Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: **www.environmentaljournal.org**
2013 Volume 3, Issue 4: 441-446

Open Access **Research Article**

Energy Economic Value and Climate Change Adaptation Potentials of *Gliricidia Sepium*

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Abstract:

This work reports the evaluation of calorific energy content, the agro-biological morphology of gliricida sepium in a derived forest in Ado Ekiti South-western Nigeria and its CO_2 absorption capacity. The wood biomass density was found to be 620.15 kg/m^3, the calorific energy content 16.67 MJ.kg which was similar to that of green oak wood. A One Tonne Gliricidia Tree has the capacity to sequestrate 3.0 Tonnes of CO_2 and by extension, one Ha of gliricidia can sequestrate 146.8 Tonnes of CO_2. 20 trees having average of 25 branches can sustain yam staking in a one hectare farmland. The report concluded that gliricidia has the potential to resolve the perennial cooking energy and environmental protection management conflict in the rural Sub-tropical Africa. It is capable of alleviating the stress associated with fuel wood sourcing and the poverty level among the rural dwellers of Africa particularly women and children.

Keywords: *Climate Change, fuel wood, Gliricidia sepium, Low income countries,*

Introduction

Climate Change became a global discussion issue in the last 50 years when its effects in terms of natural phenomena were becoming more pronounced, more frequent, advancing too to the extreme, and their threat to lives and properties became higher (Barker et al., 2007; Brooks et al., 2011). The earth became noticeably warmer after the industrial revolution as a result of increased CO_2 emission into the atmosphere from numerous production processes and increased energy consumption (Babera and McConnell, 1990; World Bank, 2010). The natural carbon sink i.e. the forest cover was under progressive destruction in support of industrial growth. As a result of which the carbon sequestration capacity of the forest is grossly compromised. The net CO_2 accumulation began to increase alarmingly. This led to an increase in global temperature by about 2.0 ^oC over a period of 100 years (Johnson and Coburn, 2010). This figure may further be increased by 2.0 come year 2050 under the current business as usual scenario (Calvin et al., 2010 and Hayashi, 2011). The United Nations and its agencies, International Organizations, Many concerned nations, NGOs and individuals have been making concerted efforts to establish a universal agreement on CO_2 emission. The meetings of Bali, Montreal, Rio de Janeiro, Copenhagen and Durban did very little to change the trend (World Bank, 2010) and the latest Doha summit achieved but a little and managed to postpone the evil days till 2020. Whereas, in the last 25 years, industrial growth and productivity in Asian fast developing economies like China, India, Malaysia, Indonesia, Singapore, Hong Kong and Taiwan have more than doubled, while energy consumption and by extension, CO_2 emission followed a similar trend. Uncertainties hover around the hope of 2020 date, because Climate Change topics are discussed on the premise of the age-old economic divides and rivalry, ego-centric political ideologies, international conspiracy and suspicion (Barret and Stavin, 2003; Bates et al., 2008). (Barke et al., 2009) and World Bank (2010) projected that climate change effects will be more felt by the poor and least developed nations in Asia, Middle East and Africa. These countries operate very fragile economic systems shrouded in the clouds of political instability, inconsistent environmental policies and weak infrastructure that will put up very lean or no resistance to the least climate change effects.

