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Estimating the Extent of Influence of two Intrinsic Fuelwood Properties on Acceptance/Retention of some Woody Species in Agroforestry Practices in Southwest Nigeria

Procjena veličine utjecaja dvaju bitnih svojstava ogrjevnog drva na primjenu nekih vrsta drva u agrošumarstvu jugozapadne Nigerije

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ABSTRACT • *Biofuel is presently still central to survival and sustenance of livelihoods in many parts of sub-Sahara African region. Demand for woodfuel in the form of firewood and charcoal is continuously increasing in this region, and it is therefore necessary to devise and sustain feasible production methods bearing in mind the influence of native intelligence, indigenous/traditional knowledge and/or users' perspectives on their success. In line with this, a survey was carried out by administering questionnaire to 240 respondents in 8 rural communities of Akinyele and Ido Local Government Areas of Oyo State, Nigeria, where the predominant type of agroforestry system practiced is that of scattered trees in croplands, to elicit information on wood species used as fuelwood and preferred by the respondents for incorporation into or retention in most agroforestry plots, out of which 179 (i.e. 75% of the total number of questionnaires administered) were successfully retrieved for statistical analyses. Twelve woody species were selected on the basis of respondents' preference and prioritization. The mean specific gravity (SG) and net calorific values (NCV) of the species were found to range between 0.42-0.84 g · cm^{-3} and 14.65-21.88 MJkg^{-1} respectively. The linear regression equation developed predicting cumulative numerical values (CNV) attached to each ranking position indicating respondents' preference using SG and NCV together as predictors gave a coefficient of determination (R^2) of 77.1% with an ANOVA result showing a significant relationship between CNV and SG. Predicting CNV using only SG as a predictor gave R^2 of 75.7% while that for using NCV alone as a predictor gave R^2 of 67.7% with ANOVA showing significant relationship between CNV and each predictor for both equations, respectively. Based on the outcome of the study, it was recommended that users' perspective, native intelligence and indigenous/traditional knowledge should be part of the criteria for selecting potential fuelwood species for incorporation into or retention in agroforestry systems in this study area and others with similar characteristics.*

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Keywords: *agroforestry, biomass, biofuel, fuelwood, net calorific value, species selectivity, specific gravity, prioritization, sub-Sahara Africa*

SAŽETAK • *Biogorivo je vrlo važno za opstojnost i održivost življenja u mnogim dijelovima regije uz afričku pustinju Sahara. Potražnja ogrjevnog drva i drvenog ugljena u toj je regiji u stalnom porastu. Prema tomu, nužno je istražiti, osmisliti i primijeniti moguće proizvodne metode uzimajući u obzir inteligenciju, dosadašnja iskustva i spoznaje te očekivanja i stajališta proizvođača biogoriva. U skladu s tim, provedeno je istraživanje primjenom ankete na uzorku od 240 ispitanika iz osam zajednica stanovnika Nigerije, gdje se najčešće prakticira sustav agrošumarstva s uzgojem stabala raštrkanih na poljoprivrednim zasadima. Cilj provednih istraživanja bio je anketiranjem dobiti informacije o vrstama drva koje se rabe za ogrjev i utvrditi koje vrste ispitanici preferiraju za uzgoj i zadržavanje na agrošumarskim zemljištima. Prikupljeno je 179 ispunjenih anketa (tj. 75 % ukupnog broja poslanih anketa) koje su zadovoljile uvjete za statitičku analizu. Dvanaest vrsta drva selektirano je na temelju odgovora i preferencija ispitanika.*

