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Estimates of Forest Residues from Selective Logging Operations in Mozambique for Bioenergy

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ABSTRACT

Species-specific stem volume equations explained by diameter and height variables were developed by applying non-linear regression analysis for three main timber species such as: Chanfuta (*Afzelia quanzensis* Welw.), Jambire (*Millettia stuhlmannii* Taub.) and Umbila (*Pterocarpus angolensis* D.C). Destructive methods were used. The ratio merchantable stem height and total stem height was used to provide the proportion of the non-merchantable component of each of the three studied species. At tree level, the residual stem length as higher as 50% of the total tree stem for the three studied species.

Keywords: Stem volume, merchantable volume, non-merchantable, timber stock, biomass

INTRODUCTION

Mozambique is a country located in the Southern Africa with a area of around 800 000 km². About 70% of Mozambique's land surface is covered by natural forests (51%) and other vegetation covers (19%). Plantations of *Eucalyptus sp.* and *Pinus sp*., cover 62000 ha (FAO, 2010), see Figure 1.

There are 118 identified commercial species in Mozambique, however only 34 are currently harvested.

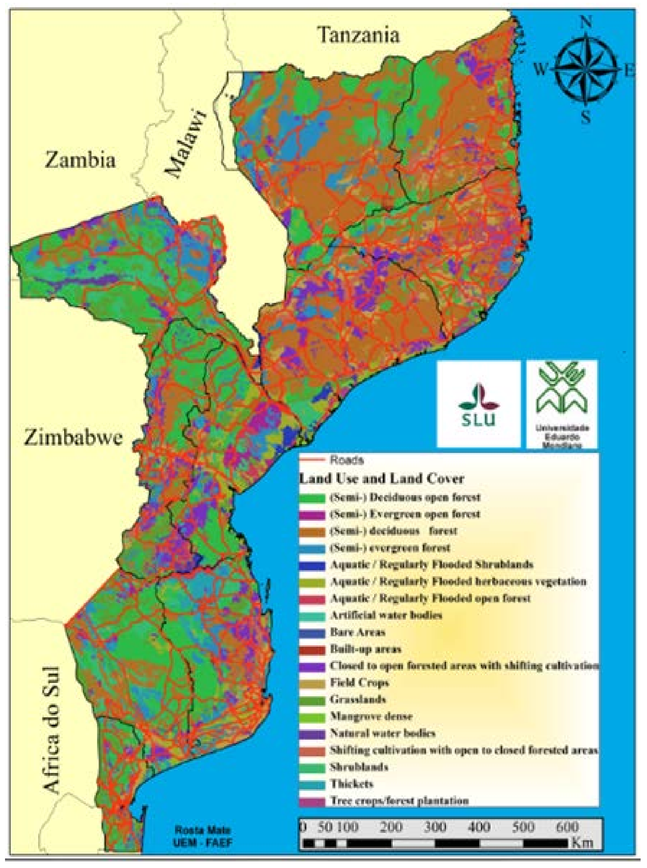

Figure 1. Land Use and Vegetation Cover in Mozambique

Chanfuta, Jambire and Umbila account for 78% of harvested timber volume in Mozambique (Marzoli, 2007; National Directorate of Land and Forest, 2010) and are the potential contributors for the bulk of primary logging residues. Standing commercial timber stock is 5 620 000 m³, 4 200 000 m³ and 2 514 000 m³ for Umbila, Jambire and Chanfuta respectively (Marzoli, 2007).

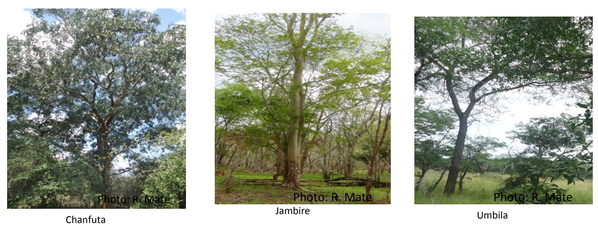

Figure 2. Studied miombo timber species

Today, the major source of energy is fuelwood (firewood and charcoal), sharing 82% in the current energy mix (Ministry of Energy, 2012). Fuelwood harvesting is among the major causes of deforestation in Mozambique (Sitoe et al, 2012) as they are obtained from clear cut of secondary and even primary forests. Current annual fuelwood consumption is 27.8 million m³ (Sitoe et al, 2007), which is 50 times higher than annual allowable volume for timber.

Use of logging residues for energy use may contribute for reducing the deforestation caused by fuelwood use. The present study was performed with the objectives of i) development stem volume equations and ii) determining the proportion merchantable and non-merchantable stem length for the three studied species, in order to provide accurate estimate of potential residual stem volume that can be directed for bioenergy use.