Trees and green vegetation remained the largest natural CO_2 sink (UNFCCC, 2011). Tree planting programmes had been mounted for a long time. But there is little result recorded in Nigeria in particular because there is a conflict of interest between cooking energy need and environmental conservation. Secondly, the target of most tree planting programmes had been to sustain timber and wood industry; focus was basically on economic trees with little or no attention to fuel wood. The poor local people whose cooking energy need depends on forest wood is not adequately catered for in the tree planting programme. Whereas fuel wood according to Kumar et al., (2009) accounted for over 90 per cent of the total energy consumption in most developing countries of the world. In Nigeria for instance, the pump price of kerosene (albeit 'fuel for the poor') was upwardly reviewed more than 8 times in the last 4 years. The current official price of N56 (0.4 US Dollar) per litre is simply virtual because most people buy the product at 120-150 per litre not without struggle and queuing for several hours under scourging sunshine. This price, according to (Guardian, 2012a) is about 3000 per cent of the price of the same commodity in 2004. An average Nigerian who, according to Guardian, (2012b) lives on less than 1:00 US Dollar daily may not be able to afford such a staggering price. The tree planting programme sponsored by EEC/FGN to arrest desert encroachment in the Sahel regions of Northern Nigeria had been constantly and consistently bastardized by the local people in search of cooking energy means not as a deliberate act but as a desperate survival action. Fuel wood sourced from sustainable plantation is regarded as carbon-neutral because it only releases an equivalent amount of CO_2 it had absorbed while living. Wood burning does not add to the CO_2 in any way because burning releases the equivalent of CO_2 which it would have released is left to decompose naturally (Wikipedia, 2012). Gliricidia has the capacity to resolve the conflict of rural cooking energy demand and environmental protection considering its morphological and agro-biological advantages which give it the strength to regenerate rapidly and capture vast area of wasteland even when environmental condition is not all that favourable (Seibert, 1987). Its rapid growth and explosive mechanism of seed dispersal also give this plant the power to smother noxious weeds like pear grass, titonia and chromolina (Simons and Dunsdon. 1996). The preference it enjoys from yam farmers as staking wood, the high seed viability after a long period of dormancy also account for its vigorous performance.

Gliricidia sepium is a leguminous flowering plant native to the Amazonia region of Latin America (Seibert, 1987). It was introduced to Nigeria during the colonial era principally as a fodder plant. It could be propagated from seed. Stem and root cutting. It can reach a height of 15 meters at maturity which takes about 2-3 years (Pertchick and Pertchick, 2000). It thrives under tropical climate and well drained soil. But it can tolerate adverse weather and harsh soil conditions as well (Rico-Gray et al. 2003). It is adjudged one of the most widely cultivated multi-purpose agro-forestry plants (Simons and Dunsdon, 1996). The seed produced in a pod is dry dehiscent which is dispersed by explosive mechanism. The seed is highly tolerant, observed to be up to 90 per cent viable after 9 months of exposure to adverse conditions. In South-western Nigerian, the long slender and very strong branches of gliricidia is used as major staking material for yam, pumpkin and other climbing crops. For its regeneration capacity, the plant is often used hut posts, living fence and hedgerow to partition paddock. The stake often regenerate and continue to grow after the harvest and as such accelerates both soil recovery and forest regeneration and shortens the length of fallow period.

One of the shortcomings of gliricidia is the poor or non-existence of the energy value of the dry wood as it is common for popular fuelwood. Red oak for instance has an energy content of 14.89 Mega Joules per kg (6,388 BTU per pound) and 10,423 Mega Joules recoverable if burned at 70 percent efficiency (Wikipedia, 2012). Gutteridge and Sheton, (1998); Yorwoods, (2008) estimated the average energy value of most fuel woods at 16.2 MJ/kg (4.5kWh/kg). Bioenergy Knowledge (2012) said energy content of wood is determined based on moisture content rather than the specie of the wood. Also that the drier the wood becomes the higher its total quantum of Joules stored. The scientific evaluation of energy value of gliricidia wood, the measurement of its physical and morphological qualities is necessary in order to assess its suitability for mitigating climate change effects as compared to other wood species.

2.0 Materials and Methods:

2.1 Materials:

The materials used for this evaluation were: 50 pieces of 30 cm long dry wood specimen of different cross sectional diameter sizes, digital moisture meter, muffle furnace (model 7SXL 1008), digital weighing balance, steel meter rule and Vanier calliper.

