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| THE TREE FARMERS MAGAZINE FOR AFRICA |

ENERGY IN WOODY BIOMASS

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| A PUBLICATION OF BETTER GLOBE FORESTRY |

Wonders of Dryland Forestry

Schools' green initiative challenge

The Schools' Green Initiative Challenge is a unique project implemented by KenGen Foundation in partnership with Better Globe Forestry and Bamburi Cement Ltd.

The main objective is the greening of over 460 acres in the semi-arid counties of Embu, Kitui and Machakos with Mukau (*M. volkensii*) and Muveshi (*S. siamea*) tree species as a way of mitigating climate change and providing wood fuel and alternative income opportunities for the local communities.

Through the setting up of woodlots in participating schools, the project acts as a change agent to establish a tree-planting culture for multiple benefits in dry-land areas.

The ten-year project is designed as a competition amongst the participating institutions for the highest seedling survival rates through the application of various innovations at the schools' woodlots.

Currently, there are 500 schools from the three counties taking part in the afforestation contest for the ultimate prize of educational trips, scholarship opportunities, and other prizes. Plans are underway to add more schools in the coming years.

The afforestation competition is in line with the Government of Kenya's Vision 2030 to achieve 10% forest cover across the country.

Panda Miti, Hifadhi Mazingira

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Energy for the nation

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Raw energy. Eucalyptus firewood in a burner of Unilever Tanzania. PHOTO BGF

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EDITORIAL

Dear readers,

This issue is about **Forests and Energy**. There is a huge link between the two, and one can argue that aside storage of Carbon, energy provision is currently the most important function of forests, at par -at least- with shielding biodiversity and water storage. In the lead article, N. Oduor gives an insight in exactly how much energy is available in trees, which is a stimulus to get out of the old-fashioned thinking of the poor man's firewood & dirty charcoal, and reflect instead on its potential to generate clean, renewable electricity.

Indeed, wood or fashionably called biomass, is the primary source of energy for Africa not only for cooking, but also for industrial processes. R. Nalule ("Tree biomass: home-grown and locally owned energy") quotes that *Uganda's primary energy is comprised of 88% biomass, 10% fossil fuels and 2% electricity. Out of the energy generated by biomass, 74% goes to domestic use, 18% to industry and institutions & SMEs take care of the remaining 8%.* This says it all. Such is its importance, that for pure survival, simple living, and for commercial gain, people hugely overcut what is available. This makes F. Mugo write about "Saving the trees", having J. Lwegaba & S. Nabakooza analyse "Why clean cooking technologies are not popular" and how the industry uses firewood and wood waste in a big way: articles on "Wood energy for curing tea", "Wood waste provides an income" and "Briquette production in Mafinga".

Which trees are we talking about? Firstly, F. Gachati writes about "The acacias of Africa", a vastly underestimated resources, ruthlessly preyed upon and having multiple benefits. Then R. Sharland explains how farms can (and have) become important providers of biomass, while a team with M. Njenga explains how *Prosopis juliflora*, an invasive species, has become an important source of charcoal in Baringo County (Kenya). The DFO of Gulu district writes about an Ordinance to achieve sustainable & controlled charcoal production, while Better Globe Forestry staff members analyse firewood consumption by schools.

As usual, our last article is related to water. In this case, a lot of it, as it talks about the current overflowing of Lake Victoria which is the 2nd biggest fresh-water lake in the world.

We wish you a happy & interesting read.

Jan Vandenabeele

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The tents set up for the participants. Photo BGF

THE UGANDA FOREST FAIR 2020

AN EXHIBITION PROMOTING COMMERCIAL FORESTRY

BY DIANA AHEBWE

The Uganda Timber Growers Association (UTGA) organized the 7th Annual Forestry Fair that took place on the 19th of March, 2020 at Silver Springs Hotel, Kampala.
The annual event is an initiative that brings together key actors in the forestry sector to showcase goods and services important for promoting the commercial forestry sector through raising awareness and promoting competitiveness.

UTGA is a members' organization that brings together commercial tree growers in Uganda for collective action. The Association was formed in 2007 and currently has 640 members who have established over 70,000 hectares of tree plantations throughout the country. It is composed of big, medium and small tree growers and continues to attract new members through promoting high quality plantations. Its overall objective is to ensure a sustainable, profitable, socio-economically and environmentally sound forestry industry.

The forest fair was combined with the Annual General Meeting for UTGA members. The meeting was intended to bring together various forestry stakeholders to discuss the Association's annual workplan and budgets and the challenges encountered. At the fair, members were enlightened on the business of tree growing. The exhibitors present included agro-chemical companies, forestry tools companies, tree nursery operators, forest contractors and commercial tree growers.

The writer is the Country Representative for Miti magazine, Uganda
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BGF INITIATES THE CERTIFICATION PROCESS FOR THE INTERNATIONAL TIMBER MARKET

WE ARE CONFIDENT

BY JAN VANDENABEELE

Better Globe Forestry (BGF) wants to be certified in the international timber market for selling sustainably produced timber products. There are different certification bodies through which this can be achieved and the Forest Stewardship Council (FSC) is one of the main players there. As such, BGF has started the process by employing an intern that during the next six months will dedicate her services towards documenting all requirements that the FSC standards prescribes on the path towards certification.

On the 10th and 11th of March this year, two prominent FSC representatives, notably Harrison Kajwang (FSC Regional Director for Africa) and Paul Opanga (Labour Issues Manager at the FSC) visited BGF's plantation of *Melia volkesii* (mukau) in Kiambere as well as several farmers enlisted in its Seven Forks farmers' programme.

At the end of the two days trip, they also had an opportunity to visit the award-winning school of phase 4 of the Green Initiative Challenge (GIC) which is a tree planting programme with schools in the Seven Forks area. On this visit, they were accompanied by BGF's Executive Director of Forestry and his Deputy in order to supply them with quality information about BGF's afforestation programmes. The visit went very well and constitutes a milestone towards certification. It will be followed up by a meeting next week at BGF's head office in Nairobi to clearly trace the different steps to follow.

The certification programme is a complex one that looks at all aspects related to afforestation not only technically but also legally, health wise and socially. BGF is very confident that it will achieve the certification.

The writer is Editor-in-Chief of Miti magazine and the Executive Director of Forestry of Better Globe Forestry

From left to right: Samuel Nakhone (Deputy Director of Forestry, BGF), Harrison Kajwang (FSC), David Kiilu (partner farmer), Abraham Biwott (Training Officer, Seven Forks Programme, BGF), Paul Opanga (FSC) and Gladys Rutto (intern, BGF). Photo BGF

ENERGY IN WOODY BIOMASS

AND THE INDUSTRIES THAT ARE USING IT

BY NELLIE ODUOR, EMILY KITHEKA AND CHURCHILL OGUTU

In Kenya, biomass energy resources are derived from forests - closed forests, community woodlands, farmlands and plantations as well as agricultural and industrial residues. This accounts for about 68 per cent of all energy consumed and for 90 per cent of rural household energy needs. The main sources of biomass for cooking and heating energy are charcoal, fuelwood and agricultural waste. Various industries use biomass energy in their processing; these include tea and edible oil processors. A study in 2013 that analysed the demand and supply of wood products in Kenya indicated that firewood and charcoal supply stood at 13,654,022m^3 and 7,358,717m^3 while demand stood at 18,702,748m^3 and 16,325,810m^3 respectively. Currently, there is unmet demand for biofuels with a 60% demand-supply gap. Forecasts for a 20-year period indicate a 20% increase in supply and 21.6% increase in demand by the year 2032 which signifies a gradually increasing deficit. However, most of the wood fuel is obtained from unsustainable sources and produced and utilized in inefficient technologies/devices. This exerts pressure on natural forests. The current moratorium by the Government of Kenya (February 2018 to date), banning logging on public and community forests has further widened the biomass fuel demand gap leading to escalating prices of charcoal.

Sustainability of the bioenergy sector is central to Kenya's aspirations to achieve middle-income status by 2030. The government has identified substantial potential for power generation using forestry and agro-industry residues, including sugarcane bagasse. Other bioenergy resources in Kenya include biogas, fuelwood, briquettes, pellets and charcoal.

Sustainable development of biomass resources for energy purposes requires not only knowledge of the biomass supply capacity but also the biomass quality which can improve the forest-based bioenergy sector and may result in its increased and more efficient use. The quality of the biomass also depends on the tree species, for not all species are suitable as a wood fuel. In this respect, sufficient details must be obtained to characterize and identify specific types of biomass because the quality of forest biomass is strongly associated with the contents of organic and inorganic components. Energy content of each species mostly depends on its chemical content (carbon, hydrogen and oxygen) and it is reduced by inorganic elements and moisture. It is therefore important that biomass is dry. Table 1 shows various energy sources and their calorific values.

A rich and abundant resource in the Aberdares, Mt Kenya and the Mau: bamboo (*Oldeania alpina*), for producing renewable electricity. Photo BGF

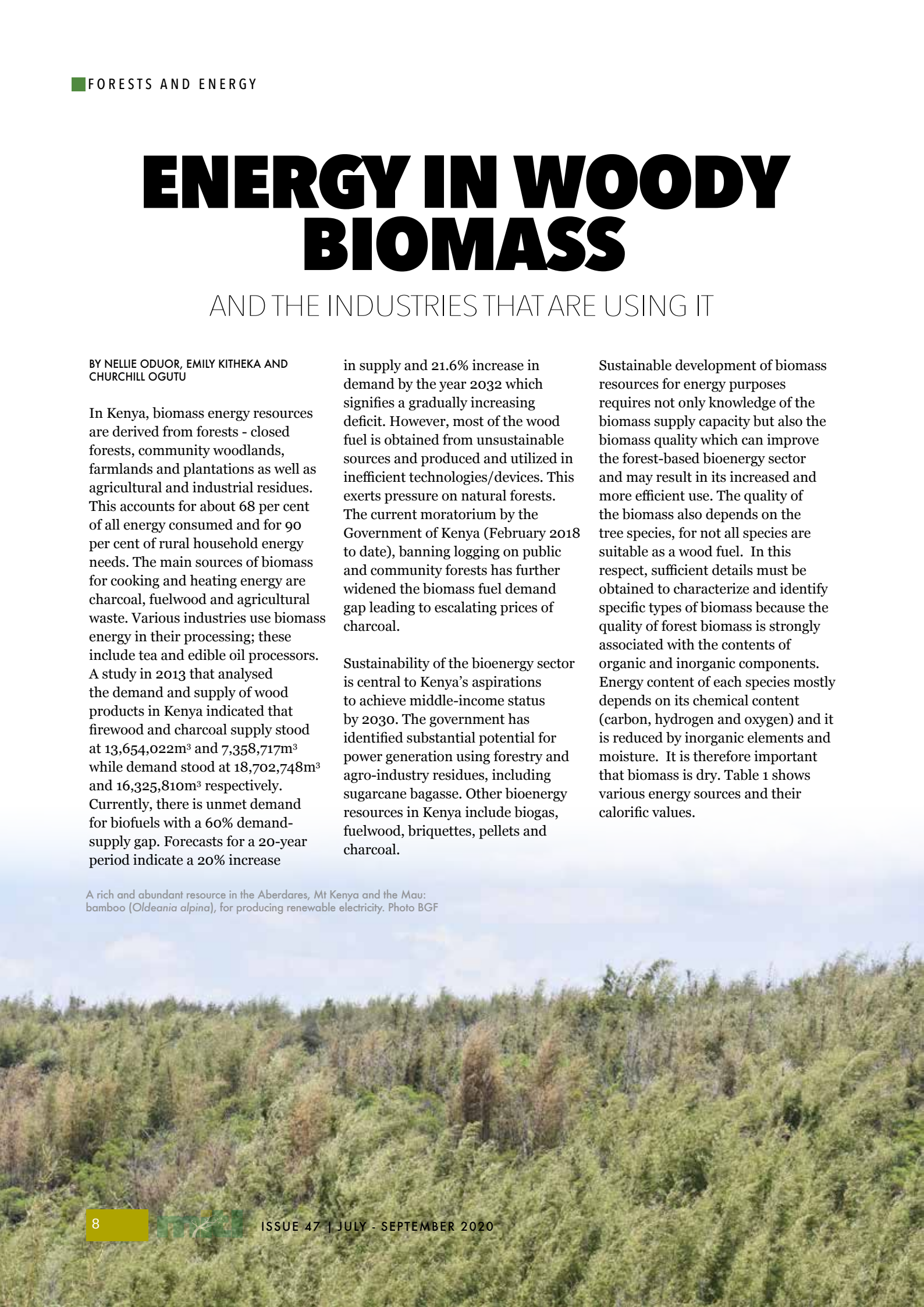

Table 1: *Energy levels of various sources of energy*

Energy source	Calorific value Kcal/g
Dry wood	General range 3.5 – 5.0
Acacia nilotica (Egyptian thorn)	4.9
Acacia polyacantha (Falcon's claw acacia)	4.0
Acacia tortilis (Umbrella thorn)	4.4
Acacia xanthophloea (Yellow fever tree)	4.4
Casuarina equisetifolia (Whistling pine tree)	5.0
Commiphora baluensis (Commiphora)	4.4
Eucalyptus camaldulensis (River red gum)	4.8
Eucalyptus grandis (Flooded gum)	4.5
Leucaena leucocephala (River tamarind)	4.6
Prosopis juliflora (Mathenge)	5.0
Terminalia brownii (Mbarao-Swahili)	4.6
Terminalia orbicularis (Spiny terminalia)	5.1
Wood chips (30% MC)	2.9
Wood pellets (10% MC)	Ranging from 3.8 – 4.3
Charcoal	General range 5.0 – 9.0
Acacia nilotica	7.3
Acacia polyacantha	6.4
Acacia tortilis	5.8
Acacia xanthophloea	7.9
Eucalyptus camadulensis	5.6
Eucalyptus grandis	7.5
Prosopis juliflora	7.9
Bambusa vulgaris (Common bamboo)	6.7
Dendrocalamus asper (Dragon bamboo)	5.3
Dendrocalamus giganteus (Giant bamboo)	5.5
Bamboo	
Bambusa vulgaris	4.4
Dendrocalamus asper	4.5
Dendrocalamus giganteus	4.5
Bamboo pellets	
Bambusa vulgaris	6.5
Dendrocalamus asper	6.2
Heating oil	10. 0

BAMBOO

Bamboo is fast becoming a source of biomass energy due to its fast regeneration if sustainably managed. Various species have been trialed in Kenya which has only one indigenous species (African alpine bamboo). Among the exotic species that have been produced in Kenya are Savanna bamboo (*Oxytenanthera abyssinica*), *Bambusa* and *Dendrocalamus* spp. Generally, if the bamboo is chipped, briquetted or pelletized, it offers a great source of biomass energy for several industries. Some tea and edible oil processors have tested bamboo chips in their boilers. The energy values for some of the species are shown in Table 1 which show great promise as a woodfuel source for industries and domestic use.

BRIQUETTES

Briquettes are biofuel substitutes to coal and charcoal and are made from agricultural and forestry residues. The huge demand for firewood by the industry calls for greater use of alternative thermal bioenergy sources such as briquettes from agricultural residues. Uncarbonized briquettes are suitable for industrial use and some tea, edible oil, cement and tobacco processors are already incorporating these biofuels in their energy mix. Carbonized briquettes are suitable for domestic use and learning institutions, hospitals and prisons.

Carbonized briquettes are made from biomass raw material that has undergone pyrolysis after which it is mixed with a binding element, moulded into various shapes then dried. Uncarbonized briquettes are processed directly from biomass sources through various casting and pressing processes also known as compaction or solidification.

