Potential for Biomass Perennial Grass as Alternative to Fuel wood in Niger Delta Region of Nigeria

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Abstract - Fuel wood consumption remains a principal contributor to the rate of deforestation in Africa. In general, the level of dependence on wood fuels by African countries ranges between 61% to 86% of the primary energy demand and 74% to 97% of the domestic energy needs. It is estimated that over 92% of the total wood harvested in Africa goes for energy purposes. Nigeria consumes over 50 million metric tonnes of fuel wood annually based on the report of Energy Commission of Nigeria. It was noted that 70% of the population of Nigeria uses biomass fuel wood for cooking. The current pattern of use however, raises concern on both local and global environment coupled with contributions to greenhouse effects. At this rate of deforestation, replenishment through afforestation programmes suffers defeat and is capable of causing desertification in the arid zones and erosion in the Southern areas of the country. In addition, the current situation of subsidy removal on petroleum products in Nigerian poses serious economic challenges especially to none and low income earners. This paper examines the potential for biomass perennial grass utilization as alternative to fuel wood in the Niger Delta region (South-South) of Nigeria. Key parameters adopted for evaluation as performance indicators are environmental sustainability of the perennial grass species and distribution within the study area, land use pattern/availability, biomass resources and utilization. Of considerable importance is the desire to reduce deforestation, loss in biodiversity resources, increase energy security and reduced habitat encroachment as against the United Nations (UN) Millennium Development Goal (MDG) of sustainable environmental development.

Keywords - biomass, perennial grass, fuel wood, alternative energy, greenhouse gases

1 INTRODUCTION

Nigeria is heavily dependent on fuel woods which in many cases are fetched from faraway farms and bushes. Sambo (2009) noted that 60% of Nigerians in the rural areas depend on fuel wood for their domestic fuel. Initially, it is harvested from within farms and was enough to meet the basic energy need for a given household. In contemporary times, increase in population has placed a huge burden on fuel wood and is now forcing the growing population to engage in deforestation.

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Given the global and regional concerns on the potential of energy resources on climate change, in particular on the poor, there are concerted efforts by the Nigerian government to address the complex problems of energy poverty and climate change. Significantly, emphasis is now directed at renewable energy resources.

As shown in Table 1, Nigeria has the very high potential for large hydropower with generation capacity of 11,250MW, small hydropower capacity of 3,500MW, solar energy is 3.5 – 7.0kWh/m3/day, wind energy is 2 – 4m/s at 10m height and biomass is 144million tonnes/yr of which 43.3million tonnes of fuel wood is consumed for both commercial and households [11], [12].
Of these vast energy resources, non-renewable fossil energy still dominates the consumption chart in Nigeria coupled with its increasing costs which is going beyond the reach of low income earners. Renewable energy is more environmentally benign when compared to fuels of fossil origin. Nonetheless,

the initial cost of installing a solar, wind, hydro and geothermal power is still too expensive for people within the lower income bracket. Recently, there is an increasing awareness of renewable energy with emphasis on their potential to serve as alternative to fossil energy. Globally, the interest on renewable energy sources is as a result of increasing cost of petroleum products coupled with emissions of greenhouse gases which are now known to be responsible for global warming and subsequent climate changes [10], [13], [18], [39]. In Nigeria, there is considerable deployment of hydro, solar and wind powered electricity which is hardly sufficient to meet the primary energy demand. The oldest and most common energy source within the rest African countries is biomass fuel wood which is mostly burned directly for household cooking/heating and in small cottage industries [9].

Availability of biomass for energy production depends on a wide range of factors which may be indigenous to the environment. In this study, emphasis is given to the potential for utilization of perennial grass species as alternative and/or complementary source of energy in the South-South Niger Delta. The metrics for evaluation includes; diversity of the perennial grass species, land resources, suitability of the soil and climatic conditions in favourable to the various species, availability of water and other resources for sustainable plant growth, competition for other uses of perennial grass species especially for food, feed and fibre. Other factors are the impacts on the local ecology, biodiversity and other environmental factors, efficiency of agricultural systems in terms of land, water and energy use, socio-economic and cultural preferences.