Srednja gustoća (SG) izabranih vrsta drva iznosi 0,42 – 0,84 $g \cdot cm^{-3}$, a neto kalorijska vrijednost (NCV) kreće se u rasponu 14,65 – 21,88 $MJ \cdot kg^{-1}$. Razvijena je višestruka regresijska jednadžba koja predviđa kumulativne numeričke vrijednosti (CNV) pridružene svakoj rang-poziciji vrste drva, a one pokazuju preferencije ispitanika. Kao veličine za predviđanje upotrijebljene su SG i NCV. Dobiven je koeficijent determinacije (R^2) 77,1 % i ANOVA rezultat koji pokazuje signifikantnu korelaciju (uz prag signifikantnosti $p<0,05$) između CNV i SG/NCV. Ako se za predviđanje CNV-a koristi samo veličina SG, dobije se koeficijent determinacije 75,7 %, a ako se za predviđanje primijeni veličina NCV, dobije se koeficijent determinacije od 67,7 %, a ANOVA test pokazuje signifikantu korelaciju između veličine CNV i veličina koje služe za predviđanje, SG i NCV. Na temelju rezultata provedenih istraživanja preporučuje se da stajališta korisnika, inteligencija i iskustvena tradicionalna znanja trebaju biti neki od kriterija pri odluci o izboru vrsta drva za ogrjev, koje će se inkorporirati i uzgajati na agrošumarskim zemljištima u uvjetima regija uz pustinju ili sličnima.

Ključne riječi: *agrošumarstvo, biomasa, biogorivo, ogrjevno drvo, neto kalorijska vrijednost, izbor vrste, gustoća, prioritet, subpustinjska Afrika*

1 INTRODUCTION
1. UVOD

The use of biomass energy, predominantly from wood, in many rural, peri-urban, and some urban areas of the developing countries particularly those of sub-Sahara Africa (SSA), is not only central to domestic and commercial cooking and heating including sustenance of livelihoods but is also increasing in quantity and intensity of use, with a trend that does not appear to have the possibility of reversing/or declining in the foreseeable future (Hall and deGroot, 1987; Leach, 1992; Barnes and Floor, 1996; FAO, 2001; 2007; Temu, 2002; Erakhrumen, 2005; 2007; 2008b).

Apart from the prevailing use of biomass in the developing countries for this purpose, developed countries, such as Austria, Finland, Germany, Sweden, and many others are also presently increasing the volume of these resources from this energy source in their energy mix, with projected high possibilities of future increases (FAO, 2007), the bulk of which is expected to be most likely sourced from the rural areas of the developing countries in the very near future (Johansson et al. 1993; Erakhrumen, 2007).

It is noteworthy that recent estimates showed that about 99.99% of fuelwood harvested in Africa is presently consumed locally (FAO, 2007). Owing to this trend of use in these and other developing countries and the likely future dependence of many developed countries on this part of the world for supply, there is present necessity for devising and improving more sustainable production methods of generating this resource, in the short and long term, for the inhabitants of this region and export to other parts of the world when the need arises, from sustainable sources.

Agroforestry systems, which is a collective name for land use practices and technologies where woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence (ICRAF, 1983), has been identified as a veritable source of wood for different purposes (ICRAF, 1991), one of which is fuelwood, in the different localities of SSA and other parts of the developing regions.

These systems, although, an age-long worldwide traditional practices, are currently being scientifically developed and continuously modified in many parts of the world thereby receiving more global attention and scientific recognition (Erakhrumen, 2008a.). Irrespective of these efforts, challenges still exist as regards the various methods of and/or rationale for selecting woody species for incorporation into and/or retention in these systems including extension strategies and services.

Agricultural extension for instance, has traditionally been based on a top-down model, where research scientists developed technological innovations that were then promulgated by extension agents that farmers were expected to adopt (Packham, 2001). This approach was based on a theoretical model of *diffusion of innovations* (Rogers, 1983), a model that has become limiting and contradictory, while also not explaining farmer behaviour, resulting in its being substantially rejected (Vanclay and Lawrence, 1994).

In the same vein, many of the agroforestry systems designs, e.g. taungya practices introduced to some parts of Nigeria were based on external perspectives that were not in tandem with local realities in the past as they did not meet the needs and aspirations of the local communities, thereby also leading to their rejection by farmers, and thus, resulting in failure of many of these systems (Mahlako, 1993; Kio, 2002).