Wood waste in a sawmill. How much is recovered? Photo BGF

PELLETS

These are biofuels made from compressed organic matter or biomass. They are similar to briquettes but relatively smaller in size. They can be used as fuels for power generation, heating, and cooking. They are extremely dense and can be produced with a low moisture content (below 10%) that allows them to be burned with a very high combustion efficiency. Pellets generally measure 6-10mm in diameter with a maximum length of 38mm and are formed by compressing biomass under intense pressure. The most recommended raw materials for use as feedstock include white wood chips from sawmills, round wood with huge diameters, untreated wood, and used wood without any contamination. Dies are used to obtain the required cylindrical shapes of the pellets by forcefully passing sawdust through them. Owing to the pressing involved and the corresponding friction that results when the particles are pressed against each other and against the wall, sawdust experiences a temperature increase of between 70°C to 100°C, then the lignin component acts as a natural binder.

Pellets formed from woody biomass remain the recommended feedstock for the bioenergy industries that deal with solid biomass. They are compact in nature and are regularly shaped hence, they are easier to handle, store and transport in bulk. Biomass pellets can be made from recyclable raw materials such as saw dust, rice husks, coffee husks and maize stalks. They are of high calorific value and burn with less smoke. They are dense and used in cooking meals in homes and institutions.

Pellets are not a new type of fuel in Kenya's energy market although its use at the domestic level remains limited. Studies have been carried out using locally produced gasifiers (WISDOM and SCODE gasifiers) that can burn both wood and pellets. Other ongoing initiatives include: Lean Energy Solutions who set up a pellet production facility in Naivasha; Green Steps Africa Limited who supply gasifier stoves for domestic and commercial use; Power Spot Limited that produces pellets and distributes gasifiers in Kakamega County and IKO BRIQ Limited and

Eco-bora manufactures that sells pellets to households.

A BRIEF OF THE TEA AND EDIBLE OIL INDUSTRIES IN USING BIOMASS ENERGY

Tea Industry

Kenya is the World's third largest producer and exporter of tea. The tea industries moved from using heavy fossil fuels to biomass fuel to wither and dry the green tea leaves. Out of the 113 tea factories in Kenya, almost 99 percent of their thermal energy comes from firewood and other sources of biomass and 1 percent is from oil fuel. The demand for firewood in the tea industry is around 1 million tons of firewood per year. A number of tea industries are using alternative biomass sources such as non-carbonized biomass briquettes. Sources of briquettes are from agricultural residues such as sugarcane bagasse, straws, husks, cobs or shells. According to the Sugar Directorate, around 2.4 million tons of bagasse generated by the country's 12 sugar mills is unutilized.

Other consumers of non-carbonized briquettes include schools, hospitals, the tobacco industry and the vegetable oil processing industry.

Edible oil processing factories

Edible oils are a crucial sub-sector of the manufacturing industry in Kenya. The industry currently operates at a production capacity of 850,000 tons and has an installed capacity of 1.5 million tons per year. These vegetable oil processing plants in Kenya use about 200 tons of dry biomass per day. For instance, Bidco Africa presently uses over 200 tons of macadamia and coffee husks to generate power, however, the supply of both is erratic and unsustainable. They have also trailed bamboo in chip form to meet their need for biomass to power one of its cogeneration plants in Ruiru. They estimate they would require 6,000 tons of bamboo a month to meet their energy needs.

IN CONCLUSION

With a rapidly growing population, there is need to look at sustainable provisions of biomass for domestic and industrial use. Processing of agricultural residues to solid biomass fuels is becoming an increasingly important path for moving towards circular economies and cascading use of biomass. Pellet and briquette production should be promoted together with their appropriate appliances - stoves and boilers. Promotion of commercial wood farming should essentially be on private and community land in marginal semi-arid areas to avoid competition with food production and security.

The writers are: Programme Director at KEFRI's National Forest Products Research Programme, Research Scientist and Research Scientist at KEFRI and also Biofuel4Kenya Project Manager

Extensive thickets of *Acacia zanzibarica* in Lamu County, with natural regeneration and coppicing. An opportunity for generating electricity? Photo BGF

SAVING TREES FROM THE FIRE

BY USE OF LIQUID PETROLEUM GAS AND FIRELESS COOKERS

BY FRIDAH W. MUGO

WOODY BIOMASS UTILIZATION: FACTS & TRENDS

In 1980, 94% of all the wood harvested in Kenya was used for woodfuel, 4% for poles and 2% for timber. By 1997, the proportions were estimated to be 90% woodfuel, 5% for industrial feedstock and another 5% for poles and posts. These proportions were projected to remain the same in the year 2000. In that year, Kenya was reported to use 34.3 million metric tons of biomass for fuel of which 15.1 million tons was in form of fuelwood while 16.5 million metric tons was wood for charcoal processed in kilns with only 10% efficiency. Up to 43% of the national consumption was from sustainable supplies while 57% was not. Of Kenya's total land area of 57.6 million hectares, only 6% (3,456,000 hectares) is forest cover and is estimated to be decreasing at the rate of 52,000 hectares (0.09%) per year. As indicated above, most of the wood is used for cooking. Over 80% of the wood used for charcoal is used in urban areas in form of charcoal, while most of the fuel wood is used in rural areas. How can these trees be saved?

Promoting industrial growing of fuelwood. Plantation of *Acacia polyacantha, in Bondo* (Siaya County, Western Kenya). Photo Nelly Oduor. Photo Nellie Oduor

USE AND COST OF ENERGY BY LOW-INCOME URBAN HOUSEHOLDS

Results from a baseline survey of 230 low-income households on energy use and cost in Kajiado town (ZEES, 2018b) indicated that households use multiple energy sources for cooking.

Table 1: Urban situation: main energy source for cooking, cost and household distribution

Energy source	*Cost (Ksh)*	*% of households*
Charcoal	1533	68
Firewood	1359	56
Kerosene	932	47.4
LPG	724	5.7
Electricity	n/a	1 household

Cost is on a monthly basis

No household reported to use briquettes, pellets, bio-gas, ethanol, sawdust, wood shavings, crop residues and cow dung. The average cost of energy for cooking considering all sources was US $ 18.52 (Ksh. 1,852) per month. Over 80% of the respondents work as casuals and others were running petty-businesses. Income is therefore not stable. The average monthly income was reported as US $ 25-50 (Ksh. 2,500-5,000). Up to 99.5% of the households preferred LPG for cooking because it is cleaner and faster in cooking, but the majority lacked the means to purchase the appliances. Only one household preferred firewood as the main source of cooking. Although this data is from one sub-location, other urban low-income areas are likely to have similar results.

Transport of firewood, the most common source of domestic energy in the countryside. Mostly a woman's task, soaking up too much time. Photo Phillip Kihumuro

USE AND COST OF ENERGY BY RURAL HOUSEHOLDS

A baseline survey of 106 households from 19 villages in Migori County indicated that almost all the rural households depend on fuel wood for their cooking energy (Mugo and Kaudia, 2018).

The households that buy all their fuel wood use about US $15 (Ksh. 1,500) per month. About 26% of the households use charcoal. Those that use charcoal for their cooking spent on average US $ 30 (Ksh. 3,000) per month. Only four households (3.8%) out of 106 were found to use LPG and one out of the four use it full-time. One household uses a combination of fuelwood and a fireless cooker and it works very well. LPG supply was readily available at the Uriri and Awendo commercial centres. Further analysis revealed that full time use of LPG for an average household of 6 persons would cost about US $15 (Ksh. 1,500) per month. A combination of LPG and a fireless cooker on full time basis would cost US $ 7.50 (Ksh 750) per month with almost no polluting emissions.

CONSEQUENCES OF UNSUSTAINABLE BIOMASS USE

The consequences of unsustainable extraction of woody biomass for energy are many: deforestation, land degradation, reduction in the ecological services of forests, woodlands and bushes such as water/river flow regulation and carbon sequestration, increased soil erosion, loss of biodiversity, loss of jobs, increased suffering especially for the women as they search for household energy, food insecurity as a result of limited woody biomass for cooking and diversion of household income to purchase wood fuel for energy. All these can be avoided by implementing a biomass substitution policy whereby households currently using charcoal and fuelwood are encouraged and supported to change to cooking with LPG.

SAVING THE TREES

Given the high demand for LPG for cooking mainly in urban areas, seven strategies have promise to save the trees and the forests:

(i) aggressive promotion of LPG for cooking in both urban and rural areas to substitute charcoal and fuel wood;

(ii) large-scale manufacture and aggressive marketing of fireless cookers that reduce LPG use by 50%, this can reduce cooking energy cost to Ksh. 1000 per month;

(iii) subsidize acquisition of LPG appliances by 75% for a limited period of time to ensure that all households can afford to purchase and use them;

(iv) mount an aggressive promotion for bio-gas use in rural areas. The bio-gas project could be in combination with intensive promotion of dairy farming.

(v) introduce low-interest loans through reliable micro-finance institutions. To ensure that households shift completely from using charcoal, its production and use should be banned completely.

(vi) stable supply of LPG should be guaranteed and

(vii) commercial growing of trees for the industry to be promoted to enhance household income for rural households.

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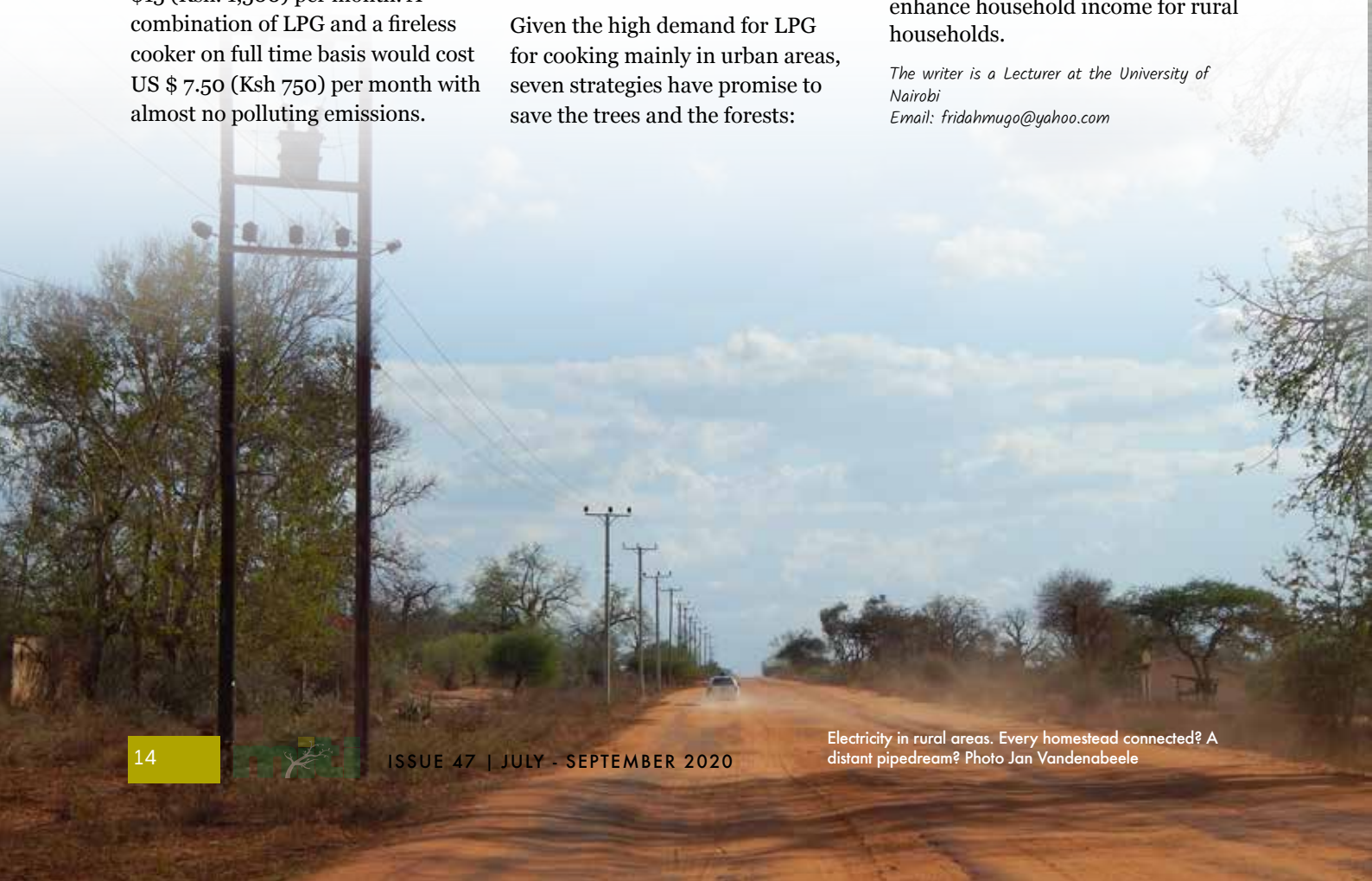

Electricity in rural areas. Every homestead connected? A distant pipedream? Photo Jan Vandenabeele

TREE BIOMASS: HOME-GROWN AND LOCALLY OWNED ENERGY

IT'S AN ASSET, AND NOT ONLY FOR THE POOR

Firewood for sale at the roadside, Karamoja. Photo BGF

BY RACHEAL NALULE

Uganda's total primary energy is comprised of 88% biomass, 10% fossil fuels and 2% electricity (Draft Energy Policy, 2019). Out of the total energy produced locally, biomass energy consumption for domestic use is 74%, industry 18% and institutions & SMEs 8% (Biomass Strategy 2013). The country's population is estimated at about 40.3 million and projected to reach 55.4 million by 2030 (UBOS Statistical Abstract, 2019) at an annual growth rate of about 3.2%. Biomass energy will still be a major source of energy given the increasing demands for energy by the growing population. Over 95% of the population especially in the rural areas depends on firewood for domestic energy. The influx of about 1.4 million refugees in Uganda has further increased the demand for

biomass energy to an estimated 1.6 million m³ of fuel wood per annum (WB/FAO, 2018). Biomass is and will remain an important source of energy for Uganda, hence the need for investment in its sustainable production and utilization. Unfortunately, it continues to be unfairly maligned by a cross-section of people including decision and policy makers. Statements such as dirty, backward, cooking fuel, unsustainable, unhealthy, environmentally harmful are very common. Yet, energy such as fossil fuels does not attract the same level of demonization and criticism like biomass.

Sadly, the positive attributes of biomass energy such as its enormous contribution to the economy, potential to generate jobs and incomes, and the country's conducive climate that supports fast growth and accumulation of biomass are rarely accorded the publicity they deserve. It is unfortunate that the role of cooking energy is often downplayed as if it is possible to have a healthy and productive population that does not cook food and drink boiled water! In the area of value addition and industrial production, biomass energy is widely used for tobacco and tea curing, pottery and ceramics, cement and lime production, brewing and brick making. The total energy consumed by the industrial sector in Uganda is dominated by biomass contributing over 68%, followed by electricity. Additionally, biomass value chains are entirely owned and controlled by Ugandans unlike other energy types, where Ugandans play a minor role or come in just at the tail-end to pick residue for their small businesses when almost all the benefits have already accrued to foreigners.

However, it is important to recognize that biomass by nature has low financial appeal compared to other sources of energy. The government hasn't recognized this. This partly explains the low level of investment and general interest in the sub-sector. On the other hand, other sources of energy are characterized by international value chains with high financial appeal and attracting big investments. A Life Cycle Assessment of these energy sources reveals that they are neither cleaner nor more sustainable than biomass. The biomass energy sub-sector is largely informal, and can hardly attract lobbyists, big local and international players to undo the injustices and misinformation levelled against it. It also lacks well-researched data and information to convince top decision makers to have it among government priorities.