2.2 Method:

The moisture content (%) was measured with digital moisture meter, the length with meter rule, and the cross sectional diameter with Veneer Calliper. Specimen sample was burnt in the muffle furnace for two (2) hours. After which whitish ash residue was obtained. The wood ash was weighed while the mass of fixed carbon content and volatile matter were taken from the recording panel of the machine. The calorific energy content of a unit weight of the wood was estimated using the relation in equation (1) below:

$$CE = 2.86(1.46 \times FC + 14.4VM)/kg \quad ..(1)$$

Where; CE = Calorific energy (MJ/kg)
FC = Fixed carbon
VM = Volatile matter

The field work involved the estimation of the canopy size of 100 stands of gliricidia trees using right-angle projection survey method. The data obtained from both field and laboratory evaluations were recorded, analysed and compared with those of popular fuel woods available in literatures. The density of 4 samples combustible gliricidia wood of 30 cm long and diameter 76.1 cm and 5.18 cm weighing between 1.0 kg and 1.4 kg was determined and found to be 732.86, 1026, 332.16 and 389.68 kg/m^3 respectively. The average density was 620.15 kg/m^3.

3.0 Results and Discussion:

Table 1: Computation Result of Field Survey and evaluation of the Energy Content of Gliricidia

SN	R1 (cm)	R2 (cm)	Height (m)	Vol (m^3)	Biomass (kg) Root	Branches	Leaves	Wood	Total	Carbon content*
1	12	8	12	0.271	43.7	18.5	1.7	104.2	168.1	84.05
2	10	7	11	0.179	28.9	12.2	1.1	68.8	111.0	55.5
3	9	7	11	0.156	25.2	10.6	1.0	60.0	96.7	48.35
4	11	9	12	0.264	42.6	18.0	1.7	101.5	163.7	81.85
5	10	8	12	0.214	34.5	14.6	1.3	82.3	132.7	66.35
6	8	7	10	0.124	20.0	8.5	0.8	47.7	76.9	38.45
								Average	**124.85**	**62.43**

R_1, R_2 Radius of tree above root and at eye level (1.6 m) respectively, Vol = $1/3\pi (R_1^2 + R_2 + R_1 \times R_2)$ * Carbon content is required to compute the carbon tree equivalent (The carbon content of woody tree is 50 per cent of its biomass) NB. A one Tonne carbon tree lucks up 3.67 Tonnes of CO_2

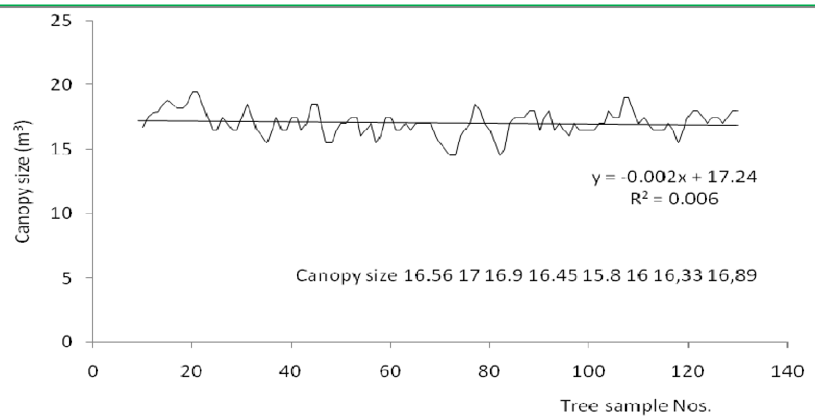

Fig. 1: Estimated canopy size of gliricidia tree (m^3)