In order to avoid similar situations, whereby local or indigenous knowledge were trivialised and marginalised in the past, thus ignoring the contributions farmers, for instance, might make to agricultural technology development (Packham, 2001) in the present and future designs, it will be necessary to incorporate the views and contributions of different stakeholders, particularly those in the rural areas, in terms of their generational experience, native intelligence, and/or indigenous/traditional knowledge into methods to be developed for selecting wood species for agroforestry systems (Erakhrumen and Ogunsanwo, 2005; Ogunsanwo and Erakhrumen, 2006; Erakhrumen, 2006; 2008a; 2008b; 2009).

Since it is only by participating in the development of an innovation with the farmer or farming community and other stakeholders that many challenges concerning agroforestry schemes can be holistically addressed, this study was therefore carried out to estimate the extent of influence of two intrinsic fuelwood properties i.e. specific gravity (SG) and energy value, (by evaluating the net calorific value, NCV) of wood on its acceptance for and/or retention in agroforestry systems based on native intelligence/indigenous knowledge, using wood samples from trees scattered in croplands, which is the predominant type of agroforestry system practiced in Akinyele and Ido Local Government Areas (LGAs) of Oyo State, Nigeria, as a case study.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

2.1 Study Area
2.1. Područje istraživanja

The wood samples for the experiment were obtained from trees sourced randomly from agroforestry plots in Akinyele and Ido LGAs of Oyo State, Southwest, Nigeria (Latitude 7°17′–7°26′N and Longitude 3°17′–3°30′E), where the predominant method of agroforestry system practiced is scattered trees in croplands (with most of the trees not planted by the farmers interviewed). This study area is located in between the humid and sub-humid tropical climate.

The mean annual rainfall ranges from 1117.1 and 1693.3 mm. The rainfall pattern has a characteristic bimodal distribution with peaks usually in June or July and September and the period of low precipitation in August with four months of dry season (December–March). The annual temperature ranges from an average minimum of 24.6 °C to average maximum of 31.5 °C. The mean monthly relative humidity reaches a minimum of 52 % in February and a maximum of 83 % in August (IITA, 1993; FRIN, 1999).

2.2 Questionnaire survey
2.2. Anketiranje

In order to prioritize the wood species in croplands in this study area and obtain those preferred by farmers in their croplands, a questionnaire was drawn for administration on this target group, in such a way as to utilize their indigenous knowledge/native intelligence for the prioritization of the species.

A random survey of respondents was done using questionnaire targeting two hundred and forty (240) respondents. One hundred and twenty (120) copies of a set of questionnaire were randomly administered in each LGA. This was achieved by partitioning each LGA into four (4) geographical zones i.e. North, West, South, and East based on the information obtained from each LGA headquarters with a village/community randomly selected to represent each zone in each LGA as follows: Akinyele LGA: North: Aba Isale Community, South: Papa Malu Community, West: Motosho Community, East: Bagadaje Community. Ido LGA: North: Odetola Community, South: Dagilogba Community, West: Tade Community, East: Patako Community.

Thirty (30) copies of the questionnaire were randomly administered on respondents in each geographical zone in order to ensure randomization, equitable distribution, and even spread of the questionnaire in the two LGAs. The questionnaire was drawn in such a way that the respondents listed all the woody species in his/her farm and prioritized them in terms of how preferable they are for agroforestry, from his/her perspective based on their experience of wood with high density and energy value. The respondents listed the woody species from 1 to 10 in order of preference with the species in position number 1 being the most preferred while the species in position number 10 being the least preferred out of the ten species in that order.

Numerical values of 1 to 10 were allocated to each position on the ranking. Numerical values were allocated to each position on the ranking in descending order i.e. numerical value 10 was allocated to position number 1 on the ranking while numerical value 1 was allocated to position number 10 on the ranking in that order.

Collating the numerical values allocated to each position occupied by each species on the ranking, it was found that twelve species had the highest cumulative values as against the ten species that were originally planned to be selected for laboratory analysis. These methods of questionnaire administration and allocation of values to ranking position of species had been extensively described by Erakhrumen, (2005).