Petrol and diesel shortages are occasional and power outages more frequent. One would wonder "why

Stacked piles of eucalyptus firewood for drying and subsequently burning to cure tea leaves (Western Uganda). Photo BGF

is the former rarely felt at the policy level and easily noticeable by the transport and power sectors? Could it be that biomass energy is for the poor and disadvantaged with no voice and other fuels are for the rich whose slight discomfort is a concern and cause of outrage for everybody?" Indeed, there is no single source of energy that can meet all the energy needs of the population.

Thus, complementarity of different sources is key in ensuring energy security and fostering national development. This makes it the more compelling reason why the government should also consider to prioritize development of the biomass sources in the on-going policy review processes and National development plans.

RECOMMENDATIONS

The recommendations to develop the biomass sub-sector moving forward include:

■ the Ministry of Energy and Mineral Development (MEMD) should prioritize biomass energy production within the energy sector, and include it in its present review that focuses on electricity;

■ the Ministry of Finance, Planning and Economic Development (MoFPED) should increase the allocation of funds for biomass energy production to the Ministry of Energy and Mineral Development and the Ministry of Water and Environment (MWE);

■ MoFPED needs to provide the private sector with incentives to support investment in dedicated biomass energy plantations and efficient biomass energy production and use technologies. These incentives include performance grants, soft loans, tax waivers and subsidies.

■ MWE, MEMD and Local Governments should strengthen regulation and enforcement of laws, ordinances and bylaws throughout the value chain of biomass energy resources especially charcoal to reduce the loss of forests, raise revenues for re-investment in biomass energy production and create a conducive environment for the private sector to invest in biomass energy production.

■ MWE should also promote the establishment of dedicated large-scale biomass energy plantations in all the seven Forest and Land Restoration landscapes.

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Firewood at Ggaba landing site, Kampala. This firewood comes from forests on Lake Victoria islands and it is mainly used for smoking fish. Photo BGF

CLEAN BUT NOT ATTRACTIVE ENOUGH

WHY CLEAN COOKING TECHNOLOGIES ARE NOT POPULAR

BY JOHN LWEGABA AND SHERIFA NABAKOOZA, ALL PHOTOS BGF

The adoption of clean cooking technologies is still a challenge in peri-urban areas. Through a rapid assessment study conducted in April 2019 by Ages Considered (ACO) in Mende sub-country (Wakiso district), it was found that 85% of households and small businesses use charcoal as the main source of cooking energy, thus imposing a huge demand on charcoal. This statistic was also consistent with several studies including the 2016/2017 Uganda National Household Survey, which noted that 90% of households use biomass (firewood or charcoal) for cooking. According to UBOS[1] Statistical abstract 2018, the Wakiso district population growth at 4%, is greater than the national annual growth rate of 3%. This results in a high demand for food for this ever-increasing population which has led to the sprouting of multiple small cooking businesses.

The adoption of clean cooking technology has not been fully embraced in peri-urban areas only, but also in rural areas due to the high costs involved in home solar systems, bio-gas, Liquefied Petroleum Gas (LPG) and electricity. A unit of electricity costs close to USh 1000, and the refilling of a 12kg LPG cylinder costs about USh 130,000. This hinders

Frying potato chips in oil, and more food being prepared. Bunga roadside market, Kampala

the majority, who are low-income earners, from accessing clean cooking technologies.Taking a close look at the situation in Wakiso trading centers, many mobile restaurants open up in the evening to sell chapatis, fried potato chips and meat; all these use poor or low quality cooking stoves that consume a lot of charcoal.

Bob, one of the businessmen running a *chapati* business in Namusera trading centre is an example. He only runs his business in the evenings since during the day he manages his *bodaboda* (motorcycle) transport business. He reports using a half a bag of charcoal a week and explained that working full-time, would see him use a bag of charcoal per week.

With this case, one can do some simple math and notice that fifty people running similar businesses like Bob in the same trading centre would require 2,600 bags a year! This means that many trees have to be cut down to satisfy the demand. This is a huge issue and requires serious intervention. It has been noted that the country uses 60 million metric tons of wood annually valued at USh 1,179,385,920,000 (approx. 350m USD) for charcoal production alone (Uganda National charcoal survey, 2016 policy brief report by the Ministry of Energy and Mineral Development-MEMD (the Green Charcoal project)).

In the earlier mentioned rapid assessment exercise, it was found that:

- 35% of the population did not know about energy-saving alternatives
- 38% said alternatives like electricity are expensive and that they cannot afford it
- 22% said charcoal is easier to find and accessible since supply is always guaranteed
- 5% gave responses depicting that they lack access and information about energy saving and clean cooking stoves.

These responses show a big gap in realising clean cooking in peri-

[1]Uganda bureau of Statistics

urban areas. Ignoring this fact has implications on environmental issues like increased deforestation and its effects, financial issues including reduced revenue from associated wood products, and health-related challenges, for example, increased respiratory diseases from inhaled fumes.To address the above challenges, there is need to formulate policies that promote use of clean energy for cooking through establishing by-laws at local level that encourage the use of clean energy and regulate the use of charcoal.

At the national level, the MEMD should make a deliberate move to reduce the cost of electricity. On the other hand, private funding opportunities for renewable energy should focus on supporting clean lighting rather than clean cooking, which has lowered the rate of adoption. To encourage this move, financial institutions such as Pride Microfinance, Centenary Bank, Finance Trust Bank, Barclays Bank Uganda, Stanbic Bank Uganda, Finance Trust Bank, and Postbank Uganda are providing loans for solar system acquisition only, with credit support from UECCC. This is highlighted in a study by Environmental Alert titled, "Unlocking Financing and Investments for Clean and Renewable Energy Access in Uganda (a case study of the Albertine region)".

Due to this fact, ACO recommends the following:

■ The MEMD and the Ministry of Finance Planning & Economic Development should subsidise alternatives like Liquefied Petroleum Gas, bio-gas and electricity to make them affordable.

■ The MEMD, the Ministry of Water & Environment, and Civil Society need to train the population and target groups like restaurant owners and similar businesses to use alternative energy efficient solutions.

■ The MEMD and the Uganda National Bureau of Standards need to promote standards for improved cooking stoves and should popularize and disseminate them to target populations.

■ Media engagements should be used regularly to educate the wider population about clean cooking alternatives.

■ Donor funding to support renewable energy technologies for cooking at community level should also emphasized rather than promoting energy for lighting only.

Some of these recommendations can be addressed through adoption into the on-going Energy Policy review. ACO is also committed to supporting initiatives geared at solving this problem with support from the Renewable Energy CSO Network (c/o Environmental Alert) and other development partners.

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This chapati is for breakfast. Bunga roadside market, Kampala

Bunga roadside market, Kampala. At least nine cooking devices working with charcoal in this small space

One of the furnaces at Unilever in Mufindi. Eucalyptus firewood on the right

WOOD ENERGY FOR CURING TEA

A VISIT TO UNILEVER IN MUFINDI

BY JAN VANDENABEELE, ALL PHOTOS BGF

Unilever Tanzania Ltd has a tea estate situated in Mufindi, Tanzania's Southern Highlands, at an altitude of close to 2,000masl. It rains plentiful, and the area is good for growing tea and trees (*Eucalyptus grandis*-Flooded gum and a bit of *E. smithii*-Gully gum) of which its estate has respectively 3,500 and 1,500ha. As common with East African tea factories, the eucalyptus is grown for firewood to cure the tea leaves. The curing involves heating the leaves to stimulate bacterial fermentation. Heavy fuel can also be used for this heating process, but it is more expensive, as proven by this simple calculation:

Calorific value of heavy fuel (diesel oil): 10,750 Kcal/kg
Calorific value of eucalyptus wood: 4,250 Kcal/kg
Ratio is approximately 2.5, or roughly 3kg of firewood for 1kg of diesel oil.

But firewood is far cheaper:
Cost of diesel at the pump in Nairobi: 102 KES/ltr
Cost of firewood: maximum 5 KES/kg (delivered at factory gate).
The ratio here is 1 to 20..., and even if it would be 1 to 10, it would still be at least three times cheaper to use firewood.

Unilever grows its eucalyptus on a 9-year cycle, achieving firewood volumes of 350-400m³/ha. After 4 rotations of which 3 are coppice management, replanting is done. When the trees are felled, the logs are cut into pieces of 50cm long and 12-18cm diameter, upon which it is dried under roof for a period of 12-15 months.

Long-term experience from the Kenyan tea sector shows that 250 kg of processed tea requires an equivalent of one m³ of stacked firewood[1], translating into 0.7 m³ of solid wood[2] .
At Unilever, all curing is done with firewood.

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[1]Note: one m³ of stacked wood is called one stere (1m x 1m x 1m). One stere is about 0.70 m³ of solid wood.

Miti #11, Jul-Sep 2011, p16 ("Calling on small-holders").

Massive storage of firewood in protected conditions, to get a minimal moisture content

WOOD WASTE PROVIDES AN INCOME

ALTHOUGH EXISTING, THE AVAILABLE MARKET FOR WOOD WASTE IN KAMPALA IS LIMITED

BY DIANA AHEBWE

In recent years, considerable attention has been turned towards the use of biomass, especially wood residues and waste, towards energy and other products. Use of biomass came as one of the mitigation measures to climate change, which was being fueled by the continued use of fossil fuels, hence the call to greener approaches. Today, biomass waste is used for several purposes including heating water, briquetting and mulching.

Sawmilling and wood workshops are some of the thriving businesses in Kampala and its suburbs, such as Ndeeba, Katwe, Bwaise, Nakawa, Nateete and Banda. These businesses accumulate a lot of waste that would potentially become a menace to the environment if not properly managed. Biomass waste includes sawdust, wood chips, off-cuts and wood shavings, with sawdust being the most dominant. Owners of the timber yards and workshops look forward to economic disposal of this waste given the opportunity, as the biomass is considered a good source of fuel, biogas, organic manure, mulch, and a basic component of particle board and briquettes. Currently, there's demand for biomass waste by many enterprises in Kampala such as poultry farms, briquetting companies, coffee farms, as well as large complexes such as Mukwano Industries. The availability of wood waste has given an opportunity for manufacturing industries that would like to reduce

Sale of wood waste at the sawmill of Global Woods. The chipper can take care of different sizes of off-cuts to produce chips of uniform dimensions, easy to transport, handle, and feed into a furnace. Photo Moses Otim.

their carbon footprint to provide a market for the waste.

Mukwano Industries in the industrial area of Kampala for example, uses biomass for its energy needs, especially its boilers. This is done because it is cheap and readily available, and, most likely as an afterthought to compensate for its carbon footprint. According to one of the wood scientists in Kampala, these industries use biomass for their boilers not only for the reasons mentioned above, but also because they have the equipment installed. In Uganda electricity mostly is renewable (hydropower), and competitive in its pricing, hence the incentive for energy out of biomass is not strong.

The waste is accessed through middle-men who buy from timber yards and carpentry workshops. Mostly, they're the same people supplying timber or wood from the countryside. Fuso trucks collect biomass from a radius of 12 kms or more from Kampala depending on the demand. People buying smaller quantities of biomass from these workshops, like for poultry farms and mulching, spend between 600-2000 USh per sack. For Mukwano, the trucks park at the roadside close to the plant, and wait to be called in. They can spend up to three days before this happens. Upon entry, the biomass quality is checked for moisture using a syringe and is rejected if it doesn't meet required standards. The requirement is that it must be dry, to avoid excessive smoke and weight, which would hike its price. The trucks line up for inspection as they wait to deliver the biomass. Over 30 trucks can be served in a day, and it generally takes two more days before Mukwano allows another batch of trucks. The trucks are weighed and a truck carrying 7/8tonnes goes for 250,000 to 280,000 USh (equivalent to 75-85 USD).

Lorries waiting alongside Mukwano Road (Kampala), which is named after the Mukwano Group of Companies, to deliver sawdust for its boilers. Photo BGF

But what is the economic sense in view of the low price offered? In most cases, truck owners engage in this business as an extra activity as their main job is transport of timber from up-country and sell it to timber yards in Kampala. They continue to sell because Mukwano occupies sort of monopoly in this respect in Kampala. Sectors like poultry and briquetting don't take much compared to Mukwano. A last aspect to consider is the seasonality e.g during the rainy season the biomass doesn't dry well and is easily rejected.

In summary, this is a "buyers" market, meaning the buyers call the shots, because the commodity is abundantly available and the market's absorbing capacity seems to be limited. In short, supply is bigger than demand.

In conclusion, Mukwano Industries has done a good job creating a market for wood biomass that would have become a menace to the environment, but also benefits from its monopoly position. However, there's need for more innovative ways to utilise this waste, and simply, for a bigger market. The "waste" should be getting a better price.

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The most important final product, packed and ready to be sold

BRIQUETTE PRODUCTION IN MAFINGA

SAWMILL WASTE PUT TO PROFITABLE USE

BY JAN VANDENABEELE, ALL PHOTOS BGF

There's lots of sawmills in Mafinga town, Tanzania, slicing trees grown in the Southern Highlands into timber of different sizes. In the process, they generate a big volume of off-cuts and sawdust. Several companies have seized this opportunity to establish factories for producing charcoal briquettes. Tractors Ltd. is one of them. It installed a furnace in the form of a giant rotating drum, a cooler, a briquette press machine and a dryer. Most of this was imported from China, although the plant manager, Mr Peter Payovela, mentioned that the steel quality of the furnace was such that it had to be rebuilt locally.

Its prime raw materials are timber rests, which are chipped. Occasionally rice husks are bought. The chips are dried to maximum 10% moisture content and fed into the cylindrical furnace operating on LPG. When the temperatures inside the furnace reach 400°C, the furnace starts producing its own gas (syngas). It is however dirty, and first wood tar is separated from it by passing through a cyclone. Next, it is cleaned through condensation, for which 4 m^3 of water per hour is required, with wood vinegar as a by-product. The now clean gas is ready for burning and through multiple nozzles heats the furnace, that at this stage doesn't need LPG anymore. At one end, the wood chips, mixed with sawdust are moved by a conveyor belt into

the furnace, that is rotating with a helix inside, so that the chips slowly move towards the other end of the cylinder, being carbonized in the process. At the other end, carbonized chips come out of the machine, at a conversion of 30% and at a pace of 1 tonne per hour. The operating cycle is 2 days, for a total of 48 tonnes. The temperatures inside the cylinder rise to 600°C and even reach peaks of 700°C which strains the material, requiring serious maintenance at least for every 100h of use. A water supply of 200m³ is required for one cycle, and the plant disposes of a pond with 700m³ water storage capacity, although most of the water is recycled.

The charcoal is bound at a rate of 20% with clay or starch like cassava, depending on what is available in the market at a good price. Some 10kg of this blend are mixed with 50 ltr of hot water and moulded in the briquette press into an egg-like shape. These briquettes are put in a drier powered by fuelwood and dried at 140°C. After cooling down on racks, they are packed in bags of 25kg.

The plant hence produces three products (i) charcoal briquettes, (ii) wood tar, and (iii) wood vinegar. The majority of the briquettes is sold to the army, while Dar Es Salaam is an important market. Wood tar is used for timber preservation, and the vinegar can be used as a fertilizer and a biopesticide.

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View of the conveyor belt that feeds the furnace with wood particles & waste

The furnace, with cyclones (greenish) and cleaning cylinders, and the pump through which the syngas is fed to the burners (at the bottom of the furnace).