MATERIAL AND METHODS

The study was carried out in Inhambane and Sofala Provinces in Mozambique. (Figure 1). A total of 58 trees were sampled for stem volume equations. To obtain data for volume estimates the stem was divided into 5 sections relative to the total height and the top. Gathered data: diameters at different relative stem positions, diameter at breast height and height (merchantable and non-merchantable). Destructive methods were used where trees were felled for measurement. Data was fitted using non-linear regression procedures in SAS (SAS Institute Inc., 2006).

RESULTS AND DISCUSSION

Allometric relationships of stem volume to diameter at breast height (DBH) shows a non-linear trend and positive correlation (Figure 3). The highest mean stem volume per tree (m³) was for Jambire (0.889) and Umbila the lowest (0.438).

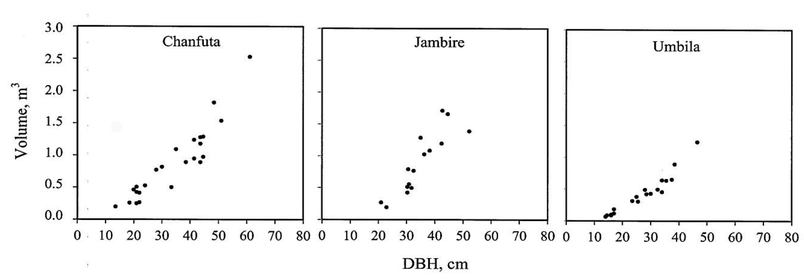

Figure 3. Volume versus height (DBH) for Chanfuta, Jambire and Umbila

DBH and height together explained the variations in stem volume, where the best model fit was as following:

$$V = \beta_0 + \beta_1 D^2 * H$$

The proportion of the commercial stem length by the total stem varied between 30 to 70% of the total stem length. Overall, at least 50% of the stem length can be accounted as residual for the studied species.

Additional volume of branches could be obtained as they are mainly left as waste in the field. Branches accounted for more than 50% aboveground biomass for the studied species according to Mate et al. (2014) as well as from secondary residues from wood processing units, other harvested species and plantation forests that were not included in this study.

CONCLUSIONS

- The study showed that there is a large volumes of forest residues from selective logging operations currently not utilized by forest industries for timber purposes with potential for being used as bioenergy feedstock.
- Effect of tree size (DBH and height) on stem volume estimates was evident, explaining 90-95% of the stem volume variations.
- At tree level, at least 50% of stem length could be accounted as residual volume. Umbila species could be the most dominant contributor to the bulky of potential forest residues due to its tree architecture dominated by branches (short bole and wider crown) as well as larger standing commercial stock compared to the Chanfuta and Jambire.
- The theoretical potential or availability of forest residues from logging operations was documented in this study, however technical and ecological issues as well as requirements for the effective logistics need to be addressed.
- Future research is needed to develop species specific stem volume equations covering the all the range of harvested species in Mozambique as well as plantation forests.

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REFERENCES

- FAO. (2010). Forest Resource Assessment – 2010 – Mozambique Country Report. Rome. 54pp.
- Marzoli, A. (2007). National Forest Inventory; Integrated Forest Assessment of Mozambique (AIFM), Maputo; National Directorate of Land and Forest (DNTF)-Ministry of Agriculture: Maputo, Mozambique, p. 92.
- Mate, R., Johansson, T., Almeida S. 2014. Biomass equations for tropical tree species in Mozambique. *Forests*, 5, 535-556.
- Mate, R., Johansson, T., Almeida S. (2014). Stem volume equations for valuable timber species in Mozambique. Submitted to Journal of Sustainable Forestry (accepted manuscript)
- Ministry of Energy. (2012). Mozambique biomass national strategy. Final Report. Ministry of Energy, 171pp.
- SAS Institute Inc. (2006). Version 9.1. Gary. NC.
- Sitoe, A., Salomão, A. & Wertz-Kanounnikoff, S. (2012). The Context of REDD+ In Mozambique: Causes, Actors and Institutions. CIFOR. Bogor, Indonesia. Occasional Publication 6, 74 pp.
- Sitoe, A.; Mirira, R.; Tchaúque, F. (2007). Assessment of Consumption levels of biomass energy in Tete, Nampula, Zambézia, Sofala, Gaza and Maputo Provinces. Ministry of Energy/Faculty of Agronomy and Forestry Engineering; Ministry of Energy: Maputo, Mozambique, 50pp.