The number of copies of questionnaires that was retrieved from Akinyele and Ido LGAs was 83 and 96, respectively, out of the 120 administered, totalling 179 owing to incomplete information in and non-retrieval of some of the questionnaire totalling sixty one (61).

The 179 copies of questionnaire served as the effective sample size used in the subsequent analyses.

2.3 Preparation of wood samples
2.3. Priprema uzoraka od drva

Four trees per each species tabulated in Table 1 were randomly located on agroforestry plots in the study area, where the predominant method of agroforestry system is the one of scattered trees in croplands. Wood samples were randomly obtained from tree stems at diameter at chest height (dch), that is 130 cm from the ground in such a way that the samples obtained represent all the wood types (sapwood, transition wood, and heartwood) by taking samples from different position radially across the bole at this position and thoroughly mixing them together to ensure randomization.

The ages of the trees were unknown owing to the fact that it was claimed by almost all the respondents in their response to the questionnaire that most of the trees were not planted by them in this study area. Samples were adequately coded for easy identification and taken to the laboratory for initial moisture content (MC), SG, and NCV determination.

Table 1: Prioritized wood species selected for their initial moisture content, specific gravity, and Net Calorific Value determination
Tablica 1. Prioritetna lista vrsta drva izabranih za određivanje početnog sadržaja vode, gustoće i neto kalorijske vrijednosti

Species scientific names *Latinski naziv vrste*	**Family** *Porodica*
Annona senegalensis Pers.	Annonaceae
Anogeissus leiocarpus (DC.) Guill. & Perr.	Combretaceae
Bridelia ferruginea Benth.	Euphorbiaceae
uto*Daniellia oliveri* (Rolfe) Hutch. & Dalziel	Caesalpiniaceae
Detarium microcarpum Guill. & Perr.	Caesalpiniaceae
Gardenia ternifolia Schumach. & Thonn.	Rubiaceae
Hymenocardia acida Tul.	Hymenocardiaceae
Lophira lanceolata Tiegh. ex Keay.	Ochnaceae
*Parkia biglobosa (*Jacq.) R. Br. ex G. Don.	Mimosaceae
Terminalia avicennioides Guill. & Perr.	Combretaceae
Triplochiton scleroxylon K.Schum.	Sterculiaceae
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae

2.4 Determination of Initial Moisture Content
2.4. Određivanje početnog sadržaja vode

One of the main factors affecting the value of wood for fuel is its moisture content (MC) (Forest Service, 1994). The amount of moisture in wood is termed as MC. It can be expressed as a percentage of either dry or wet weight. For most purposes, the MC of lumber is based on dry weight, but the MC of wood fuel is usually based on wet weight (FPL, 1999).

The properly coded wood samples were placed in a regulated oven at a temperature range of 95$\pm$3 °C until a constant weight was achieved. MC on wet weight basis was calculated in conformity with ASTM D 4442 (ASTM, 1984), using the equation:

Moisture Content (%) = (Fresh weight – Oven dry weight) (Fresh weight)$^{-1}$ x 100

2.5 Determination of Specific Gravity
2.5. Određivanje gustoće

SG was measured for ten (10) samples from each of the four trees per species of predetermined weight using the mercury displacement method i.e. ASTM D 2395 (ASTM, 1989) at mean ambient room temperature of 25$\pm$2 °C after oven drying the wood samples. 80 ml volume was used in a 100 ml beaker, which made it possible to measure the wood SG directly with or without bark as obtained.

2.6 Determination of Net Calorific Value
2.6. Određivanje neto kalorijske vrijednosti

The oven-dried wood samples of the twelve species were hammer milled differently to pass through a mesh of < 3.5 mm, pelleted, and one gram (1 g) of each sample was measured in succession using electric portable balance, placed in the steel capsule of the oxygen bomb calorimeter and completely burnt in excess oxygen to determine the NCV in ten (10) replications. The maximum temperature rise in the bomb calorimeter was measured with the aid of thermocouple and galvanometer systems and the values obtained were computed.