Racks with dried briquettes, coming out of a kiln

THE ACACIAS OF AFRICA

THE ECONOMICALLY MOST IMPORTANT INDIGENOUS SPECIES OF THE DRYLANDS

TEXT AND PHOTOS BY FRANCHIS GACHATHI

BACKGROUND

Acacias are among the most widespread and dominant trees in sub-Saharan Africa, where different species provide fodder for livestock and wild herbivorous mammals, firewood and charcoal, construction and fencing materials, tool handles, carvings, bee forage and other valuable non-wood products like gums, tannin, dyes, nectar for honey bees, traditional medicines and fibre for tying and making mats. Seeds of some species are boiled and eaten. They stabilize soil and improve soil fertility, act as windbreaks and provide shade in hot weather. They are trees and shrubs that are prominent and form an important feature of dryland vegetation of Africa, being endowed with necessary features that enable them to adapt to the hot and dry environments. In general, acacias of Africa are very distinctive and easily recognized by their characteristic thorns, feather-like leaves and pods. Most trees have flattened or umbrella-shaped crowns and are popularly called "thorn trees" while most shrubs have hooked prickles. These are the most economically and socially important indigenous trees in Africa, based on the following:

FODDER AND BROWSE

Nomadic pastoralism and agro-pastoralism constitute the predominant production systems of land use, and the mainstay of economy of the arid and semi-arid lands (ASALs) which occupy extensive areas of Africa. Herd

A magnificent *Acacia tortilis*, growing on a rocky soil

diversification (cattle, sheep, camels, goats and donkeys) ensures that both browsers and grazers are present and that an extended dry spell or a single disease is less likely to wipe out an entire herd.

New herbs including grasses sprout immediately after the rains (often inadequate and erratic) and are both nutritious and palatable. They are, however, soon consumed by sheep, cattle, and donkeys, which are primarily grazers, and later the animals must be fed entirely on leaves and shoots lopped mostly from the acacia trees, or on picked or fallen pods from the same trees. Camels and goats, which are browsers and quite hardy for the drylands, are sustained almost exclusively from foliage and pods of acacia trees. The species of acacias browsed depend on their occurrence in any particular area but some popular browse species are well-documented. These include: Prickly thorn (*Acacia brevispica*), Whistling thorn (*A. drepanolobium*), Red thorn tree (*A. gerrardii*), Black thorn (*A. mellifera*), Egyptian thorn (*A. nilotica*), Gum Arabic tree (*A. senegal*), White thorn (*A. seyal*) and Umbrella thorn (A. tortilis). *A. tortilis* in particular, is a very important tree of the drylands; leaves, flowers and pods are excellent fodder. Pods are especially important as dry season fodder reserve, with reputation for fattening animals.

Pastoralism is therefore an important area of economic production that utilizes acacia browse resources by converting into high quality food stuffs (meat, milk) and industrial products (skins, hides, bones etc.). Livestock rearing is not only a source of food, but also a source of investment and wealth building as well as means of transport in the drylands. They are essential in traditional ceremonies and sacrifices. Even waste products such as manure are exchanged with other commodities like cereals or sold to farmers who grow crops in high potential areas.

CHARCOAL AND FIREWOOD

The majority of people in sub-Saharan Africa are still strongly dependent on firewood and charcoal for their day-to-day domestic energy requirements; cooking and warming their houses. There is therefore unceasing pressure to ensure a sustained supply of fuelwood. The same acacia trees preferred for firewood are also used for charcoal production, normally those with hard dense wood with high proportion of heart wood. Charcoal is mainly produced in earth kilns where a stack of logs and branches is tightly piled, covered completely with soil with regulated vents at the rear to control air supply for slow carbonizing process which could take several days. Thousands of bags of charcoal on roadsides, ready for transport, are a common site in the drylands. Much of this charcoal is largely destined for urban slum dwellers and restaurants. Charcoal from acacias is indeed a huge business, involving different categories of stakeholders from poor tree cutters and charcoal producers, middlemen, transporters from donkey carts to huge trucks, wholesalers and retailers, traders of different categories to consumers.

Stacks of firewood on roadsides are also familiar although much of it is usually used in the rural areas, but also for some industries. Preferred acacias for fuelwood include: White swollen-gland acacia (*Acacia bussei*), *A. drepanolobium, A. nilotica*, Falcon's claw (*A. polyacantha*), False umbrella thorn (*A. reficiens*), *A. seya*l, *A. tortilis* and Yellow fever acacia (*A. xanthophloea*).

GUMS

Acacia senegal is the source of true gum arabic (hashab) of international commerce; a widespread tree species in tropical Africa from Senegal in the west to Somalia in the North-east, and southward to Natal in South Africa. The gum exudes from the stem and main branches but the flow is generally stimulated by tearing off a thin strip of the bark (tapping). After about 2 weeks, it hardens on exposure to air in form of round or oval "tears" which are pale yellow to orange in colour. This is gum arabic, traded since biblical times and still fuels a multi-billion industry in the drylands. Thousands of tons are exported annually from African countries, particularly Sudan, the world leader in production, Nigeria, Chad, Senegal, Niger, Burkina Faso, Mali, Cameroon, Mauritania, Ghana, Ethiopia and Kenya to Europe and the USA.

The use of gum arabic falls into three main sub-sectors: food and beverage industry, pharmaceutical industry and technical areas such as printing, ceramics and textiles. It's a natural emulsifier, keeping together substances which

Sorting of gum, one of the few job opportunities in remote drylands

Another important use of acacias: energy providers. In this case firewood

normally would not mix well. Pharmaceutical companies use it to keep medicines from separating into their different ingredients and as binding agent in tablets. It is used in soft drinks and beers. It is used to make lozenges, adhesives and sweets. It makes printing ink more cohesive and permanent. Acacia seyal is another important commercial gum-producing species whose gum (talha) has similar uses to that of *A. senega*l. Others include: *A. polyacantha*, *A. paolii,* Black-hooked acacia (*A. laeta*), *A. drepanolobium*, *A. gourmaensis*, *A. macrostachya* and *A. tortilis*. Acacia gums are very nutritious and are collected for domestic use as dietary supplements by many people all over Africa especially in times of food scarcity and when herding livestock or simply as sweets.

HONEY, TANNIN AND MEDICINES

Natural honey has been produced by traditional communities for generations in Africa and its demand still remains strong. It is a well-established article for both local and export trade with health benefits. Honey from the drylands is generally free of chemicals and therefore fetches better prices in the world honey market. Locally, honey is sold along roadsides in drylands and in shops and supermarkets in urban centres. Flowers of acacia species, which are arranged in rounded or elongated clusters, are valuable sources of nectar for bees and production of honey. An excellent resource is the shrub *A. mellifera* which flowers profusely over extensive areas attracting many bees which produce excellent-quality honey (specific epithet "mellifera" is Latin for "producing honey"). Other important acacias for honey production include: Flame thorn (*A. ataxacantha*), *A.*

A population of acacias in drylands

Ships of the desert. Camels wading & browsing through acacias, their lifeline during the long dry season in ASAL

drepanolobium, *A. senegal*, *A. seyal* and *A. tortilis*.

The bark, pods and even leaves of several acacias including *Acacia nilotica* contains high concentrations of tannin, useful for tanning and dyeing leather into various shades of brown.

Various species of acacia are much used in traditional medicines. For example the bark of *A. nubica* is used to treat rheumatism and backache. An infusion made from macerated roots of *A. brevispica* is taken to expel intestinal worms. A bark decoction of *A. nilotica* is used to treat various stomach problems including indigestion and painful joints. Fresh leaves of *A. tortilis* are chewed into paste and applied as a poultice on a boil to make it ripen. Gum from *A. senegal* or *A. seyal* readily dissolves in water to form mucilage used as soothing agent in various inflammatory conditions of the respiratory, digestive and urinary tract. It is also used to control diarrhoea and dysentery.

The fruits of *A. tortilis*, a hot commodity because the high protein content. Much loved by goats

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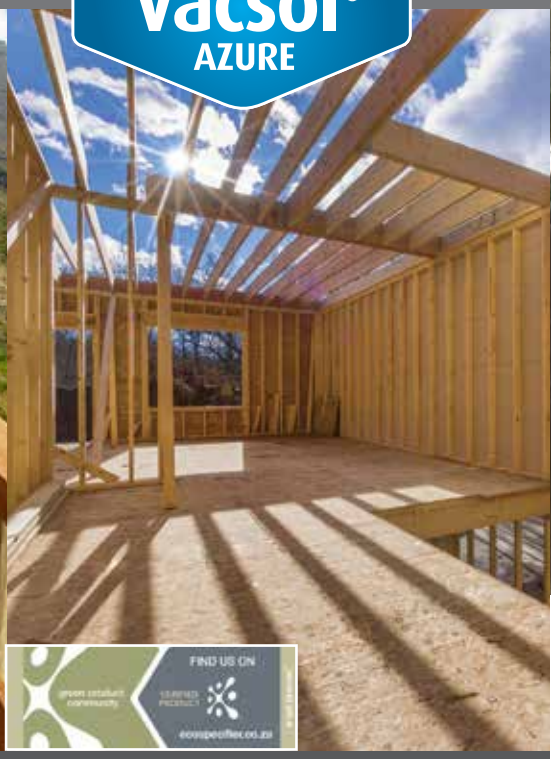

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WORKING WITH TREES RATHER THAN AGAINST THEM

INTEGRATING TREES ON THE FARM AS A SOURCE OF RENEWABLE ENERGY

TEXT AND PHOTOS BY ROGER SHARLAND

Firewood is the commonest source of fuel for most families in Eastern Africa. The demand for firewood has increased substantially in recent years as more people live in urban areas and is further exacerbated by the demand for charcoal. This has led to widespread destruction of trees and is cited as a cause of environmental degradation, deforestation and soil erosion. This in turn has contributed to natural disasters such as flooding, landslides and siltation of lakes and reservoirs. So many have come to see the use of fuelwood as an

Cutting back a hedge on the REAP farm (Rural Extension with Africa's Poor)

Stacking firewood behind the REAP kitchen

environmental crisis. However, firewood is potentially a renewable and sustainable source of energy, and our experience is that it is very compatible with agriculture, especially on small-scale family farms where the family home is surrounded by the family farm. In traditional agricultural systems, the farm was integrated with the natural environment and trees were categorised as to their effect on the agricultural environment. It was understood that some trees were not compatible with an agricultural environment, others were not much of a problem while others were beneficial and were treated according to their properties. With the introduction of agricultural teaching from temperate zones, and in some cases mechanisation, the 'wisdom' started spreading that agricultural land should be completely cleared of trees, and that clean exposed soil was good soil. This has led to an unsustainable form of agriculture which as a spin-off has led to a shortage of fuelwood even on farmland.

If we take the view of balance between agriculture and nature, and the inherent sustainability of natural habitats, we see that trees have a very significant place in agricultural land. As well as trees which are crops, trees have many other roles on the farm and if encouraged in the right way can easily enable fuelwood sufficiency while improving agricultural sustainability. This requires a shift in thinking as to what is good agricultural practice and what is best for the sustainability of the farmland and the overall holistic benefit of the farm family. Firewood is a significant need within the family, and if available on the farm reduces the outgoings needed to purchase fuel as well as we will see as increasing productivity. Working with trees rather than against them on the farm is a clear renewable strategy.

TREES AND CROPS

In the natural environment, trees are significant in protecting the soil and in the creation and maintenance of fertile and healthy soils. When trees are cleared, the land has good productivity and holds moisture well for a few years,

Sesbania trees planted to revitalise exhausted soil

Cutting a Sesbania tree on the REAP farm to create space and

Natural regeneration of Black Wattle (*Acacia mearnsii*) on small-holder farm around Eldoret. It just comes by itself and it is perfect sense to let it grow, and then just exploit it for firewood and poles. Photo BGF

but this soon declines. This was understood by traditional farmers who when land was plentiful practiced shifting cultivation. When the land became unproductive, they left it to return to the natural bush, and cleared a new piece of land. This is no longer a viable method of farming with increased population pressure and shortage of agricultural land. The ideas behind it however can be applied in settled farming by learning to work with trees rather than against them. In so doing, a sustainable productive system can be achieved, and as an added benefit, abundant fuelwood can be produced.

There are several agricultural crops grown from trees, especially fruit. These are important on many family farms, and their importance may be increasing with climate change. Other trees are being promoted for other edible sources, especially notable being Moringa (*Moringa oleifera*) for its nutritious leaves, and medicinal properties. If planted strategically on farmland, these trees also create microclimates suitable for niche crops. Like all crops, these trees need to be managed and controlled.

Pruning helps improve the trees themselves and keeps the trees from overgrowing and shading out crops. The prunings are a good source of fuelwood, when managed properly. Hedges are significant on most farmland for demarcating land and

Mahogany trees planted at the REAP farm

Loading firewood sold from the REAP (Rural Extension with Africa's Poor) farm in Kajulu, Kisumu County

dividing fields. If well selected trees are planted in hedges, they can protect crops from severe weather events such as driving rain, wind and even drought, but also need to be maintained; by cutting back such trees, regular sources of fuelwood can be maintained. Where land is adequate, a fuelwood lot can be planted; possibly in a part of the land not suitable for crops or a corner. A fuelwood lot can generate considerable amounts of fuelwood for home use, and for selling like a cash crop.

Many farmers have seen the benefit of timber trees for generating money on the farm. Eucalyptus is widely grown in some areas, though it is not compatible with crops and draws a lot of water from the ground with a tendency to dry up streams. However, in recent years more farmers have been planting Grevillea (*Grevillea robusta*). This has the advantage of being compatible with crops nearby as well as very productive. However, these are also exotic, and there are a number of indigenous trees which are underrated but good for timber, such as Nile tulip (*Markhamia lutea*), East African cordia (*Cordia africana*) and *Croton spp*. Timber trees are often seen as men's trees, whereas it is the women who are concerned about fuel. However, all timber trees benefit from side pruning and the pruning of such trees can generate significant fuelwood on the farm.

MULTIPURPOSE TREES

Many trees have a number of different uses and benefits for the family farm. One of these is almost certainly the availability of fuelwood. Trees that have multiple benefits are very beneficial to a family farm as they make much better use of the land. Mangoes for example are an excellent fruit tree, but also provide very good shade for sitting under near the home, and branches can be pruned from mature trees to thin them out and used as firewood.

One particularly significant category of beneficial multipurpose trees is the legumes. Legumes have the property of fixing nitrogen through nodules on their roots. This is the same as with crops such as peas, beans and groundnuts. They thus increase the fertility of the land. This can be observed in indigenous species such as Acacias. The grass can be seen to be healthier and more productive close to the tree because of the effect of the nitrogen fixed in the roots. We therefore particularly encourage the planting of leguminous trees on farmland. They benefit the land and when they have grown to a size where they are becoming a nuisance they can be cut out for abundant fuelwood, as well as poles and other needs on the farm.

Grevillea (*Grevillea robusta*) is a very popular agroforestry species in Kenya. It is compatible with crops and produces good timber. It tolerates heavy pruning, which branches are used for firewood. Photo BGF

There are three common leguminous trees that are easy to grow and work well for the purpose of improving the land and producing abundant fuelwood. These are Sesbania (*Sesbania sesban*), Leucaena spp. and Calliandra spp. All three are good at fixing nitrogen but have different properties. Sesbania is the only one indigenous to Africa but is normally a relatively short-lived tree. It is very useful for reclaiming exhausted land. It can be broadcast and after a couple of years harvested for fuel, and by that time the land will be greatly improved. All three can be used for fodder for livestock, but Calliandra is particularly nutritious while also adding to the soil and providing fuel. Leucaena is a

harder wood than the other two, and while improving the soil and providing fodder is a good source of sustainable wood for poles and charcoal production.

