Actual and Potential Industrial Uses of *Eucalyptus* Wood in Addis Ababa, Ethiopia

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--*ABSTRACT*--
Demand for industrial forest products has risen sharply in Ethiopia in recent years due to population, urbanization and economic growth. In the past industrial wood products demand were covered by indigenous timber species, which now-a-days have declined due to unwise exploitation and deforestation. An alternative solution is planting of exotic fast growing species, and this has been promoted and utilized in the country to narrow down the gap between supply and demand. One of the exotic species most planted in Ethiopia is Eucalyptus. Despite the abundance of wood from this species now in Ethiopia, its industrial uses are not wide and apparently face several challenges. The aim of this study was to investigate the extent of use of Eucalyptus wood and to identify factors affecting its acceptability in furniture factories. Both quantitative and qualitative data were collected using semi-structured questionnaires. Focus Group Discussions (FGD) and Key Informants interview (KI) were also conducted. Data were analyzed using descriptive statistics as well as Binary logit model to identify determinant factors for using or not using eucalypt wood. The results of the study showed that eucalypt wood was used by different industries but to a limited quantity. About 34.2% of the respondents indicated that they were using eucalypt wood in some forms, while 65.8% of the respondents do not use eucalypt wood at all. Binary logit model has identified that product types and information about the species have significant effect on the utilization of eucalypt wood by the industries.
KEYWORDS-Acceptability, alternative species, Eucalyptus wood, industry, factories
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I. INTRODUCTION

Demands for all forest products have been increasing in Ethiopia due to growth in population, urbanization and economy (Mulugeta and Habtemariam, 2014). Estimates in the year 2010 showed that 85 million m^3 of wood products is needed in Ethiopia for different purposes. The sustainable supply from domestic sources on the other hand amounts only to 12 million m^3 (Getachew and Wubalem, 2010); hence a huge gap exist between demand and supply for wood products in the country. In the past about 85% of this demand has been covered by indigenous timber species logged from natural forests and agro forests (Getachew and Wubalem, 2010). Now most of the forests and valuable timber tree species are gazette not to be harvested as they are severely endangered from unsustainable exploitation (FDRE, 2007). Therefore, the low level of industrial wood supply from domestic production is compensated by a large volume of imports. For instance, according to Getachew *et al.* (2015), the forest products import amount and the corresponding hard currency value for the period between the years 2000-2013 has been 170721.3 tons costing ca 159 million USD. Habtemariam and Zeleke (2014) pointed out that if no intervention measures are considered, the import bill by the year 2035 will reach about 3 billion USD. This importation of large wood products would demand the country a large foreign currency, which compromises the country's economic development. As an alternative, Ethiopia's wood industries should switch to potential species growing in the country, and one of such a species is eucalypt.

Since the past decade forest plantation area has been increasing in Ethiopia. The major species in the new plantations (woodlots) constitutes eucalypt (Million Bekele, 2011). In commercial forest plantation, eucalypt species make up 56% of the standing stock, while in woodlots it makes up over 99%. The most widely planted *Eucalyptus* species in Ethiopia are *Eucalyptus camaldulensis, Eucalyptus globulus, Eucalyptus grandis* and *Eucalyptus saligna* (Friis, 1995). According to Tsegaye (1994) even though eucalypt is mostly planted everywhere in Ethiopia, its processing and marketing are not linked well, due to lack of knowledge and experience in sawing and drying of its wood. As stated by CSIRO (2002), globally *Eucalyptus* has many uses

and became economically important tree species, while in Ethiopia little is known about its industrial uses. Overall, information is lacking on the exact amount of eucalypt wood used by wood industries today and their willingness to use in the future as well. Since the species is fast growing, increasing its industrial use is believed to decrease the country's dependence on import while also minimizes the pressure on the limited natural forest from being illegally logged to supply the growing demand. The aim of this study is to assess the acceptance and uses of lumber of *Eucalyptus* in furniture making factories and to differentiate factors affecting the acceptability of *Eucalyptus* wood in furniture industries. Moreover, there is a need to assess the annual amount of *Eucalyptus* raw material used in different wood industries for veneer and composite products such as particle boards.