2.7 Statistical analyses
2.7. Statistička analiza

The SG and NCV obtained from all the species were subjected to basic descriptive statistical analyses such as mean, standard deviation, and standard error of mean. Linear regression analysis was employed in developing predictive equations. Graphical representation of initial MC was done using Microsoft Office Excel® 2003 while the statistical package used for the analyses was Minitab13® for Windows®.

3 RESULTS
3. REZULTATI

The twelve woody species that were at the top of the priority ranking of the respondents based on the cumulative numerical values (CNV) attached to each position on the ranking are tabulated in Table 1. Fig. 1 has the mean initial MC while Table 2 shows the mean values for SG and NCV, standard deviation and standard error of mean for the properties of twelve species. The initial MC of the samples for the study was determined on wet weight basis. The mean initial MC (as received) was calculated for all the samples from each species and was found to range approximately from 46.10 % for *Anogeissus leiocarpus* to 88.20 % for *Daniellia oliveri*.

Results of linear regression for equation predicting CNV from both SG and NCV together is tabulated

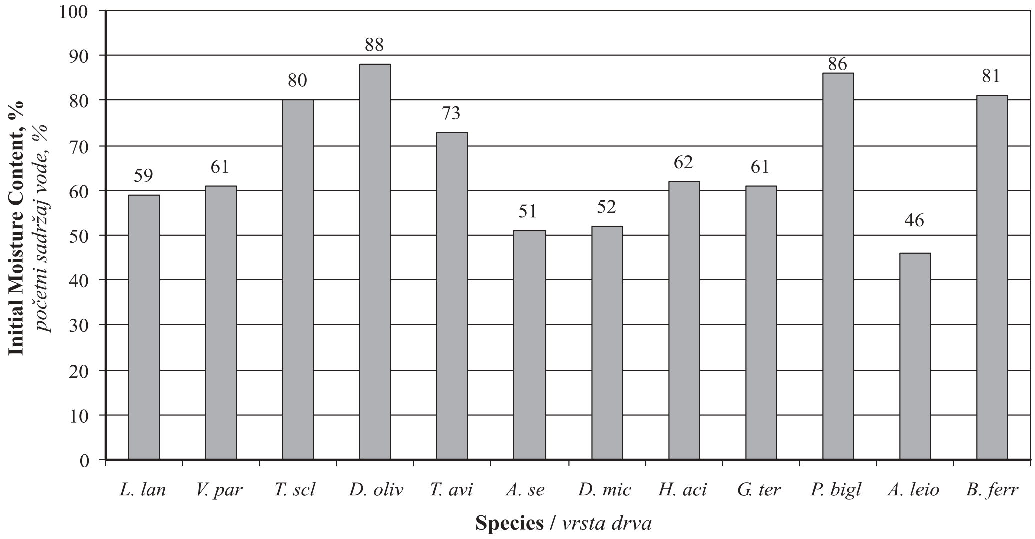

Figure 1 Mean initial moisture content for wood samples from twelve species
Slika 1. Srednje vrijednosti početnog sadržaja vode za uzorke od 12 vrsta drva

in Table 3 while Table 4 shows the one-way ANOVA for the regression equation. Table 5 presents the results of linear regression for equation predicting CNV from SG alone, while Table 6 shows the one-way ANOVA for the regression equation. Table 7 and 8 show the results of linear regression for equation predicting CNV from NCV alone and one-way ANOVA for the regression equation, respectively. The P values in the ANOVA tables are the actual probability of tests of adequacy of the models and were found to be lower than or equal to 0.05 except that for NCV in the model depicted by equation 1 (Table 3).

4 DISCUSSION
4. DISKUSIJA

According to the literature, the success of any agroforestry system is largely dependent on stakeholders' participation and cooperation, particularly those of the farmers and inhabitants of the rural areas. This fact resulted in the idea of using this target group's ranking and prioritization of woody component of scattered trees in croplands, which is the predominant agroforestry system in this study area, as the basis for selecting woody species for this study (e.g. Erakhrumen, 2008a; 2009).