WILDLINGS

In our experience wildlings are very significant in working with trees on the farm. Wildlings are those trees that germinate from seeds dispersed from mature trees and which germinate where the seeds land. Whereas trees can be grown in a nursery and planted out in an orderly manner, wildlings often grow randomly over the land. If we see trees as a resource to work with, wildlings take on a different significance. Trees germinate and as long as they are not a nuisance can be left to grow where they are until such time as they become a nuisance. They can then be cut out and will have benefitted the land and produce abundant fuel for home use and surplus for selling. Best practice is to leave beneficial trees that germinate on their own, but to be comfortable to cut them as soon as they become a nuisance or impede other production. They result in an abundance of fuel but also greatly improved living soil.

MULCH

Tree leaves are an important source of mulch for protecting farmland from the hot sun and heavy rains. Larger trees shed their leaves periodically and rather than burning them, they can be spread over the land for the benefit of the soil. When trees have been left on the farm and later cut for fuel, they can be left for a few days on the farmland so that the leaves mulch the soil for greater benefit before collecting the fuel.

EFFICIENT USE OF FIREWOOD

Whereas firewood is a sustainable source of fuel when grown on farmland, it is also a fuel that is often wasted because of inefficient use. Much more firewood is used in most homes than is necessary because of inefficient usage. We have developed a number of principles which help reduce the home firewood consumption. Here are some of them:

- Store your firewood so that it is dry by the time you use it
- Use dry wood which will burn better and more efficiently
- Use more efficient stoves such as the *Maendeleo Jiko*
- Cut and split firewood for faster drying and so that they burn better
- Soaking dry food such as maize and beans reduces firewood needed for cooking
- Cutting solid foods like potatoes and meat into smaller pieces will make them cook faster and use less fuel
- Covering food while it cooks saves fuel
- Fireless cooking in an insulated basket continues the cooking without using fuel
- Put out the fire when you have finished cooking and save the half-burnt wood for another time.

In conclusion, when trees are understood as an important component of the farm environment, they can be encouraged rather than destroyed. They are important for maintaining healthy soil, and at the same time produce abundant renewable energy, both for use at home as well as for selling. Fuelwood can be a significant source of cash, and sustainable charcoal can also be produced from trees grown on the farm.

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Maendeleo stove using only two pieces of firewood

UTILIZING MATHENGE (*PROSOPIS JULIFLORA*) FOR CHARCOAL

THE OTHER SIDE OF AN INVASIVE SPECIES

Improved Earth mound Kiln (IEK) outfitted with 6 breathers and 2 chimneys. Photo Mary Njenga/ICRAF

BY GRACE KOECH, ERICK OTIENO WANJIRA, MOSES KIRIMI, IGNATIUS SIKO, PHOSISO SOLA, MIEKE BOURNE, JONATHAN MURIUKI AND MARY NJENGA

INTRODUCTION

About a third of the world's population relies on solid biomass for cooking and heating using traditional stoves. Of those users, 50% are in developing countries especially Sub-Saharan Africa where 90% of households rely on woodfuel (charcoal and firewood) for cooking and heating (IEA, 2017). By 2013, Kenya used 2.5 million tonnes of charcoal and earned 1.6 billion USD annually, despite the deficit in supply of 55% (MEWNR, 2013). This growing demand for charcoal following urbanization and population increase and the need to find sustainable solutions for supply, are good reasons to utilize the invasive mathenge tree (Prosopis juliflora) which covers 2% of the land in Kenya with a biomass of 37t/ha utilizable for charcoal production (Choge, 2011).

Prosopis juliflora has spread and colonized the tropics of Latin America to Asia and Africa. In Kenya, *Prosopis juliflora* was introduced in the 1970's- 1980's to arrest desertification and address woodfuel shortages, but the species aggressively adapted itself and now covers another 500-1300ha/year in drylands such as Turkana, Baringo, Garissa, Tana River and Taita Taveta Counties blocking roads, waterways, and displacing settlements, crop lands, woodlands, and pasture lands (Ng *et al.,* 2017). This brought dissatisfaction to the local communities in the affected areas as the tree was associated with dangerous thorns that caused injuries to humans and their livestock. Efforts to manage the tree did not bear much fruit because the tree is thorny, impenetrable and requires sophisticated tools to cut. The local communities campaigned to the government to remove the species; little did they know the species could be a valuable resource.

AN INITIATIVE ON *PROSOPIS* CHARCOAL

Recently the government of Kenya has allowed communities to make charcoal using Prosopis.
This presented a win-win case for the community as they now have an incentive to promote the management of the species. The World Agroforestry (ICRAF) in partnership with the Adventist Development and Relief Agency International (ADRA), the Food and Agriculture Organization of the United Nations (FAO) and Baringo County are implementing a project aimed at generating knowledge,

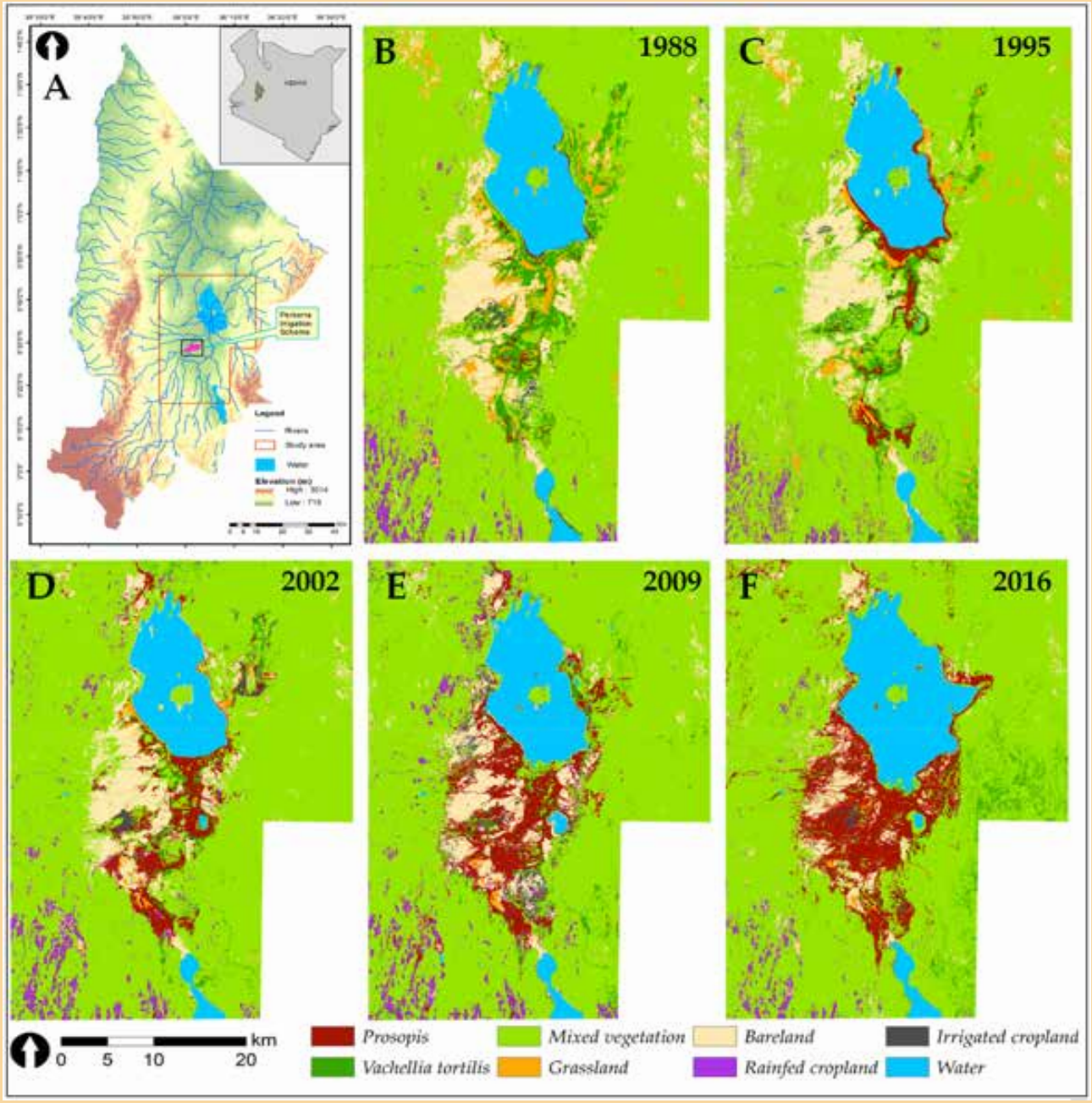

Figure 1. The evolution of an invasion (source Mbaabu *et al.*, 2019).

(A) Overview map of Marigat subregion, Baringo County, Kenya;

(B-F) Land Use maps from 1988 to 2016. The red-brown colour shows the areas where Prosopis juliflora dominates the vegetation. Prosopis advanced on average by 640ha/year

Stacking wood tightly to reduce air spaces and enhance heath transfer. Photo Mary Njenga/ICRAF

policy options and facilitating engagement for more sustainable woodfuel value chains in Kenya. Extra support was provided by the CGIAR programme on Water, Land & Ecosystems (WLE)-sustaining rural-urban linkages.

Analysis from the project has showed that the species has potential to provide communities with 14 different products and services with charcoal ranking highest and food for humans the lowest (Njenga et al. 2019: Table 1).

Table 1. *Commodities and services provided by mathenge (Prosopis juliflora)*

Benefits of Prosopis as ranked by women and men	***Women Rank***	***Men Rank***
Charcoal	1	1
Firewood	2	4
Fencing	3	2
Shade	4	6
Posts	5	3
Roofing	6	8
Soil erosion control	7	5
Furniture making	8	10
Improvement of soil fertility	9	9
Medicinal value (roots)	10	13
Animal feeds	11	11
Windbreak	12	7
Wound soothing	13	14
Food for human beings	14	12

In terms of contribution to livelihoods, both men and women rank charcoal among the top three livelihood sources after farming and livestock keeping (Table 1). Pods, another product from Prosopis can be sold as feed for livestock at KES 100 (USD1) per 50kg bag.

Table 2: *Annual livelihood calendar for communities in Marigat in Baringo county*

Activity	*Months*											
Rank of product	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
(1) Charcoal production	xx	xx	x	xxx	xx	x	x	xxx	xx	x	xx	xxx
(2) Bee keeping	x	x	xx	xxx	xx	x	xx	xxx	x	xx	xx	xxx
(3) Livestock keeping	xx	x	x	xxx	xx	x	x	xxx	xx	x	x	xxx
(4) Farming	x	x	xxx	xxx	xxx	xxx	xxx	xxx	xx	xx	xx	x

xxx- high, xx-medium, x-low

High charcoal production in April, August and December is attributed to availability of labour as schools are closed and the youth are at home. This is fueled by high demand for money for school fees and favorable weather conditions; active Prosopis management can be achieved during those months.

Sustainable charcoal production includes consideration of the entire charcoal value chain. From the production to the end of the value chain, it includes wood sourcing, drying wood well to reduce moisture content, proper stacking of wood to reduce air spaces and enhance heat transfer and monitoring kilns to enhance charcoal yield.

During trainings of the community, Improved Earth Mound Kilns (IEK) were demonstrated. Other improvements of Traditional Earth Mound Kiln (TEK) included fixing 6 breathers and 2 chimneys at a cost of KSH5500 (USD50.5) which each producer was supported with by the project. After the training, charcoal yield from the IEK was 50% higher than from the TEK.

Demonstration on thinning & pruning of Prosopis at KEFRI Baringo. Photo Mary Njenga/ICRAF

Similar results were obtained in Democratic Republic of Congo where charcoal yield from IEK between trained and non-trained charcoal producers tripled for the former group (Schure *et al.*, 2019)[1].

If thinned and pruned stems are below 5cm in diameter they are better carbonized using a drum kiln, a kiln type which was introduced during the training. The resultant charcoal is then used as fuel or added into the soil as biochar or processed into charcoal briquettes.

CHALLENGES THAT STILL NEED TO BE ADDRESSED

Despite the high promising potential of Prosopis for charcoal as a management tool, the

Note from the Editor: Many kiln types have been proposed and tried, both of the mobile and fixed kind. Despite those efforts, the traditional earth mound, although less efficient, is still the most widely used, by far. This is because it is convenient (no extra materials except soil, grass and the biomass), cheap and, well, traditional, meaning the skills are wide-spread. And it can be constructed fast and anywhere.

The Improved Earth mound Kiln (see text box next page), stands a fair chance of adoption, because it greatly resembles the traditional type, and because the extra inputs are few, simple, cheap, sturdy, and easy to find.

communities still face a wide range of challenges such as,

1) perception of Prosopis charcoal as of low quality compared to indigenous species such as Acacia,

2) fluctuation of charcoal prices,

3) long and complex permit system for charcoal production and trade, and

4) it is hard to cut the tree with machetes (pangas) and axes, limiting the area charcoal producers can be able to harvest the wood.

The challenges could be addressed through collaborative actions of the government, research and development organizations, community-based organizations, and local communities by:

1) strengthening CPAs so that they can manage leasing and sharing of equipment for harvesting and processing Prosopis,

2) promoting formation of Village Saving and Loan Association (VSLAs) and links to other rural finance options to enable producers to buy the equipment for harvesting and processing the tree,

3) promoting charcoal production using IEK to increase yield and earn more income to support other livelihood activities and enhance environmental health.

TAKE HOME MESSAGE

Management and utilization of the almost 19,000 hectares of *Prosopis juliflora* in Baringo for sustainable charcoal production presents potential for improving livelihoods and the environment. It presents an opportunity for supplying the growing urban centers with affordable cooking fuel, a strategy that can be scaled out to the other affected counties.

Also, there is need for complete removal of mathenge in some pockets to create room for enrichment with native high-value multipurpose tree species to enhance biodiversity.

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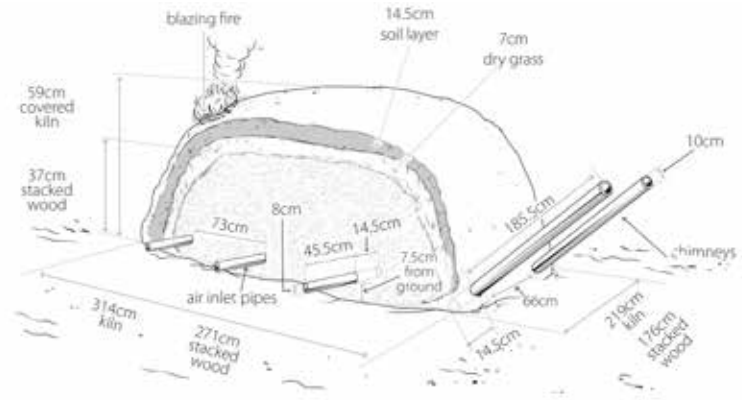

Drawing by Fucha Media

NOTES ABOUT THE IMPROVED EARTH MOUND KILN (IEK)

The improvement consists of the use of chimneys and inlets, in the form of Galvanized Iron (GI) pipes. The kiln shown on the design is small, 2x3m and 60cm high. This covers about 750kg of dry wood. Bigger kilns are possible. For this size, there are 2 chimneys and 6 air inlets. The kiln is covered by a layer of grass (7cm thick) and soil (15cm thick), total cover thickness 22cm.

Chimneys
Diameter 10cm, total length 2m of which 185cm sticking out of the kiln, and 15cm inside, penetrating the soil layer and sitting on the grass layer, and should not touch the wood to avoid burning.