On grounds of sustainability, biodiversity, agricultural conservation, health, environment, carbon sequestration and greenhouse gas (GHG) emissions, continuous use of fuel wood as primary energy source projects a serious threat to forest reserves and a resultant climate change, desertification and erosion [5], [19], [21]. Notwithstanding the domestic use of fuel wood for cooking and heating, the demand still remains very high. In efforts to find a substitute to fuel wood, several research studies show the potential of using perennial grass as fuel in North America and Europe [1], [6], [16], [22]. Perennial grass species are of diverse species and the growths are dependent on soil types and climatic condition of the environment [26], [34], [43]. In Africa, there is limited literature on the use of perennial grass as alternatives to fuel wood. More so, there is sufficient literature suggesting that energy from perennial grass species has lower CO_2 emissions when compared to other fuels of fossil origin (coal and crude oil). The works of Semere and Slater (2007) as well as Shengzuo *et al. (*2011) are typical. Perennial grass is a clean source of energy and reduces atmospheric CO_2 through photosynthetic sequestration and secondly, it becomes cleaner when processed and combusted by using improved gasification technology [25], [27], [33], [38]. These perennial grass species have approximate life span of twenty five years and more. In other words, they grow naturally as long as there is favourable soil and climatic conditions with moderate rainfall requirement [37]. In a related manner, Odia (2006) identified a number of highly regenerative grasses, weeds and leaves as an alternative source of renewable energy. They are renewable and capable of mitigating the effects of climate change [8], [35]. Considering the growing population of Nigeria and the rest of Africa, biomass perennial grass species offers a matrix for effective utilization of land resources, better erosion control, increase in biodiversity and realization of earnings through carbon credits.

An earlier study by Ibrahim, Ukwenya, and Eboka-Eloka (2012) on the consumption pattern of fuel wood in selected rural areas of Benue State in the middle belt (North-Central) Nigeria discovered that the rural populace rely more on fuel wood than any other source of energy. This is mainly due to its availability, and accessibility. Estimated daily average of fuel wood consumption per household was between 9 – 20 kg with considerable number of the population living below the poverty margin in line with the United Nations standards. The study analysis shows that the correlation coefficient between household size and quantity of fuel wood consumed was 0.914. This figure is statistically significant at 5 % probability level with a strong positive correlation of near unity [42]. This scenario is not somewhat different with the situation in the Niger Delta region and indeed the entire domestic Nigerian household. The implication therefore, is an imminent danger to the Nigerian vegetation and forest reserves.

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2. NIGERIA ENERGY RESOURCE

Table 1 shows the current energy resources in Nigeria. The energy resources in Nigeria include: crude oil, natural gas, coal, tar sand and renewable (biomass, hydro, solar, wind and others) [2]. The crops grown which are also energy-based include: cassava, yam, cocoyam and sweet potato. Tree crops like cocoa, oil palm, rubber and timber constitute the main commercial products. Cocoa grows mostly in the southwest; oil palm is predominantly in the southeast and south-south. The main export in Nigeria before the discovery of crude oil in 1956 was cocoa, groundnut, cotton, oil palm and rubber. After the discovery of crude oil, there was significant reduction in the cultivation of these crops due to the reliance on revenues from oil which has continued to spell doom for the country Presently, Nigeria is the fourth highest producer of cocoa and the highest producer of cassava in the world [32].

Table 1: Nigeria Energy Resource

S/No.	Resources Type	Reserves (Natural Units)	Production/Consumption		
1.	Crude oil	35 Billion barrels	0.73 Billion barrels/yr		
2.	Natural gas	187 Trillion SCF	2.4 TCF/yr		
3.	Coal & Lignite	2.175 Billion tonnes	Negligible		
4.	Tar Sands	31 Billion barrels of equivalent	Negligible		
5.	Large Hydropower	11,500MW	1,900MW		
6.	Small Hydropower	3,500MW	30MW		
7.	Solar Radiation	3.5 - 7.0 KWh/m^2/day	2MW		
8.	Wind	(2-4)m/s at 10m height	Negligible		
9.	Biomass	Fuel-wood	11 Million hectares of forest and wood land	Excess of 1.2m tonnes/day	1.2 million tonnes/yr
		Animal waste	211 Million assorted animals		
		Energy drops and Agric. Residue	72 hectares of Agric. Land		
10.	Nuclear				

Source: Energy Commission of Nigeria (1992); Edirin and Nosa (2012).