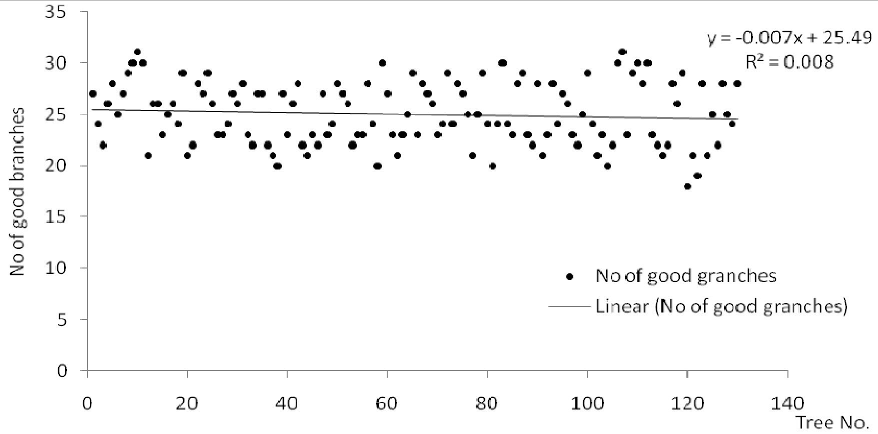

Fig 2: Average No of good granches on surved gliricidia trees

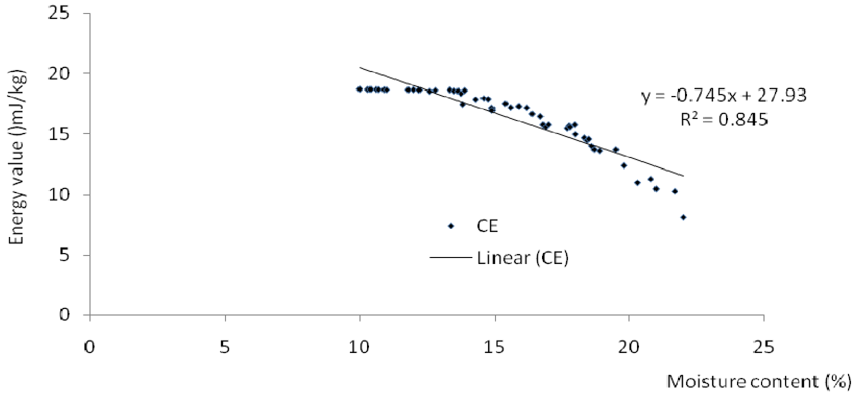

Fig 3: Energy content of gliricidia fuelwood with respect to moisture content

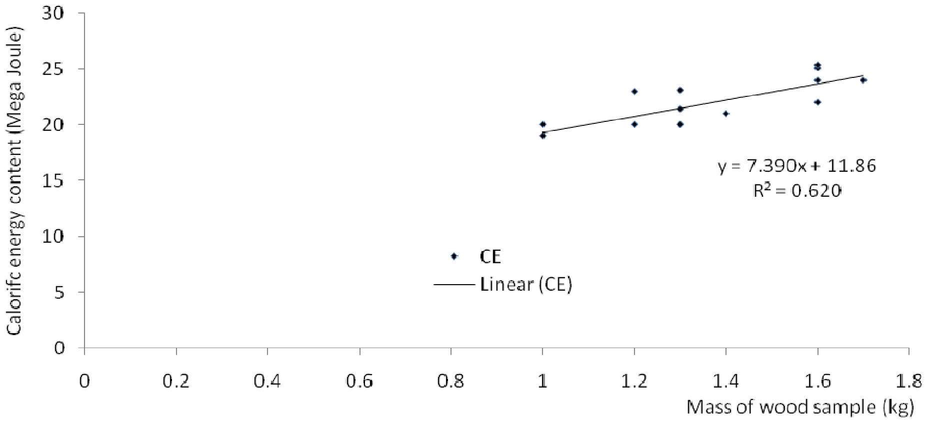

Fig 4: Energy content of dry gliricidia fuel wood (MJ/kg)

Fig 1 presents the average canopy size of randomly selected 130 trees samples for this survey. The size taken as the volume of a sphere ranged between 13 m^3 and 20 m^3 (presented as a model of straight line y = -0.002x + 17.24) and R mean square (R^2) of 0.006. This value is close to the value of 1 Tonne Tree which according to (Econometrica, 2010) can absorb 3.67 Tonnes of CO_2. The average number of good branches (above 2.5 m length and strong enough for staking yam) is about 25, shown by the graph model of fig 2 as y = -0.007x + 25.49. Y in this model represents number of good branches and x is 1 (tree). Ordinarily, one Hectare of yam will require about 500 stakes. This means 20 gliricidia trees will suffice for one hectare of yam farm. This number can be planted at the edge of the farm or within the farm itself without compromising the healthy performance of the farm and the plant.