Table 2 Descriptive statistics for Specific Gravity and Net Calorific Values for the twelve wood species
Tablica 2. Deskriptivna statistika za podatke gustoće i neto kalorijske vrijednosti za uzorke od 12 vrsta drva

Species *Vrsta drva*	Specific Gravity, $g\cdot cm^{-3}$ *Gustoća, $g\cdot cm^{-3}$*			Net Calorific Values *Neto kalorijska vrijednost*		
	Mean values* at 25 °C *Srednja vrijednost pri 25 °C*	SD *Standarda devijacija*	SE Mean *Standardna pogreška*	Mean values *Srednja vrijednost* $MJ\cdot kg^{-1}$	SD *Standarda devijacija*	SE Mean *Standardna pogreška*
Lophira lanceolata	0.81	0.01	0.03	21.68	0.08	0.02
Vitellaria paradoxa	0.85	0.03	0.08	19.47	0.02	0.06
Triplochiton scleroxylon	0.42	0.03	0.06	14.65	0.15	0.05
Daniellia oliveri	0.64	0.03	0.02	16.03	0.06	0.02
Terminalia avicennioides	0.79	0.05	0.01	18.25	0.12	0.04
Annona senegalensis	0.71	0.03	0.07	17.71	0.06	0.02
Detarium microcarpum	0.73	0.02	0.03	17.67	0.04	0.01
Hymenocardia acida	0.81	0.02	0.04	19.00	0.08	0.03
Gardenia ternifolia	0.81	0.03	0.08	18.46	0.22	0.07
Parkia biglobosa	0.83	0.03	0.07	19.63	0.10	0.03
Anogeissus leiocarpus	0.83	0.02	0.03	18.63	0.28	0.09
Bridelia ferruginea	0.81	0.02	0.05	18.04	0.11	0.03
Mean / *srednja vrijednost*	0.75			18.25		

*Values are means for 10 test samples per tree / *vrijednosti odgovaraju srednjoj vrijednosit za deset uzoraka svake vrste drva*; SD – standard deviation / *standardna devijacija*; SE Mean – standard error of mean /*standardna pogreška srednje vrijednosti*

Table 3 Results of linear regression for Equation 1
Tablica 3. Rezultati linearne regresijske analize za jednadžbu 1.

Predictor *Varijabla modela*	**Coefficient** *Koeficijent*	**SE Coefficient** *SE koefeicijent*	R^2, %	*T*	*P*
Constant / *konstanta*	344.55	94.60		3.64	0.005
SG	287.20	126.7	77.1	2.27	0.050
NCV	11.101	8.681		1.28	0.233

Table 4 One-way ANOVA for Regression Equation 1
Tablica 4. Jednosmjerna ANOVA analiza za regresijsku jednadžbu 1.

Source of Variation / *Izvor varijacije*	*DF*	*SS*	*MS*	*F*	*P*
Regression / *regresija*	2	30204	15102		
Residual Error / *preostala pogreška*	9	6957	773	19.54	0.001
Total / *ukupno*	11	37160			

Table 5 Results of linear regression for Equation 2
Tablica 5. Rezultati linearne regresijske analize za jednadžbu 2.

Predictor *Varijabla modela*	**Coefficient** *koeficijent*	**SE Coefficient** *SE koefeicijent*	R^2, %	*T*	*P*
Constant / *konstanta*	445.02	54.35	75.7	8.19	0.000
SG	423.09	71.31		5.93	0.000

Table 6 One-way ANOVA for Regression Equation 2
Tablica 6. Jednosmjerna ANOVA analiza za regresijsku jednadžbu 2.

Source of Variation / *Izvor varijacije*	*DF*	*SS*	*MS*	*F*	*P*
Regression / *regresija*	1	28940	28940		
Residual Error / *preostala pogreška*	10	8221	822	35.20	0.000
Total / *ukupno*	11	37160			

Table 7 Results of linear regression for Equation 3
Tablica 7. Rezultati linearne regresijske analize za jednadžbu 3.