2.1 Biomass Resources

Biomass resources available in the country include: agricultural crops, agricultural crop residues, fuel wood and forestry residues, waste paper, sawdust and wood shavings, residues from food industries, energy crops, animal dung/poultry droppings, industrial effluent/municipal solid waste [3], [35], [40], [41]. Nigeria has a population of about 140 million and a growth rate of 3.3 % (Obioh & Fagbenle, 2009), total land area of 923,768 km^2 (comprising 910,768 km^2 of land and 13000 km^2 of water). Out of this, approximately 33 % (300,550 km^2) is arable, 3.1 % (28,235 km^2) is under permanent crop, 44 % is under permanent pasture, 12 % is under forest and woodland and approximately 0.3% (2,820 km^2) is under irrigation [2], [28], [32], [35]. These are huge resources uncommon in most countries of the world. Some biomass resources excluding perennial grasses and the estimated quantities in Nigeria are shown in Table 2.

Table 2: Biomass Resources and the estimated Quantities in Nigeria

Resources	Quantity (million tonnes)	Energy Value ('000 MJ)
Fuel wood	39.1	531.0
Agro-waste	11.244	147.7
Sawdust	1.8	31.433
Municipal Solid waste	4.075	-

Source: (Sambo, 2009).

2.2 Perennial Grass as Fuel

Conventionally, most solid biomass heating fuels include: woodchips, wood pellets, and agricultural residues came from forests and the forest products industry. Over the past 15 years, however, growing crops (both herbaceous and woody) specifically for energy has gained widespread appeal, and perennial grasses such as Switchgrass, Miscanthus, and Reed Canary grass presents an exciting new renewable energy options especially in countries within the European Union. In the Sub-Saharan countries of Africa, several perennial grass specials abound. Apart from its use for roofing and as feed for animals, most of it remains underutilized. In some remote communities of the south-south Niger Delta, perennial grasses are used as a solid fuel for direct cooking. In developed countries like the United Kingdom, perennial grasses have been used in co-fired coal power plants [6]. Again perennial grass species have also been deployed as choice feedstock for advanced bio-fuels and for production of cellulosic ethanol [8]. Despite focus on the generation of electricity and production of liquid fuels, perennial grasses can also be pressed into fuel pellets, briquettes, and cubes which can be used as heating fuel to replace or complement fuels made from wood fibres. [20], [23].

Fig. 1: Swithgrass, Miscanthus and Reed Canarygrass

In the late 1800s, grasses were widely used as a heating fuel in the prairie regions of the United States, an area with little forested land. Farmers in these areas relied on harvested straw and prairie grasses, or "prairie coal," which were often twisted into bundles and burned in simple stoves. Today, modern solid biomass heating systems are highly engineered, automated with clean-burning potentials. Like the existing wood pellet market in Europe and the developing market in the United States, grasses may soon be pelleted and delivered in bulk by a special tanker truck, pneumatically blown into storage systems, and automatically fed into the combustion system with no manual labour required [7].

2.3 Benefits of Using Grass for Energy

Perennial grasses have many benefits as bioenergy crops. They are readily available energy feed stock, an efficient and fast growing plants. Perennial grass species like other plants are solar energy collectors through natural photosynthesis. They are relatively easy to grow, harvest, and process. These species do not only sequester and store vast amounts of carbon in their root systems and soil, they conveniently occur globally in a wide range of geographies, climates, and soil types. Furthermore, perennial grass species can be grown on marginal lands ill-suited for continuous row crop production and/or in open rural land currently not in agricultural production [7]. The yield per acre is more when compared to fuel wood and once established, it requires far fewer inputs in comparison to annual crops in terms of diesel, fertilizer, and pesticides. In addition, perennial grasses grown for energy can provide new revenue streams and opportunity for income generation to farmers and other landowners. Other advantages of perennial grass species include: reduction in soil erosion, increase in residue cover, increase in water infiltration, increase in soil organic carbon and improves water quality through reduction in nutrient losses, pesticides and sediments. In the same way, perennial grass species and other agriculturally produced crops can be grown easily (with conventional equipment), quickly, and in large acreages and volumes [23]. This can help increase the production of biomass fuels through the use of local resources. Soil erosion, water quality, and wildlife benefits can also be enhanced depending on what type of land and current crop cover that is converted to energy crops.