Fig. 3 shows the graph of energy content of gliricidia as a function of moisture content of the wood. The maximum energy content obtained from the experiment was 18.73 MJ at 10 per cent moisture content. While the average represented by the model y = -0.745x + 27.93 and R^2 of 0.845. This confirms the statements of (Bioenergy Knowledge, 2012) of the dependence of energy value of fuel wood on its moisture content. The energy value rate became almost constant as the moisture reduced to 12 per cent and further to 10 per cent. When the moisture content was higher than 22 per cent the output of the experiment instrument became unstable. This could be as a result of the limitation of the equipment.

Fig. 4 presents the average value of calorific energy per unit mass (kg). The model of the graph was y = 7.39x + 11.86 and R^2 of 0.62. This means that the average energy value of gliricidia fuel wood 16.67 MJ/kg. This value is a little higher than that of red oak of 14.89 MJ/kg and almost tallies with the average value of most wood species of 16.2 MJ/kg. Table 1 shows the average value of biomass of four randomly selected mature gliricidia trees was found to be 124.85 kg and the corresponding amount of CO_2 this carbon tree could hold is 0.3 Tonnes. If this value is weighted to the tune of multiple of 10 i.e. (124.85 x 10 = 1248.50 kg = 3.0 Tonne. An average gliricidia tree is capable of holding 0.367 Tonne (i.e. 3.67 Tonne divided by 10). At a plant population of 400 plants per hectare, the amount of CO_2 that could be sequestrated in a gliricidia plantation was estimated at 146.8 Tonnes per hectare. Gliricidia could therefore be used in the REDD programme where developing countries can participate in the carbon market to earn carbon fund while at the same time enjoy domestic energy supply in terms of cooking fuel wood.

4.0 Conclusion

Gliricidia planted at average plant population of 400 per Ha, 146.8 Tonnes per hectare which makes gliricidia a formidable material for carbon sequestration programme and could therefore be a good alternative in REDD programme. The agro-forestry view of this plant shows that it could be a sustainable source of fuel wood that will not undermine the goals of tree planting programmes in Nigeria or elsewhere. The energy content showed that gliricidia is comparative to most popular fuel woods and therefore is a ready source of cooking energy that is capable of alleviating the problems of poor people around the world. The fact that the seed could remain viable even when exposed to adverse conditions makes propagation of the plant easy, perhaps by aerial broadcasting. The wastelands in the middle belt and the fringe of the Sudan savannah could be secured against desert encroachment.

4.1 Recommendation

Further investigation of the energy content at moisture content higher than 22 per cent will be of advantage to researchers who may be interested in burning this wood under very humid conditions in the tropical countries located close to the equator. Agronomic propagation of this plant under extreme weather prevalent in the Sahel and desert may be worthwhile in the effort to make those areas productive and in getting the place prepared for the eventual arrival of these adverse conditions in the business as usual scenario. Since, gliricidia is highly prolific and tolerant, adopting this tree in the tree planting programme for climate change mitigation will be a low hanging fruit for every Climate Change stake holder.

References:

1) Babera, A. I and V. D. McConnell. 1996. The Impact of Environmental Regulation on Industrial Productivity; Direct and Indirect Effects. Journal of Environmental Economic Management. 18 (1) 50-65
2) Barke, M., D. B. Lobell and L. Guarino. 2009. Shift in Africa Crop Climates by 2050 and the Implications for Crop Improvement and Genetic Resource Conservation. Global Environmental Change 19 (3) p317-325
3) Barker, T., I Bashmaker, A. Alharthi, M. Amann, I. Cituentes, J. Drexhage, M. Duan, O. Edenhofer, B. Flannery, M. Grubb, M. Hoogwijk, F. I. Ibitoye, C. J. Jepma, W. A. Pizer and K. Yamaji. 2007. Mitigation from a Cross Sectorial Perspective. Climate Change 2007 Mitigation Contributions of Working Group III to the 4th Assessment Report of IPCC. Cambridge University Press UK
4) Barret, S. and R. Stavin. 2003. Increasing Participant and Compliance in International Climate Change Agreements. International Agreement Politics, Law and Economics 3 (4) 349-76
5) Bates, B., Z. W. Kundzewicz, S. Wu and J. Palutikov. 2008. Climate Change and Water.