Air inlets
Two times 3 GI pipes of diameter 8cm and length 60cm of which 45cm sticking out of the kiln and 15cm inside penetrating trough the soil layer and touching the grass layer. The inlets should not touch the wood to avoid burning.

Firing of the kiln is done at the opposite (windward side, that's the direction the wind is coming from) of the chimney side, on the upper part.

Developed by KEFRI (Nelly Oduor *et al.*, 2006)

TOWARDS SUSTAINABLE CHARCOAL PRODUCTION IN GULU DISTRICT?

A LEGAL INSTRUMENT THAT MIGHT WORK

BY JAMES OCAKA

Gulu district in northern Uganda is faced with a serious deforestation problem, caused by unsustainable charcoal production to meet the energy demands of the urban population. To address this problem, the district developed an ordinance known as the "Gulu district sustainable charcoal production, transportation and marketing ordinance, 2019".
The background to the ordinance is that "This country is ours! We must live here!" Living here means we must keep it well, as it was kept for us. Our children must find it safe, and leave it safe for their children too. Charcoal is a key commodity we use to feed ourselves and our children. The slogan behind the ordinance is "Our environment, our life, our wealth, our heritage". We must therefore guard it, survive in it, and preserve it for our future generations.

The vision of this ordinance is to achieve a bottom-up control of environmentally sustainable charcoal production by local households and small businesses, and innovative marketing. All these must complement and support community and private sector organizations to ensure energy security in a manner that increases rural household incomes and enhances local government revenues through concerted environmental politics to realize environmental justice in Acholi. The ordinance has 46 sections arranged in 11 parts with 4 schedules.

- Part 1 is the preliminary section with the following content: short title, commencement, application, interpretation, object and purpose of the ordinance.

- Part 2 has prohibited activities in charcoal production. The ordinance prohibits the following activities: cutting of certain plant species for charcoal production; production of charcoal using unsustainable and destructive methods, and unlicensed production of charcoal.

- Part 3 entails the establishment of

a local environment committee, its composition, functions and powers.

■ Part 4 explains the establishment of charcoal producers associations, their role and functions, charcoal farming and community participation.

■ Part 5 contains the licensing procedure: establishment of licensing committees, revocation, suspension or cancellation of license, prohibition relating to licenses, requirement to provide production and sales data.

■ Part 6 has reforestation and conservation plans, protection of endangered or threatened plant species and tree felling (stumpage) fees.

■ Part 7 relates to charcoal farming: requirements and licensing of charcoal farms, revocation, suspension, cancellation of license, prohibition relating to licenses and requirements to provide data.

■ Part 8 concerns charcoal transportation: charcoal movement permit, trade in charcoal, record keeping and inter-district trade relations.

■ Part 9 has offences and penalties under inspection, presumption, general penalty and effect of conviction.

■ Part 10 emphasizes enforcement, composition of enforcement team, powers of the team and powers to make subsidiary legislation.

■ Finally, part 11 has miscellaneous items such as compensation for loss or damage.

The district has realized considerable success in regulating and controlling the charcoal industry. For example, the number of unsustainable industrial charcoal producers has reduced drastically, the local community has embraced tree farming for fuelwood, charcoal, poles and timber, and investors establishing tree plantations for charcoal production have started their operations in the district. One example is Kijani Forestry Company. It has established nurseries in the community which are managed by the community groups (8 groups so far). Seed is locally collected and the only thing the company provides are potting bags and technical advice. Some of the species raised: *Acacia senegal*, *Eucalyptus camaldulensis*, *Gmelina arborea*, *Terminalia brownii* (Red pod terminalia) and *Combretum molle* (Soft-leaved combretum). So far 10 villages have benefited from the program, with about 250,000 seedlings planted. The same company is training tree owners in modern methods of charcoal production using the Casamance kiln (commonly used because it's cheaper (500,000 USh) but with low recovery (25%)) and the Sam I retort (more expensive (5,000,000 Ush) though with better recovery (30%)). It also manufactures these kilns in partnership with the Consultant holding the Patent. These technologies are implemented through farmer groups starting in Paibona sub-county, Gulu District.

Despite the above and the existence of an ordinance, the district still grapples with a number of challenges including putting a stop to unsustainable commercial charcoal production; incentivizing local household and small business charcoal production; improving rural household incomes and livelihoods; ensuring environmentally-sustainable charcoal production; increasing local government tax revenues from trees and charcoal; adopting alternative and affordable energy sources like biogas and solar, and ensuring regular fuel wood and charcoal supply for national energy security.

Charcoal production out of the valuable Shea tree (*Vitellaria paradoxa*), prohibited under the Charcoal Ordinance. Photo Philip Kihumura/ICRAF

Some of the lessons learnt are; we should not blame household or small-scale charcoal producers for the problems caused by industrial unsustainable charcoal production. Problems arise from top-down control of charcoal production, transportation and marketing, lack of accountability at all levels, lack of community organization to protect common resources and uninformed leadership.

This ordinance is anticipated to have the following outcome:
(a) Enhance local custodianship and stewardship of tree cover;
(b) Ban current environmentally unsustainable industrial charcoal production practices;
(c) Prohibit felling of certain tree species for charcoal production, such as the Shea nut tree (*Vitellaria paradoxa*) and *Afzelia Africana* (African mahogany);
(d) Introduce improved charcoal production technologies: Casamance kiln and Sam I retort kiln;
(e) Introduce local licensing. This will be done through associations like the Gulu Charcoal Dealers Association, of which each member pays a monthly fee, the current one being 36,000 USh and a stumpage tax. The fee will depend on the size of the tree, though currently communities charge per acre e.g. Ush 1,000,000.
(f) Introduce incentives for indigenous producers;
(g) Enhance local government revenue through the movement permit. The tax per bag is Ush10,000 as a district collection, paid to the district general fund account.
(h) Transform charcoal packaging from sacks and other means of measurement to kilogram bagging;
(i) Ban energy-wasting cooking methods;
(j) Introduce 'Charcoal Farming' for environmental sustainability;
(k) Brand 'Environmentally Sustainable Charcoal'; and
(l) Leverage the comparative advantage of the Acholi Region in biomass production into competitive advantage in wood fuel and charcoal production.

New Casamance kiln Units in Gulu District. Photo James Ocaka

Some of the suggested solutions to the challenges are:
- to inform the leadership of the true nature and scale of the problem;
- to end the current unsustainable industrial charcoal production through concerted political action by local governments, cultural leaders, religious leaders, opinion leaders, civil society and donors;
- to expand, regulate and improve the household and small business modes of charcoal production so that more revenue is retained by communities.

IN CONCLUSION

Most people that burn charcoal come from outside the District like from Kampala. The ideal is that the community only sells trees if the charcoal dealers association is trained in efficient charcoal production, that they are able to burn the charcoal by themselves and make more money.
If the charcoal industry is formalised, the district will be aware of what is taking place and be able to advise the community on which trees to cut. In the case of clear-felling, they can advise on how to replant to ensure environmental sustainability; to improve rural household incomes and enhance tax revenue to local governments; and to engender environmental politics that ensure environmental justice.

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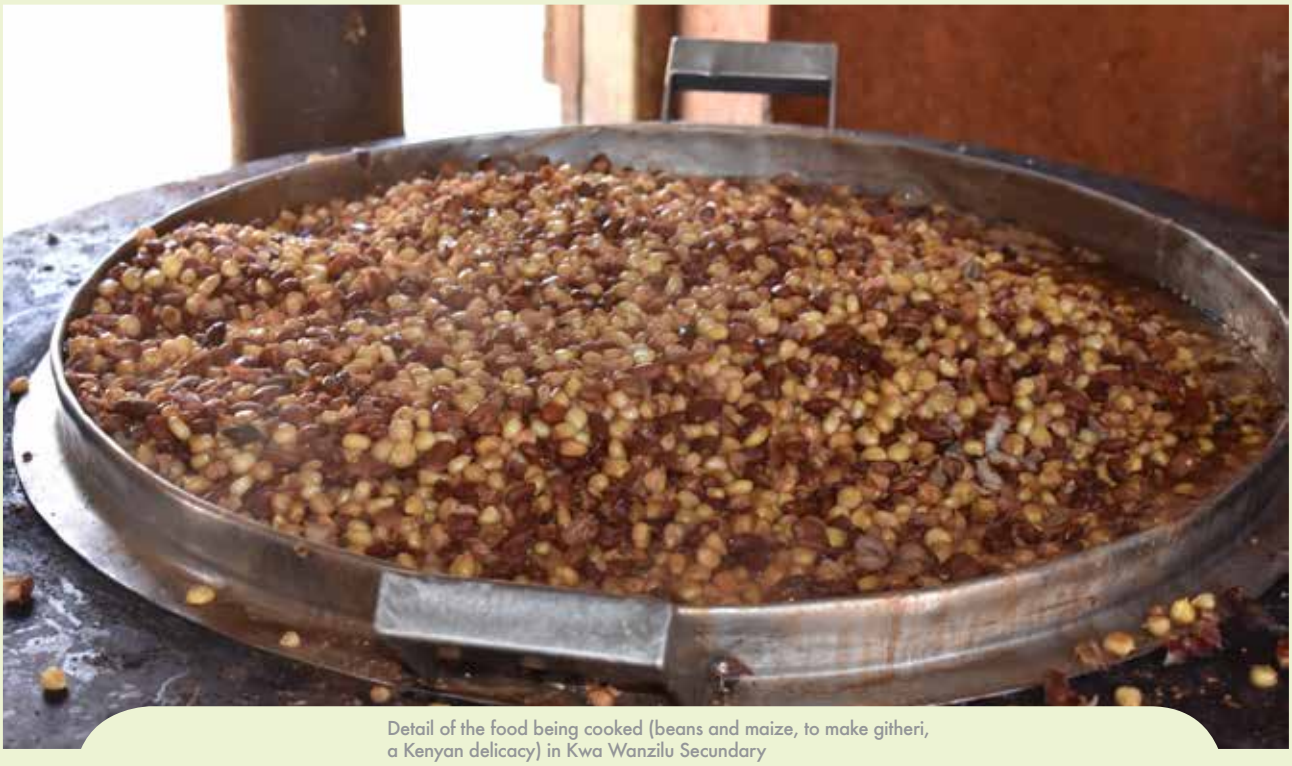

Detail of the food being cooked (beans and maize, to make githeri, a Kenyan delicacy) in Kwa Wanzilu Secundary

SCHOOL CHILDREN ALSO NEED TO EAT

RURAL SCHOOLS PUT AN ADDITIONAL BURDEN ON THE ENVIRONMENT

BY DANIEL NDOLO AND JAN VANDENABEELE, ALL PHOTOS BGF

Over 2.5 billion people in the world depend on burning biomass for fuel. Smoke from stoves and fires in homes has been associated with over 1.6 million deaths per year of women and children (World Vision, 2013). In Kenya, wood fuel is the main source of energy at household level in rural areas. Currently, schools in these areas also depend on firewood as the main source of energy for cooking. This is because it is affordable and readily available as compared to other sources of energy. The wood is mostly obtained from nearby communities whose resource base is rapidly dwindling due to overuse.

School budgets are strained because of several factors, one of them being over-reliance on firewood. Therefore, it has become crucial for schools to establish their own woodlots. The firewood consumption depends on the type of cooking stove and the calorific content of the wood, among others.

Adoption of energy-conservation strategies especially the use of energy-saving stoves, helps in conservation of wood fuel, reduces energy costs and minimizes in-door pollution consequently controlling respiratory diseases.
A visit was conducted in two schools in Masinga Sub-county (Machakos County) where the School's Green Initiative Challenge (GIC) project is being implemented. The main objective was to establish the volume of fuel wood used per day, the source of wood and the type of cooking stove used. The price of fuel wood is considered the same, at 0.5Ksh/kg. The results are presented in the table below:

School	Kwa Wanzilu Secondary	Masaku Secondary
type	Boarding school	Day school
Meals per day	3	1
population	554	100
Wood consumption (T/y)	100	18.5
Cost/y (Ksh)	200,000	37,000
Stove type	Energy-saving (boiler)	Improved traditional *
Stove cost (Ksh)	180,000	6,000

** Note: this is a modified traditional stove, if it was the traditional three stones stove, it would consume even more firewood. It has a fired-clay liner that provides thermal insulation to minimize heat loss so the stove stays hot for a longer time.*

Improved traditional cooking stove at Masaku Secundary

Modern stoves at Kwa Wanzilu Secundary

The fuel consumption per day in the two schools depend on the following:

a) The number of meals prepared per day,
b) The days per year spent in the school (41 weeks, of which 7 days per week boarding, and 5 days per week non-boarding),
c) The number of students per school,
d) The type of stove used.

Comparison between the 2 schools (for 41 weeks of school time per year)
In consumption of firewood/ student/day (in kg)
For Kwa Wanzilu School: 100,000kg/554/3/(7*41)=0.21kg
For Masaku School: 18,500kg/100/ (5*41)= 0.90kg
Hence, the consumption of Masaku Sec School is 0.90/0.21 = 4.3 times higher with its modified traditional stove.

In financial terms (at 0.5Ksh per kg of firewood)
Kwa Wanzilu: 0.21*0.5 = 0.1 Ksh/ meal/student
Masaku: 0.90*0.5 = 0.45 Ksh/ meal/student

The initial installation cost for an energy saving stove is high (Ksh 150,000-300,000) though this depends on the size and the distance from the supplier.

The fuel wood is purchased by the schools from the nearby community. The fuel type is mainly from assorted tree species such as *Terminalia brownii* (Red pod terminalia, muuku) and different acacia species which have high calorific value. It was also noted that some parents bring firewood to off-set school fees balances.
Over-dependence on indigenous tree species to meet energy needs is exerting pressure on the surrounding ecosystems resulting to reduced tree cover.

To put this into perspective, the following calculations and assumptions are made:
- one tonne of wood equals about 1.25 m^3 (medium dense wood, not dried at 800kg/m^3)
- one young acacia of about 20 years old: 1.5m^3 of wood, branches included
- one tonne of wood is then 1.5/1.25 = 1.2 trees
- the wood consumption of Masaku Sec School is then 1.2x18.5 = 22 trees per year
- the wood consumption of Kwa Wanzilu Sec School is then 1.2x 100 = 120 trees per year

It is obvious that the Acacia/ Commiphora woodlands in ASAL, at standing volume of 25-70m^3/ha and a growth rate of barely 0.5-2m^3/year or some 20-50 mature acacia trees per ha, cannot cope with the simultaneous exploitation for charcoal (to export to major cities), firewood for households, and for schools; even in theoretical circumstances where regeneration and regrowth through coppicing can take place. Real conditions include heavy browsing by goats, a major factor in destroying both new seedlings and sprouting from tree stumps.

Therefore, there is need for schools to establish own woodlots and explore use of energy saving stoves. The tree growing activities help the students/pupils to understand the need to protect and conserve our environment. This also instils positive attitudes, knowledge and behaviour to care for the environment, not only in school but also at their homes.

