991), Assessment of Biomass Energy Resources: A Discussion on it's Needs and Methodology, World Bank.
Tegemeo Institute of Agricultural Policy and Development (2009), Maize production outlook and implications for food security, Egerton University
Tim, Adams (2013), Can coffee transform lives in Africa , Andrew Rugasira, 27 March 2014
USAID (1989), Baling Sugarcane Tops and Leaves: The Thai Experience.
Vimal, O.P. (1979), Residue Utilization, Management of Agricultural and Agroindustrial
Residues of Selected Tropical Crops (Indian experience), Proceedings of UNEP/ESCAP/FAO Workshop on Agricultural and Agroindustrial Residue Utilization in Asia and Pacific Region.