Energy studies indicate that significant gains in energy return and reducing carbon emissions can be achieved with using perennial grass species [6]. Switchgrass used for heating has an energy output to input ratio of at least 10 to 1, compared to other bioenergy sources with output to input ratio of 1:1 [7], [6]. Similarly, it was reported that one acre of farmland is capable of producing an average annual yield of herbaceous biomass sufficient to meet the annual space and water heating needs of an average home [20]. A shift from fuel wood to perennial grass species promises a robust prospect for communities to produce domestic size energy for cooking and heating. The most promising areas for development of a grass-based energy industry are the Niger Delta region of Nigeria which has great potential for flora from where the Nigerian oil deposit are drained from with little or no remediation impacted land and aquatic resources. On the contrary, unutilised flora is capable of constituting threat to the aquatic environment which may result from eutrophication.

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2.4 Conversion of Perennial Grass to Fuel

There are many different routes for converting biomass to bio-energy and industrial products, involving various biological, chemical, and thermal processes as depicted in Figure 2. The conversion can either result in final products, or may provide building blocks for further processing. The routes are not always mutually exclusive, as there are some combinations of processes that can be considered as well.

Furthermore, there are often multiple energy and non-energy products or services from a particular conversion route, some of which may or may not have reached commercial levels of supply and demand. In the Niger Delta region, thermal conversion is favoured through combustion. However, for environmental sustainability, thermal gasification operated cook stove exists [27].

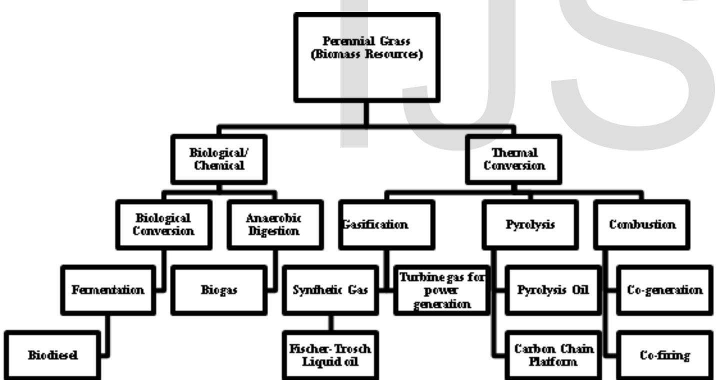

Fig. 2: Biomass (Perennial Grass) Conversion Pathways
Source: UNIDO, 2007

3.0 Agriculture and Socio-Economy

The agricultural sector has been critical to the development of perennial grass biomass in the Niger Delta region and remains the dominant sector in the rural areas. It provides employment for over 60% of the population [24], [31]. It is the main source of food for the majority of the population. The agricultural sector did very well after independence and was the main stay of the economy. The country was one of the world's highest producers of palm oil, cocoa, and groundnut [24], [30]. Up till the mid-1960s, Nigeria controlled more than 1 percent of world agricultural exports, it supplied more than half of world palm kernel, one third of groundnuts and about one fifth of oil palm [30]. However the sector has witnessed drastic decline and currently Nigeria's world market share for agricultural products is less than 0.1% [31].

3.1 Agricultural Land Resources

Land is very important for agriculture, it has been estimated that less than 50% of the cultivatable land is under cultivated at any point in time and according to Manyong *et al*. (2005); Olomola (2007), only about 40% has not been cultivated. The distribution of land is highly skewed, the majority of farmers cultivate less than 2 hectares, a few (less than 10 percent) have land holdings of between 2 and 10 hectares. The land use decree of 1978 vested the ownership of land in the hands of government in trust for the people [24]. According to FAO (2003) records, total land area of Nigeria is 91,077,000 hectares, while the total arable land as at 2003 was 30,500,000 hectares.

However this does not mean that the whole of this 91,077,000 is suitable for agriculture, in other words not all of the land is arable. Arable land is an agricultural term meaning land that can be used for growing crops. It refers to land that is suitable for producing crops. Table 3 is the distribution of land use in Nigeria. Studies on Nigeria further shows that at every particular point in time only 50% according to Manyong et al. (2005) and 40% (according to Olomola (2007) of cultivable land is under cultivation. If we sum up the two figures 50% and 40% and take the average, it implies that at every point in time only 45% of arable land (land suitable for agriculture) is utilized leaving 55% of arable land unutilized. Agricultural land is currently grossly underutilized and the production of biomass could actually go on without competing with food for land; this finding concurs with the report of Mathew (2007).