II. MATERIALS AND METHODS

2.1. Description of the Study area

Data for this study was collected from nine sub-cities in Addis Ababa, the capital of Ethiopia. Addis Ababa was selected because of its higher level of business activities and large number of furniture manufacturing firms located in it than any other cities or towns in the country (CSA, 2014). According to CSA (2014) data, the city accounts for about 30% of the furniture industries in the entire country, which makes it a good candidate city for the study. The city has a total area of 540 square kilometers and divided into 10 boroughs named sub cities and 99 wored/district as (AACIB, 2006). Based on the 2007 census conducted by the Ethiopian National Statistics Authority of Ethiopia, the population of Addis Ababa is 3,384,569 million people. All Ethiopian ethnic groups and religions are represented in Addis Ababa, due to its position as capital of the country.

2.2. Methods of data collection
2.2.1. Sampling method

Purposive sampling method was applied to select nine out of ten sub-cities of Addis Ababa by considering the abundance of wood processing industries. Wood industries were categorized into two sub-types: composite industries (chip wood factory, plywood factories and hard board factory), and furniture industries (large, medium and small scale). From the composite industries, four factories were selected while for furniture industries a stratified random sampling technique was used.

Table 1 Sample distribution of furniture and composite industries from the study site

Kinds of industry	No. of factories in Ethiopia	No. of factories in Addis Ababa	
		Total	No. of sample selected
Large and Medium	299	78	48
Small Scale	17,693	4938	120
Chip wood factory		2	1
Plywood factory		2	2
Hard board factory		1	1
Total	17,992	5022	172

2.2.2. Sources and types of data

Both quantitative and qualitative data were collected from primary and secondary sources. Quantitative data were collected from survey work, while qualitative information was gathered through focus group discussions, observations and key informants interview. To collect primary data, reconnaissance survey was done first to gather information on availability of furniture industries in the selected sub-cities. And then survey was carried out in different wood enterprises such as plywood factories and furniture factories found in the study area. Secondary data was collected from Central Statics authority (CSA) and different wood factories. In addition, different related literatures such as text books, manuals, journals and reports were reviewed.

Closed and open ended structured questionnaires were used, for collecting both quantitative and qualitative data from selected composite and wood furniture factories. During data collection technical managers or technical employees were requested to fill the questionnaires. The key informants' interview was carried out with eight identified individuals who have knowledge about forest resource and the need for alternative timber species. Focus group discussion was conducted with selected wood factories and different end users. Data from direct observation during sawing, processing of chip wood and plywood from eucalypt was taken.

2.3. Data Analysis

Among a total of 172 questionnaires distributed 170 were collected back making the response rate 98.8%. However, only 152(89.4) questionnaires were used for analysis, 18(10.6) questionnaires were rejected due to incomplete information. Descriptive statistics like summation, average, percentage and other tests of significance were calculated using Microsoft Excel Software and SPSS version 20. Binary logistic regression model was applied to identify the factors affecting the acceptability of Eucalyptus wood for different industrial

uses. In this study, the dependent variable (acceptability) was treated as dichotomous variable (dummy variable): Accept or not accept. The most widely used approaches to estimate dummy dependent variables in regression models are the linear probability model (LPM), the logit, the probit and the tobit models (Gujarati, 1995). The logit model was applied in this study to estimate the probability of acceptability of eucalypt wood for various industrial applications.