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CROTON NUTS FOR BIOFUEL, FERTILIZERS AND FODDER

ECO FUELS KENYA MAKES SUSTAINABLE USE OF CROTON MEGALOCARPUS

BY MCRAE MUTHOMI & JAN VANDENABEELE, ALL PHOTOS BGF

Based in Nanyuki, Laikipia county, is a company that pulled off the trick of simultaneously making money, eradicating poverty by improving community livelihoods, and helping to conserve the environment. This is all done by utilizing trees in a sustainable way, as the trees are not chopped down, but to be harvested yearly for their fruits. Eco Fuels Kenya (EFK) makes biofuel, animal feed and various fertilizers from the nut of the *Croton megalocarpus* tree, locally known as Mukinduri. The company began its operations in 2012 with a mission of creating value out of croton trees and a vision to become the world's first croton agro-value chain business. Since then, it has mobilized over 6000 farmers that have been supplying the main go-downs in Nanyuki and a recently opened one in Nakuru. Nut collection takes place over a 300 kilometer radius covering over 17 counties viz Meru, Kirinyaga, Nyandarua, Laikipia, Makueni, Machakos, Kiambu, Nairobi, Bomet, Samburu, Baringo, Kajiado, Narok, Nyeri, Muranga, Nakuru and Kericho. The company directly employs 30 people. Annually, the company collects 2000-3000 tonnes of croton nuts that are processed into various products. Collection takes place on the ground through collectors/ farmers who are paid by agents to gather the nuts from their farms, in turn the agents aggregate the nuts and deliver them to the warehouse in Nanyuki or Nakuru. The company buys a kilo of nuts for Ksh. 5 from collectors / farmers while the agents are paid Ksh. 10 per kilo at delivery.

CROTON MEGALOCARPUS (MUKINDURI)

Croton megalocarpus, or simply croton, is a widely distributed tree species in Kenya thriving at altitudes of 1200-2450 m and mean annual rainfall 800-1900 mm. It can grow up to 35 meters and has a rather flat crown with layering

Seeds of *Croton megalocarpus*

Empty husks of *Croton megalocarpus*

The pyrolysis equipment, in operation

branches. A young tree has broader leaves that are silvery at the bottom and dull green at the top which grow smaller as the tree ages. Its bark is grey and in good conditions will have a straight bole up to 10 or 20 meters.

Unripe fruits are green but turn grey when mature, each containing 3 grey-brown seeds that are shaped like a tick. The tree begins to fruit between 3-5 years depending on climatic conditions. A mature tree will yield up to 70 kg of nuts per year in ideal conditions. Mukinduri is used by various communities for medicinal purposes, for timber and as a live hedge.

Nut processing for biofuel

In processing, the nut contains 30% seed and 70% husk, cold pressing seeds produces 30% oil and 70% seedcake. Meaning that one tonne of fruits contains 300kg of seeds and 700kg of husk, and from those seeds, one can extract 90ltr of oil, leaving 210kg of seedcake.

Annually, EFK has the capacity to produce 900,000 ltr of croton oil. By using a screw press (oil expeller), croton seeds are pressed into oil that can be used straight as fuel in heavy engines and is miscible with normal diesel. EFK does not do transesterification, a process used for making bio-diesel. The oil goes through a filter press, to get filtered oil and sludge. In addition, the oil is used for tanning leather, paint manufacturing and soap production.

ORGANIC COMPOSTS

EFK is a zero-waste manufacturing company hence we turn our waste into other products that are on sale in the market.

After extracting the seeds using a dehulling machine, tonnes of husks remain as waste but this is turned to compost and fertilizers. Their machine has a capacity of dehulling 10 tonnes of husks per day.

To make the compost, the husks are decomposed for 6 weeks occasionally adding fresh water when required; and when ready, it is ground into a finer product. EFK's eco planting compost sells at Ksh 1750 per 50 kg bag. Four to six bags can be applied

The difference between the 2 types of compost is in terms of

- Texture
- Calcium composition
- Repellant effect of the Top dress

The table below shows the content of Eco-planting mix (Specialized compost for planting) and Eco-Top dress (Specialized compost for top dressing)

Nutrient	Eco-planting mix Composition (%)	Eco-top dress Composition (%)
Nitrogen (N)	>1.85	>2
Phosphorus (P)	>0.4	>0.3
Potassium (K)	>1.5	>1.5
Calcium (Ca)	>3.8	>1.7
Carbon	>40	>40
pH	5.5-8.5	5.5-8.5
Moisture	15-25	15-25
C/N ratio	<20:1	<20:1
O.M	>70	>70
I.M.	<3	<3

Croton vinegar and bio-fertilizers Further, the husks are carbonized in a kiln to produce biochar, through a process called pyrolysis, where biochar is one product and the vapours generated during the process are condensed into a liquid called "croton vinegar". The latter is condensed into separate containers. A kiln can take up to 380 kgs of husks to produce 90-120 kgs of bio-char. In two days, a single kiln produces 20-22 liters of vinegar. The biochar produced usually has inactive ingredients, but when soaked in compost tea, the resultant product is a highly potent soil conditioner. "Compost tea" refers to the watery solution in which the husks have been soaking during the composting process. The biochar is sold at 40 Ksh/kg, and the chemical composition is as follows:

Table 2: Chemical composition of the biochar produced & sold by EFK

Nutrient	Composition (%)
Nitrogen (N)	1.98
Phosphorus (P)	0.6
Potassium (K)	6.5
Calcium (Ca)	1.86
Magnesium (Mg)	0.6
pH	8.5-10.5
C/N ratio	20:1
O.M	>70
I.M	<3

Croton vinegar has insect repellent properties to it repels harmful soil-based *dudus* like aphids and thrips. Croton vinegar is also used as a foliar spray that promotes shoot development and when drenched, promotes root development. A liter of croton vinegar sells Ksh 500, and a 20 liter jerry-can at Ksh 10,000. Market for these specialized composts & biochar comes from small-holder farmers and flower farms in Naivasha, Kajiado and the Mt. Kenya region. In cooperation

Wood vinegar, packed in different sizes

with farmers, EFK has established various demo plots where the benefits of applying its compost are shown, on crops like potatoes, maize, cabbages, French beans, onions etc.

Another by-product of this carbonization process is tar, that can be used as a wood preservative.

THE SEED MEAL

After the oil press, the seed cake is ground using a milling machine into a relatively coarse powder that is sold as a protein supplement (chicken feed) at Ksh. 22 per Kg. The feed is sold to smallholders and companies that make chicken feed. The seed meal is a safe source of protein (32%) ideal for proper poultry development, improved egg production for layers and faster weight gain for broilers.

CONCLUSION

EFK encourages preservation, sustainable utilization and increased planting of croton trees in order to contribute to the 10% forest cover in Kenya and consequently reduce the impacts of global warming and climate change. Since 2016, the company has planted 150,000 croton trees with various institutions, community-based organizations and farmers. Their target is to plant 300,000 trees by 2022, all outsourced from farmers at Ksh 15 per seedling.

The list of benefits of the croton tree is big. A visit to EFK by Miti team was an eye-opener, seeing tonnes of nuts packed, waiting to be processed, and tens of workers busy in different operations. It was a glimpse of what one tree species can do when its usefulness is harnessed by a sustainability-minded team. Surely, there are other useful trees, but the fact that this is a relative abundant species, and easy to multiply in nursery and establish in the field, makes it quite valuable. The potential of this particular species is one more reason to promote research & investment that is geared towards conservation and livelihood transformation.

The writers are Editor of Miti magazine and the Editor-in-Chief of Miti who is also the Executive Director of Forestry at Better Globe Forestry
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THE WATER LEVEL OF LAKE VICTORIA ON AN ALL-TIME HIGH

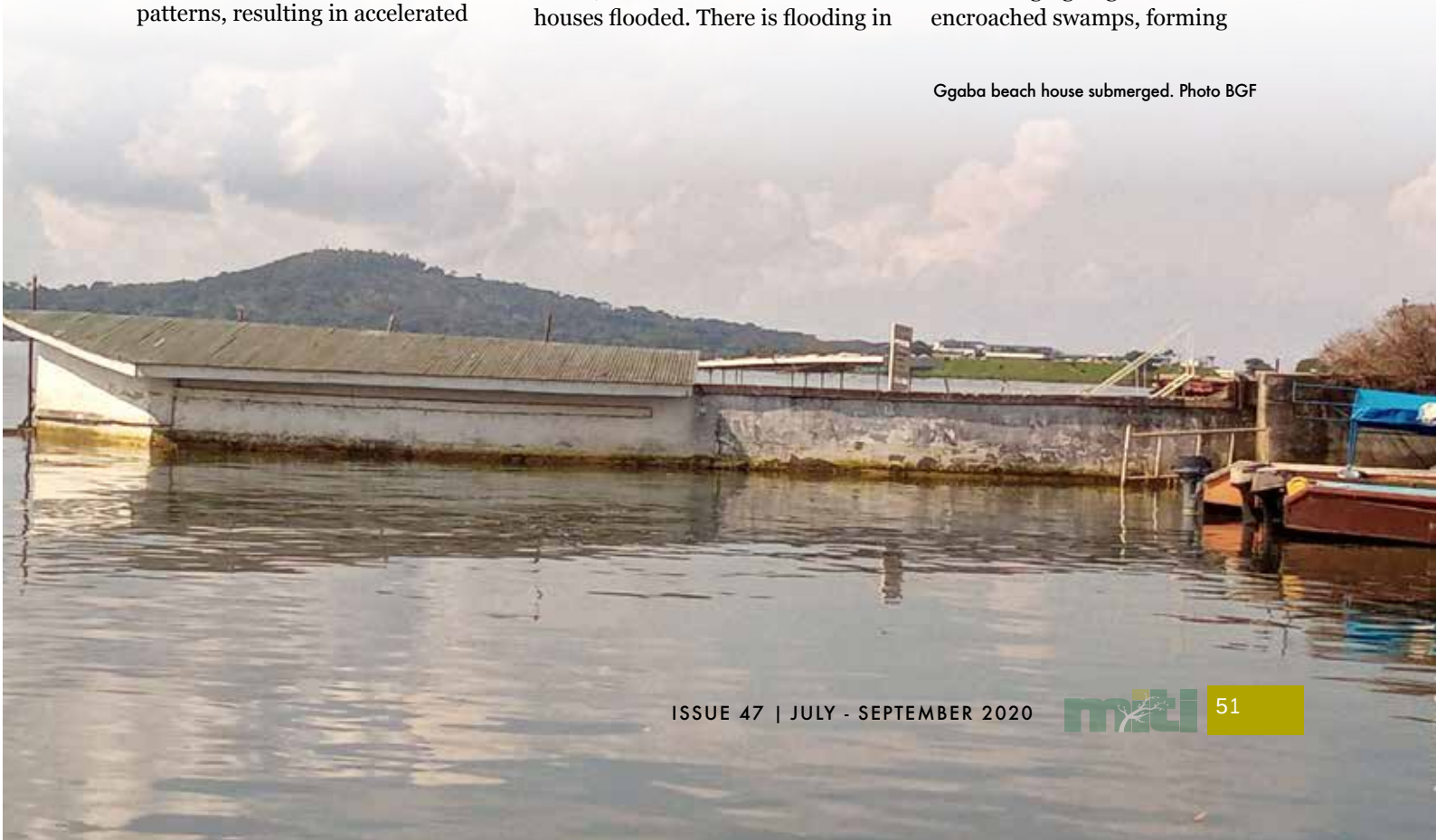
LOADS OF ECONOMIC CONSEQUENCES

BY CALLIST TINDIMUGAYA

The water levels of Lake Victoria have been steadily rising since October 2019 and continue to rise due to the increase in inflows by rivers, and heavy rains in and around the lake. On top of that, urbanization has created impermeable surfaces like roads, roofs and pavements. These human induced factors have reduced water interception and infiltration into the soil. Environmental degradation has further caused alteration in land use patterns, resulting in accelerated surface run-off with increased erosion, siltation and reduced storage capacity of water bodies. The onset of rains from March to May is expected to magnify the situation as most water bodies are saturated by now.

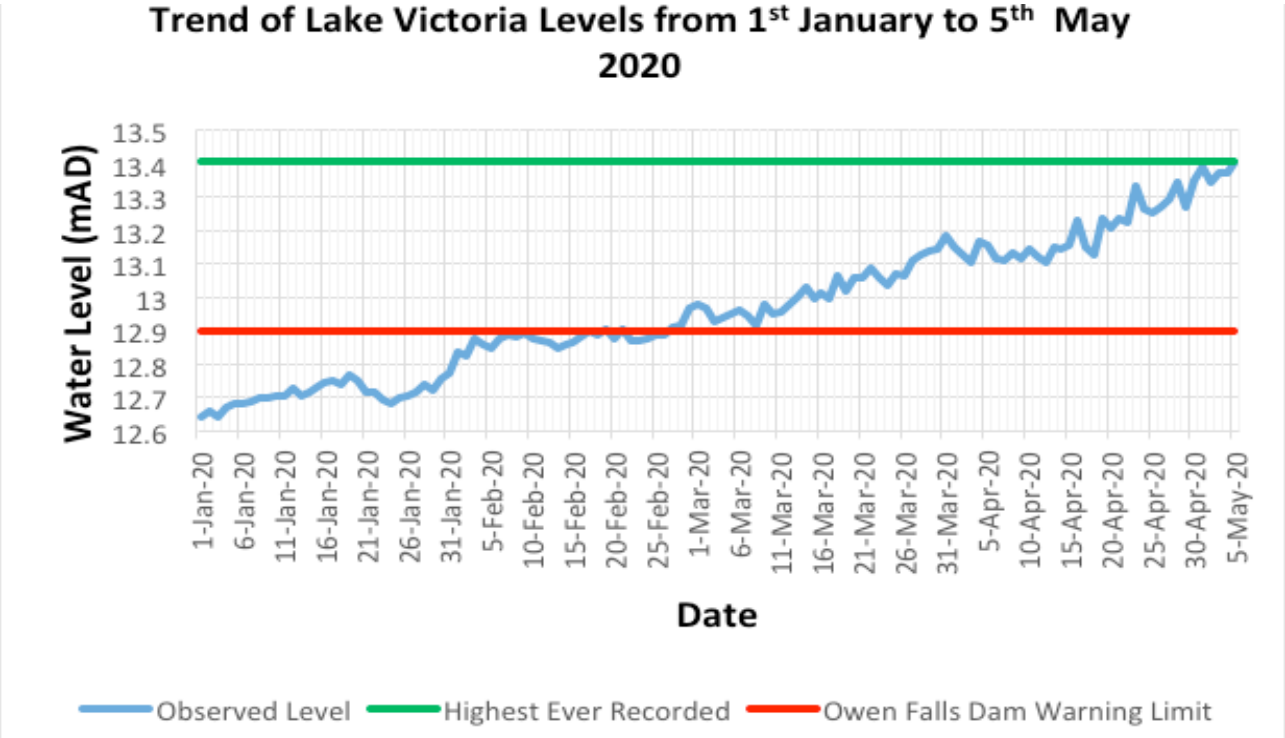
The rising water levels have already had negative impacts on people and various activities. Specifically, the rise in water levels has had serious effects on development around the lake and River Nile with many hotels, beaches and individual houses flooded. There is flooding in parts of Kampala, Wakiso, Masaka and Rakai.