Table 3: Land Use in Nigeria

Land Use	Unit	1979 -81	1989 -91	1999 - 2001	2002	2003

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Total Land	1000 ha	91.077	91,077	91,077	91,077	91,077
Arable Land	1000 ha	27,827	29,564	28,300	30,200	30,500

Source: FAO (2003).

3.1 Perennial Grass Diversity in Niger Delta

Biomass perennial grass fuel is suitable for both household and industrial utilization. Similarly, a shift from fuel wood to perennial grass not only deploys the vast biomass resource but also of significant importance in the development of the Niger Delta region. In this case, dried grasses will be prepared and processed into pellets of predetermined sizes to fit into recommended burners for cooking in rural/urban areas of the Niger Delta and across other states of the federation and neighbouring countries of Africa.

Fig. 3: Map of Niger Delta
Source: Federal Ministry of Lands and Survey (2012)

Fig 3 shows the distribution of biomass perennial grass in the Niger Delta area map, south-south of Nigeria. The distribution of perennial grasses in the region is quite enormous. Identified species of considerable importance are: *Pennisetum purpureum* Shumach., *Echinochloa pyramidalis* Hitchc. & Chase, *Echinochloa stagnina* Beauv., *Leersia hexandra* Sw., *Oryza longistaminata* A. Chev. & Roehr. Others include; *Paspalum scrobiculatum* Linn., *Sacciolepis africana* Hubb. & Snowden, *Vossia cuspidate* Griff., *Andropogon gayanus* Kunth var. gayanus, *Andropogon tectorum* Schum. & Thonn., *Anthephora ampullaceal* Stapf & C. E. Hubbard, *Axonopus compressus* (Sw.) P. Beauv., *Brachiaria falcifera* (Trin.) Stapf, *Chrysopogon aciculatus* (Retz.) Trin., *Cymbopogon giganteus* Chiov., *Cynodon dactylon* (Linn.) Pers. The list also extends to *Eragrostis atrovirens* (Desf.) Trin. ex Steud., *Heteropogon contortus* Roem. & Schult., *Hyperthelia dissolute* (Nees ex Steud.) W. D. Clayton, *Imperata cylindrical* (Linn.) Raeuschel var. africana (Anderss) C.E. Hubbard, *Loudetia arundinacea* (Hochst. ex. A. Rich.) Steud., *Panicum maximum* Jacq., *Panicum repens* Linn., *Paspalum conjugatum* Berg., *Paspalum scrobiculatum* Linn and *Setaria megaphylla* (Steud.) Dur. & Schinz [4]. These grasses are by no means in exhaustive in the POACEAE family. Further studies will be focused on unearthing the calorific values, heat retention, content and other properties necessary for higher energy performance of perennial grass species. The potentials of these floras is capable of driving Nigeria's fuel economy and moving from fuel wood to grass fuel and overall, biomass to wealth instead of the much orchestrated militancy in the area.

4.0 CONCLUSION

In the face of the prevailing pressure on vegetation, perennial grass species as alternative to fuel-wood makes economic and at the same time, renewable energy sense. Apart from the fact that it saves cost in comparison with petroleum products and reduces burden on vegetation, perennial grasses are renewable. They grow simply by using sunlight and CO_2 captured through photosynthetic processes. The process of burning biomass merely recycles the CO_2 stored by the plant. Other biomass fuel and feedstock are agricultural residues such as corn, wheat and rice straw, forest residues, waste wood (sawdust) and deforested woods. Away from the aforementioned, perennial grasses are renewable and readily available in Nigeria and in the Niger Delta. In fact, they currently constitute wastes and nuisances to the ecology; farmers spend fortunes to get rid of them especially as weeds on arable lands and block water ways.

The agricultural sector has been critical to the development of perennial grass biomass in the Niger Delta region and remains the dominant sector in the rural areas. Apart from projected employment which may arise from the cultivation of perennial grass species, there will be increase in energy mix in the south-south Niger Delta and in Nigeria at large

Finally, there is no doubt that there is high potential for perennial grass resource as alternative fuel capable of boosting energy security in Niger Delta and Nigeria. On the question of competition for land which would have hitherto been used for food production, several reports affirm that existing cultivatable arable land in Nigeria was/and currently being underutilized and therefore exist sufficient land to accommodate both the production of biomass perennial grass and food crops.

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