III. RESULTS AND DISCUSSION

3.1. Average annual volumes of Eucalyptus wood used in different wood industries

Eucalyptus wood is used as raw material in different wood and wood based industries (Table 2). In small scale furniture factories, the total average annual use of solid wood was 183.6 m^3. Out of this, the share of *Eucalyptus* wood was only 16.8 m^3 (9.2%) (Table 2). In large and medium scale furniture factories, *Eucalyptus* wood used in solid form was 10.8m^3 (3%). The majority of the wood used in both categories of furniture industries is from indigenous tree species. There is limited volume of imported hardwood and softwood used in the country. This finding is in agreement with the study of Abebe *et al.* (2009) reported that wood of native species that are often smuggled illegally form the protected natural forests and wood from plantation forests, including eucalypt species, contribute only about 10% of the wood consumed in wood industries nationally. However, all chip wood factories in Ethiopia use only wood of *Eucalyptus globulus* as the main raw material. This is in agreement with the study of Seyoum (2012) that wood from other *Eucalyptus* species are not used as raw material in chip wood factories. In the past five years, the average annual volume of *Eucalyptus* wood used in Addis Ababa chip-wood factory (ECAFCO) was 21600 m^3. Similarly, two plywood factories in Addis Ababa have used on average 21894m^3 slices of logs and hardboard factory processed 2000 m^{3}of *Eucalyptus* logs annually (Table 2).

Table 3.Annual average volumes of *Eucalyptus* wood used in different wood industries

Factory type	Eucalyptus(M^3)	Other species (M^3)	Total (M^3)	Contribution of Eucalyptus in (%)
In SS factories	16.8	167.4	183.6	9.2
In LMS factories	10.8	349.2	360	3
In chip wood factories	21600	0	21600	100
In plywood factories	21894	0	21894	100
In hard board factory	2000	0	2000	100

3.2. Category of uses of Eucalyptus wood in different factories

About 34.2% of the respondents indicated that they use *Eucalyptus* in their factories in different forms, while the majority of the factories (65.8 %) do not use wood from eucalypt in any form (Table 3). About 20 factories use *Eucalyptus* for upholstery furniture where its wood is completely hidden. Another 11 factories use in the form of chip wood, and 8 in the form of panel board. Six factories use plywood made from *Eucalyptus.* Only three factories from small scale industries use *Eucalyptus* wood in solid form. All composite factories, uses *Eucalyptus* log as raw material for the production of composite products.

Table 3. Current uses of Eucalyptus woods in various furniture industries

Category of utilization	SS factories	LMS factories	Composite factories	Total	%
In solid form	3	0	0	3	2
Panel board	8	0	0	8	5.3
Chip board	6	5	0	11	7.2
Ply board	5	1	0	6	3.9
Upholstery furniture	14	6	0	20	13.2
In log form	0	0	4	4	2.6
No use in any form	68	32	0	100	65.8
Total	**104**	**44**	**4**	**152**	**100**

3.3. Types of Eucalyptus species used in different furniture industries

About 70 *Eucalypt* species have been introduced and are growing in the country. However, wood from most of these species are so far neglected for use in wood based industries. Among the 18 small scale and seven respondents from large and medium scale furniture factories that use eucalypt wood, wood of *Eucalyptus globulus* is the only they use (Table 3 and 4). Another nine respondents indicated that they are using other types of *Eucalyptus* in addition to *E. globulus* and *Eucalyptus camaldulensis.* Fourteen (11 from small scale and 3 from large and medium) are using two types of eucalyptus: *E. globulus* and *E. camaldulensis.* From this result, it was understood that both types of Eucalyptus species were better used in both furniture factories. This conforms

to the study of Haileab (2010) that reported *E. camaldulensis* and *E. globulus*, locally known as "key baharzaf" and "nechbaharzaf", respectively preferred by the public.

Table 4.Types of *Eucalyptus* species used in furniture factories.