Predictor *Varijabla modela*	**Coefficient** *Koeficijent*	**SE Coefficient** *SE koefeicijent*	R^2, %	*T*	*P*
Constant / *konstanta*	259.70	103.30	67.7	2.51	0.031
NCV	27.589	5.631		4.90	0.001

Table 8 One-way ANOVA for Regression Equation 3
Tablica 8. Jednosmjerna ANOVA analiza za regresijsku jednadžbu 3.

Source of Variation / *Izvor varijacije*	*DF*	*SS*	*MS*	*F*	*P*
Regression / *regresija*	1	26234	26234		
Residual Error / *preostala pogreška*	10	10927	1093	24.01	0.001
Total / *ukupno*	11	37160			

Owing to the fact that listing and prioritization of wood species were done by each respondent, many species made their lists and subsequent rankings but the twelve that featured mostly and had the highest CNV were the ones selected for the laboratory analyses. The necessity for prioritizing tree and shrub species for agroforestry purposes has also been earlier highlighted in some studies such as Popoola et al., (1996); Erakhrumen, (2005, 2008a, 2009).

The data obtained from the experiment for the determination of initial MC gave variable mean values (Fig. 1). The knowledge of the presence and quantity of this wood constituent is important if it is to be used for fuel since moisture generally decreases wood calorific value as established by a number of earlier investigations (Murphy et al. 1974; Ince, 1977; Panshin and deZeeuw, 1980).

Nonetheless, it is important to note that MC is not an intrinsic property of wood, as also noted by Erakhrumen, (2006), since it may vary with species due to differences in the hygroscopicity of different fiber complexions (Senelwa and Sims, 1999) and it may also vary from one tree part to another (Hakkila, 1984). It is often lowest in the stem and increases toward the roots and crown in many species. Apart from physiological differences that might cause variation in MC in different plant parts, seasonal changes and geographic location also contribute towards its difference among different species (Diaz and Golueke, 1981). Thus, much emphasis was not laid on initial MC of the species in this study since the NCV was determined for oven-dry samples of the twelve species.

Apart from the mean SG value for *T. scleroxylon,* which was 0.42, the remaining eleven species had values ranging between 0.64 and 0.85, values comparable to the ones obtained for some wood species obtained from some agroforestry systems by Shanavas and Kumar, (2006). It has been established that SG is an intrinsic factor that has influence on wood quality and many of its other properties (Panshin and deZeeuw, 1980; Larson *et al.*, 2001). It is also said to indicate the amount of actual wood substance present in a unit volume of wood (Zobel and Jett, 1995).

It is important to note that many other factors, that were not part of this study, can also influence the SG of wood e.g. source of wood material along and across the stem (Akachuku, 1980; Ogunsanwo and Onilude, 2000; Espinoza, 2004; Shanavas and Kumar, 2006), age of trees, silvicultural and/or management regimes, geographical and site factors (Akachuku, 1980; Bada, 1990), genetic influences, among others.

The NCV or lower heating value of wood is the total amount of heat released during combustion, less that taken up in heating and vaporizing its MC. It is a more practical value in that it is a measure of the usable heat released when wood is burned. In the case of oven-dried wood, the only water expected or likely to be involved is the relatively small amount produced by the chemical reaction of the hydrogen contained in the wood with oxygen during combustion (Foley, 1986).

The mean NCV obtained for the twelve species had values in the range comparable with those obtained in studies by Harker *et al.*, (1982); Lucas and Fuwape, (1984); Deibold and Bridgwater, (1997); Twidell, (1998); Ladipo *et al., (2002); Ogunsanwo et al.*, (2008). As stated for SG, other factors, not investigated in this study, like presence of other combustible material in wood (Panshin *et al.,* 1962; Tillman, 1978; Harker *et al.*, 1982; Wang *et al.,* 1989; Groves and Chivuya, 1989; Jain, 1994), influence of various parts of species and position of wood along and across the bole (Puri *et al.*, 1994; Oluwadare and Omole, 1999; Lemenih and Bekele, 2004), age of species (Klasnja *et al.*, 2002; Lemenih and Bekele, 2004), variation of the components properties of species (Sheng and Azevedo, 2005), species' genetic character and biochemical composition (Kataki and Konwer, 2002), difference in applied silvicultural techniques during growth (Senelwa and Sims, 1999), source of provenances, geographical region, seed source, types and nutrient status of soils on which the species are grown among others may also be important when fuel value of wood is to be determined.