Technical Paper, International Panel on Climate Change (IPCC) Geneva p5
6) Bioenergy Knowledge. 2012. Calculating the Energy Content of Wood Taking into Account the Moisture Content. www.biomassenergycentre.org p6. Retrieved 19/11/2012
7) Brooks, N., Anderson, S. Ayers, J. Burton, I and Tellam, I. 2011. Tracking adaptation and Measurement. Climate Change Working Paper No. 1. IIED, UK . www.iied.org Retreived 12/10/2012
8) Calvin, K., J. Edmonds, B. Bond-Lamberty, L. Clerke, P. Kyle, S. Smith, A. Thomasson and M. Wise. 2010. Forthcoming. Limiting Climate Change to 450ppm CO_2 Equivalent in the 21^{st} Century. Energy Economics.
9) ECONOMTRICA, 2011. A One Tonne Carbon Tree. www.thepaperstory.co.za/2011. Retrieved 03/06/2011
10) Guardian, 2012a. Perennial reoccurrence of fuel scarcity; the plight of the rural poor. Guardian Newspaper of Nigeria PLC. Lagos issue of 10/12 p34
11) … 2012b. Rural infrastructure and economic development. Guardian Newspaper of Nigeria PLC. Lagos issue of 17/12 p31
12) Gutteridge, R. C. and Sheton, H. M. 1998. Forage Tree Legumes in Tropical Agriculture. Tropical Grassland Society of Australia Inc. Australia. P 56
13) Hayashi, D., A. Michaelowa, B. Dresfield, M. Niemann, M. A. Marr, N. Muller, S. Wehner and M. Krey. 2011. PoA Guidebook for PoA Coordinator under CDM/JI. 2 Revised Edition. KFW Banfengruppe Germany p1-5
14) Johnson I. and R. Coburn. 2010. Trees for Carbon Sequestration. Primefacts for Profitable, Adaptive and Sustainable Primary Industries. www.industry.nsm.gov.au/pdf p5-6. Retrieved 5/12/2012
15) Pertchik B and H. Pertchik. 2002. Flowering Trees of the Caribbean. Rhinehart and Co. New York p125
16) Rico Gray, V., A. Chema, and S. Man du Jano. 2003. Uses of Tropical Deciduous Forest Species. Yucatan Agroforestry Systems. Yucatan. P149-150
17) Seibert, B. 1987. Management of Cocoa Plantation under Gliricidia. NFFA Special Ed of Proceeding of CATIE Workshop Costa Rica Special ed. 87-01 p102-110.
18) Simon, A. J. and A. Dunsdon. 1996. Evaluation of the Potential of the Genetic Improvement of Gliricidia sepium. Report of ODA in Forestry Research Project. Oxford Forest Institute p176.
19) UNFCCC, 2011. Fact Sheet: Reducing Emission from Deforestation in Developing Countries, Approach to Stimulate Actions. http://climate-iisd.org/news/unfccc.publishes.de Retrieved 9/01/2013
20) Wikipedia, 2010. Wood Fuel. http://en.wikipedia.org/wiki/wood_fuel. Retrieved 19/11/2012
21) World Bank, 2010. Development and Climate Change. World Development Report. The World Bank Washington D. C. p23-30
22) Yorkwoods, 2008. Woodfuel Facts and Figures. www.yorwoods.org.uk p. 3-4 Retrieved 15/11/2012