The high-water level has resulted in the rise in head water levels at the Nalubaale and Kira power station, threatening the safety of the 60-year-old Nalubaale/Kiira dam. Floods interrupt essential services like water supply, power, farming, sanitation, health, education, and livelihoods with possible long-term effects. The rising water and resultant waves are dislodging huge chunks of encroached swamps, forming



Ggaba beach house submerged. Photo BGF

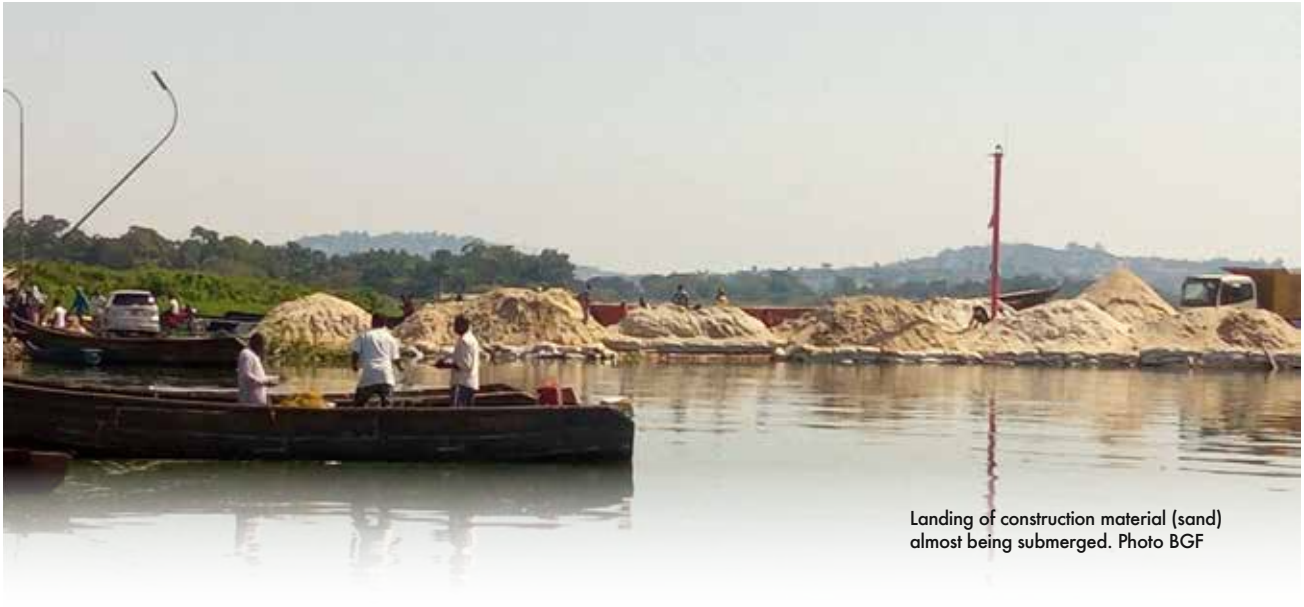
Figure 1: *Trend of Lake Victoria water level. In a span of about 4 months, a rise of 80cm, that's quite something.*



floating islands. An example of this is the floating island of papyrus mats which docked at the Owen Falls Dam Complex on 14th April 2020, choking inlet screens and affecting the cooling system of the power generating units and resulting in a national power blackout. This island has since been removed but many similar floating islands have been reported. From the water resources point of view, increase in water level and floods are not totally without benefits. Flooding for example is good for increased storage, ground-water recharge, fish spawning, restoring floodplain ecosystem and providing fertile soils for productive farming. However, with the current situation of environmental degradation, population increase (6 times the population of 1964), encroachment on wetlands, lakeshores, riverbanks and floodplains with establishments, settlement and farms, the cost is higher than the benefits.

As of 12th May 2020, the Lake water

Increased outflow of water from Lake Victoria at 2400m3 per second. Photo Callist Tindimugaya



Landing of construction material (sand) almost being submerged. Photo BGF

level had risen to 13.42 meters which is higher than the highest recorded in 1964, where the level was 13.41 meters.

To address the problem of increasing water levels, water releases at Jinja had to be increased progressively since 10th March from 1,300 cubic meters per second to 2,400 as of today.

As releases increase, the Ministry of Water and Environment (MWE) is working closely with Eskom Uganda Ltd and other hydropower dam operators on the River Nile to monitor the impacts of the releases downstream. The increase in release to 2,000 cubic meters per second as of 24th April 2020, was already leading to a rise in water levels of all receiving lakes downstream (Kyoga and Albert) causing negative impacts. The rains from mid-April to end of May are expected to be between normal and above-normal, and will make the situation worse.

Downstream impacts are felt on transport systems, where six ferry crossings operated by Uganda National Roads Authority (UNRA) have been affected. In addition, ferry movements along River Nile and Lake Kyoga have been stopped as there is inundation and submergence of jetties and landing sites. Other impacts are felt in tourism, fish landing sites, water level monitoring stations and settlements. The Kyiko bridge construction, downstream of Isimba Hydropower Dam has come to a halt.

ACTION TAKEN

■ Increase of outflows with the intention of lowering the lake water level (Eskom Uganda, Bujagali Energy Limited and Isimba Hydropower dam). Despite action taken, there has been low and insignificant lake level reduction due to increased rainfall in the basin.

■ The dam operators (Nalubale/ Kiira, Bujagali and Isimba) routinely communicate to the downstream users/community (ferry operators, fisher men, hotels, etc) about the releases. An alarm is installed and acts as an early warning system to downstream water users to get prepared.

■ The MWE continues to monitor the change in the water levels and take action to protect the people and developments around the lake, as well as the safety of Nalubaale/ Kiira dam and including authorizing increased water releases.

■ A real-time data sharing arrangement among all the Hydropower operators indicating discharges per hour has been established through Google Drive to authorized personnel to improve coordination and communication among the dam cascades (Eskom, Bujagali and Isimba).

■ The floating islands at the Owen Falls Dam Complex have been removed. Additional ones that appear are also taken care off, before they can affect the dam at Jinja.

CONCLUSION

The Lake Victoria water level continues to rise despite increased releases due to higher inflows and heavy rains around the Lake basin. Evacuation of people from high risk areas will also be considered if measures already taken prove to not be enough to control the situation.

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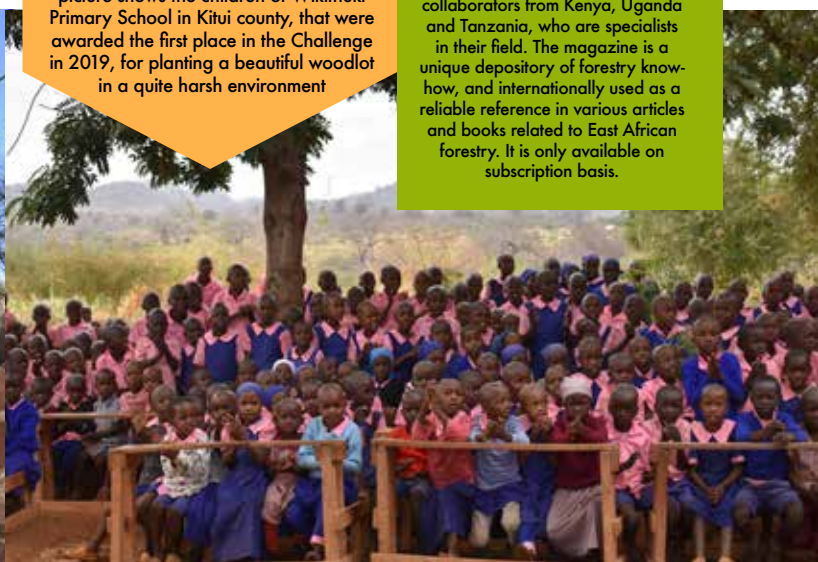
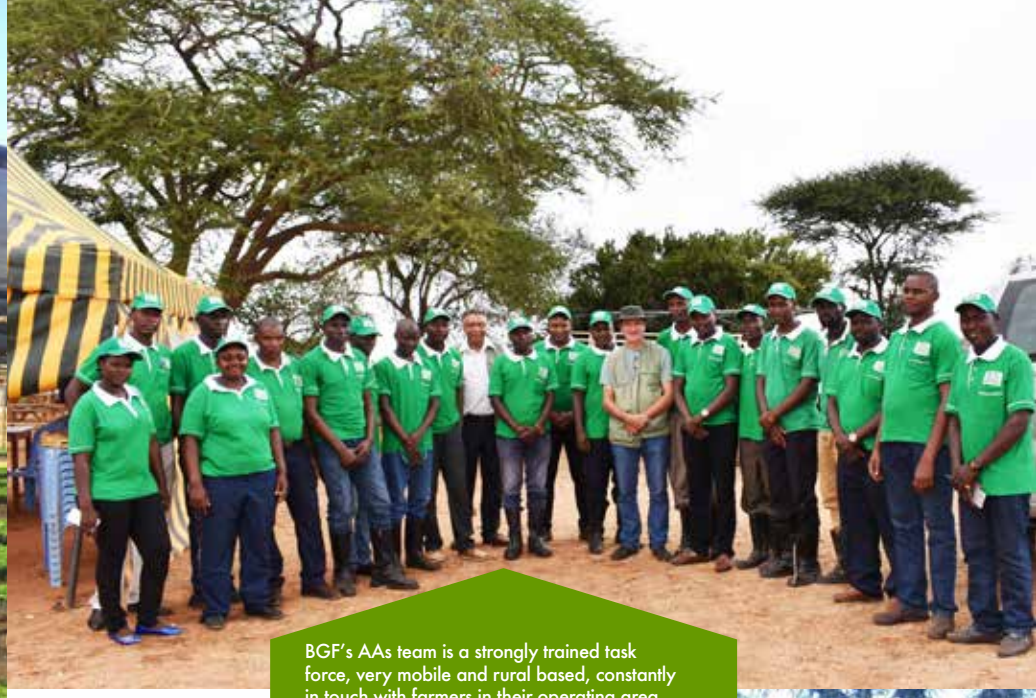
The plantations of BGF can be distinguished into two categories: (i) traditional plantations on a large scale, on leased land, and (ii) trees planted by farmers on their land, in an agro-forestry lay-out, meaning widely spaced and intercropped with food crops. This photo shows training of pruning techniques by BGF's extension agents, called Agro-forestry Agents (AAs), and a farmer group.

In partnership with the KenGen Foundation and Bamburi Cement Ltd, BGF executes a school supporting programme called the Green Initiative Challenge in the Seven Forks area, that is reaching out to hundreds of thousands of school children, to teach them how to plant trees in their schools. This picture shows the children of Wikithuki Primary School in Kitui county, that were awarded the first place in the Challenge in 2019, for planting a beautiful woodlot in a quite harsh environment



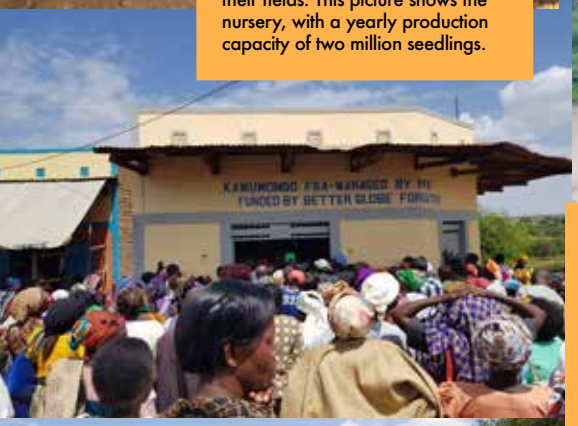
Since the beginning of 2009 BGF publishes “Miti” magazine, on a quarterly basis, as a service to the environmental fraternity. This is now 10 years back, and the magazine keeps consistently appearing, with ever better articles and photos. Apart from a few exceptions, all photos are from East Africa. The articles are written by voluntary collaborators from Kenya, Uganda and Tanzania, who are specialists in their field. The magazine is a unique depository of forestry know-how, and internationally used as a reliable reference in various articles and books related to East African forestry. It is only available on subscription basis.

BGF has a substantial operation in northern Uganda, Dokolo district, with thousands of farmers planting giant lira (*Melia azedarach*) in their fields. This picture shows the nursery, with a yearly production capacity of two million seedlings.



BGF's AAs team is a strongly trained task force, very mobile and rural based, constantly in touch with farmers in their operating area, which is in Seven Forks alongside Tana River in Machakos, Embu and Kitui counties.

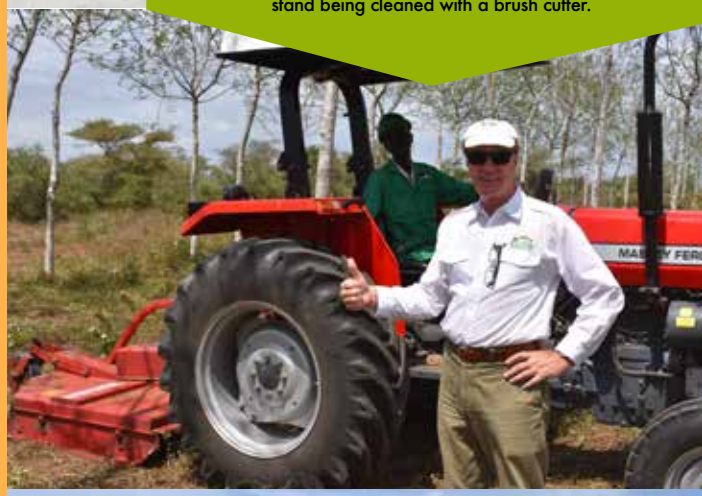
In Nyongoro, all pitting is done by mechanical drills, mounted on tractors.



BGF provides micro-credit to farmers, as part of its Corporate Social Responsibility Programme. Through its partner K-Rep Fedha Services Ltd, it has several Financial Services Associations, commonly called Village Banks, in the Kenyan country side. In Dokolo district, Uganda, BGF supports the farmers organisation YICAFA, through a Revolving Fund that is yearly reviewed.

The industrial plantations are located at the Kenyan coast, in Lamu county, and in the Seven Forks area, up-country. At the coast, the plantation is in Nyongoro ranch, with operations that are strongly mechanized. This photo shows Rino Solberg, Chairman of Better Globe Forestry, in a stand being cleaned with a brush cutter.

BGF practices year-round planting in Nyongoro, including during the dry season, for which the seedlings have to be watered. This is also mechanised, with sprayers mounted on a bowser as can be seen on this photo.



View of stand of mukau trees (*Melia volkensii*) in Kiambere plantation, in the Seven Forks area.

Seedlings are being transported to farmers in hundreds of crates, a complex logistical operation, that has to be timely and executed in a prudent manner, so as not to damage the plants (Dokolo nursery).

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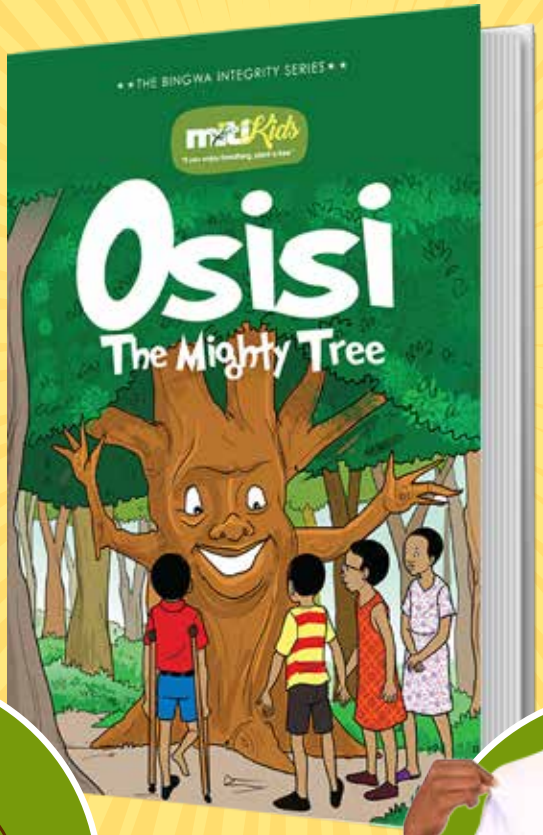

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Osisi the Mighty Tree is the flagship edition of the *Miti Kids* Nature Series. It is a powerful book with inspiring stories for the African child.

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