Type of *Eucalyptus*	Small scale industries	%	Large and medium industries	%
E.globulus	18	17.3	7	15.9
E.globulus, E. camaldulensis and others	7	6.7	2	4.5
E. globulus and *E. camaldulensis* only	11	10.6	3	6.8
Non user	68	65.4	32	72.7
Total	**104**	**100**	**44**	**100**

3.4. Respondents preference to use Eucalyptus in furniture manufacturing

Out of the 152 factories, 52 (41 from small scale and 11from large and medium scale) and all of composite factories think that *Eucalyptus* is good for furniture and like to use it as alternative timber species in the future (Table 4). This finding is in agreement with the report of FAO (2007). This report indicated that *Eucalyptus* logs from plantations will have a larger share in the sawn wood and plywood industry, and will take market shares of tropical timber from natural forests in the future. A result of the FGD and KI showed that information regarding the lumber value and acceptability of Eucalyptus for furniture production in different wood industries and as the lumber in the market is very low. Therefore, providing relevant information about potential and suitability of *Eucalyptus* species as lumber and composite raw material to different end users and producers is very crucial. This agrees with the recommendations of Amarasekera (2014) that indicated the need to identify alternative timber species and popularize them in wood industries to meet the growing national and global timber demand.

Table 5. Respondent's choice of alternative wood species in small scale furniture factories

Alternative species	small scale	%	large and medium	%
Eucalyptus	41	39.4	11	25
Pines species	32	30.8	14	31.8
Imported wood	20	19.2	16	36.4
Bamboo	3	2.9	1	2.3
Any other species	8	7.7	2	4.5
Total	**104**	**100**	**44**	**100**

3.5 . Most preferred wood species in furniture factories

From the many timber species available in Ethiopia, only few species were found on the market and utilized in furniture industries. According to the survey result, the usage of timber in furniture industries, especially in solid form, is highly selective and dominated by a small number of preferred timber species. Although banned by the government of Ethiopia, the majority of furniture factories in Addis Ababa still continue to utilize endangered indigenous species such as *Cordia afrcana*, *Pouteria adolfi-friederici*, *Hagenia abyssinica* and *Podocarpus falcatus* both in solid and panel forms. Similar findings reported earlier (Adugna, 2004 cited in Abebe Haile *et al.*, 2009). According to this study about half of the timber supplied (47,590m^3) to carpentry workshops in Addis Ababa originated from natural forests where 30% is originated from protected forest species.

Respondents were asked to list down timber species they would like to use in their factory in the order of their preference. Accordingly, all respondents from composite factories preferred *Eucalyptus.* Majority of respondents from furniture factories (148 or 97.4%) preferred *C. afrcana*, *P. adolfi-friederici* and imported lumber for furniture production. *H. abyssinica* is among the most preferred wood species for furniture production followed by *P. falcatus*. About 67 respondents from the furniture industries ranked *C. afrcana* as their first preference. Only few respondents from furniture factories prefer to use *Eucalyptus* for industrial applications.

Table 5. Most preferred wood species in furniture factories

Species name	N	Respondents those prefer the species in (%)	No. of respondents prefer the species	Rank
Cordia afrcana	148	97.4	67	1st
Pouteria adolfi-friederici	148	97.4	34	2nd
Hagnia abysinica	133	87.5	26	3rd
Podocarpus falcatus	102	67.1	17	4th
Eucalyptus species	17	11.2	5	7th
Imported wood	148	97.4	3	5th
Pinus species	78	51.3	0	6th
Total	**152**	**100**	**152**	

3.6 . Reasons for low preference of Eucalyptus wood in furniture factories

The reasons for low preference for eucalypt wood included: 39(25%) stated because of distorted information about *Eucalyptus* wood; 36(23.9%) stated due to its difficult wood properties such as high density, defects during and after processing, difficult machining properties, whereas 30 (19.7%), 21(13.8%) and 11(7.2%) respondents stated due to unavailability of *Eucalyptus* lumber on the market, preference of end users and due to their bad texture, respectively. According to information from FGD and KI there is a general or common belief among the people about *Eucalyptus* so-called "poor" wood quality and difficult properties of *Eucalyptus*. Majority of them complained about the difficulties of its processing and wrappings during drying.

During FGD, generally participants agreed that in the future *Eucalyptus* could be a *good* alternative timber species in the country for furniture production. They also indicated the need for attention from research and government to generate knowledge and technology that will help increased utilization of the species in furniture industries. This will also help to avoid the illegal logging of the endangered indigenous species. According to information from KI, currently there is distorted and mostly negative information about *Eucalyptus* wood suitability for use it in furniture industries.