In order to estimate the extent of contribution of the properties evaluated i.e. SG and NCV to respondents' preference of species for agroforestry in this study area, three regression equations were developed. The first one was a multivariate of the type ($y = b_o + b_1x_1 + b_2x_2$) predicting CNV from both SG and NCV (Equation 1).

$$\text{CNV} = 345 + 287\ \text{SG} + 11.1\ \text{NCV} \qquad \text{Equation 1}$$

The coefficient of determination (R^2) obtained for the equation (Table 3) showed that 77.10% represents the proportion of variation in the CNV explained by both the SG and NCV together as predictors. The implication of this R^2 value is that these intrinsic properties may likely have significant influence on the perception, acceptance for and/or retention of woody species in agroforestry plots by the respondents in this study area.

The results in Table 3 showed that, statistically, SG significantly predicted CNV (P=0.05) in equation 1 while NCV did not significantly predict CNV (P=0.233) according to the results in Table 3. On subjecting the regression equation to ANOVA, the results showed that the predictive power of the equation is significant with 95% confidence (Table 4). The values obtained for R^2 for equation 1 was high enough for predictive purposes in this study, although statistically, NCV did not significantly predict CNV in equation 1.

It should be noted that if the correlation between any pair of independent variables is too high, the dependent variable in a multiple regression analysis might likely be poorly estimated or described as a result of problem of auto-correlation (Freese, 1964). In line with this, two different univariate regression equations of the type ($y = b_o + bx$) using SG and NCV alone (equations 2 and 3) were developed to ascertain if this problem exists.

$$\text{CNV} = 445 + 423\ \text{SG} \qquad \text{Equation 2}$$

$$\text{CNV} = 260 + 27.6\ \text{NCV} \qquad \text{Equation 3}$$

The R^2 values obtained for equations 2 and 3 in Tables 5 and 7, respectively, also had similar values compared with that of equation 1. The R^2 values showed that 75.70% represents the proportion of variation in the CNV explained by SG alone as a predictor, while 67.7% was the proportion of variation in the CNV explained by NCV in this study.

The results imply that SG and NCV are correlated as also noted by Erakhrumen, (2006), and this might likely be the reason why NCV did not significantly predict CNV in equation 1 as a result of likely auto-correlation between SG and NCV, while the reverse was the case in equation 3 where NCV predicted CNV. This might also explain why R^2 was not significantly better when both SG and NCV are put in the regression model depicted by equation 1 when compared with univariate regression equations 2 and 3. Nevertheless, the results obtained for the three equations reinforced and supported the works by Erakhrumen, (2006; 2008a; 2009).

The ratio of the corresponding value under coefficient and its standard error coefficient of the constant and SG and NCV known as the T-value showed that SG and NCV singularly significantly predicts the CNV in this study since the calculated values were greater than the pre-selected α-level of 0.05 (Table 5 and 7). On subjecting the regression equations 2 and 3 to ANOVA, the results showed that the predictive power of the equations was significant with 95 % confidence (Table 6 and 8).

These results showed that SG and NCV of wood species in this study area and perhaps in others can be used as a likely indication of their being accepted for agroforestry. It is important to note that the earlier stated factors and others not investigated in this study are likely to influence predictive power of these kinds of equation stated above in different localities.

5 CONCLUSION
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The outcome of this study supports the idea that stakeholders will have to work together as a team for achieving a successful and sustainable renewable natural resource system of production. Results of this research have also shown that one of the reasons why woody species are either selected and/or retained in agroforestry land use pattern is their potential usefulness as fuelwood and they will prefer high density wood particularly those with high energy density for this purpose. It is therefore recommended, based on the outcome of this study, that when woody species are to be selected for incorporation and/or retention in agroforestry schemes or plots, properties to be considered should include high SG and wood energy value, since these properties are observed to either directly or indirectly influence this choice in this study area.

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