3.7. Factors determining acceptability of eucalypt wood

In this section, the results from econometric model was presented in which the relative influence of each of the explanatory variables identified to affect eucalypt wood use. Accordingly two variables were significantly affect uses of eucalyptus wood for industrial application at less than 1% significance level. These were lack of information about wood of the species and end product types.

Lack of information significantly and negatively affected the use of eucalyptus wood in industry (P<0.01). Note that, after controlling the effects of other variables, effect of lack of information about the *Eucalyptus* wood on odds of acceptability is less than one and in probability terms the effect is less than 50%. The likelihood of industries without information about *Eucalyptus* to accept it as industry raw material is 0.3%.This means those industries with low information about *Eucalyptus* wood were less likely to use *Eucalyptus* wood for furniture production (Table 6).This is in line with the findings of Getachew and Wubalem (2010) that lack of information is assumed to have negative impact on industrial uses of eucalyptus wood.

Keeping the effect of other variables, the effect of product types on odds of acceptability is less than one and in probability terms the effect is less than 50%. Types of products manufactured from Eucalyptus wood were positively associated with the log of odds of acceptability of *Eucalyptus* wood by industries as a raw material. This means wood industries those produce upholstery furniture such as sofa frame were users of *Eucalyptus* wood. The model result indicated that the odds ratio in favor of using of eucalyptus wood increased by 42% if wood industries produce their products like sofa frame and panel boards. This result is in line with the finding of Boampong *et al.* (2015) that type of product is the influential factor for the selection of wood species for industrial application.

Table 6. Estimate for acceptability of *Eucalyptus* wood in furniture industries.

Variables	coefficient	S.E.	Wald	Sig.	Exp (B)	probability
LACKINFO	-5.714	1.266	20.356	0.000*	0.003	0.30
DEMAND	0.951	1.623	0.343	0.558	2.588	72.13
PRODUCT	0.867	0.321	7.311	0.007*	0.420	29.58
TOTALCAP	0.000	0.000	0.025	0.873	1.000	50.00
TYPINDUS	0.472	1.453	0.105	0.746	1.602	61.57
Constant	4.348	3.795	1.312	0.252	77.303	

-2 Log likelihood function = 25.389 Chi-Square (x^2) = 169.907 Pseudo (R^2) = 0.8776 P= 0.0000

IV. CONCLUSION

Eucalyptus wood is used as raw materials in some wood industries such as in chipboard, hardboard and plywood factories in Ethiopia. From many timber species available in Ethiopia, only few species were found on the market and utilized in furniture industries. The availability of sawn *Eucalyptus* wood is also limited on the market. Due to this, its wood in solid form has not yet gained distinct utilization share in furniture factories. According to survey result in small scale furniture factories, the total average annual use of *Eucalyptus* wood in solid form was only 16.8 m^3 (9.2%). While In large and medium scale furniture factories, *Eucalyptus* wood used in solid form was 10.8m^3 (3%). In both industries, the total annual eucalypt wood used was 27.6 m^3 (12.2%) of the total annual wood consumption.

Despite the overall small volume of eucalypt wood used annually, 52 respondents (34.2%) indicated that they use Eucalyptus in different forms, while 100 (65.8 %) of respondents do not use Eucalyptus in any form. Furthermore, many people in furniture industries indicated that as they do not know different varieties of the species in a lumber form. So far, the use of this species in furniture industries is limited to making frameworks for upholstered furniture, where they are completely hidden. Only small scale factories that could not raise substantial financial capital to stock expensive timbers are likely to use this species as alternative raw material more than large scale furniture factories. All composite factories in Addis Ababa use eucalypt wood as the main raw material.

Finally, factors those determine the use/acceptability of *Eucalyptus* wood in the industries were identified. According to the result from logistic regression model, lack of information about *Eucalyptus* wood and product types significantly influences the use of eucalypts wood in furniture factories.

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