# DOES MANAGEMENT MATTER? ASSESSMENT ON MIOMBO FORESTS IN ANGOLA

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The aim of this paper is to assess the predominant management knowledge of miombo forests in Angola. It interlinks with decision support methods to assess future management plans for miombo forest where the community's interests evolve (wild fruits, animals, firewood, charcoal, and timber). The management of miombo forests is a complex subject due to multiple outcomes particularly because of their uniqueness, while charcoal and firewood are the major products. The application of Analytic Hierarchy Process (AHP) to data collected in Bié province showed that timber is not a priority for people that live around miombo area, whereas charcoal appears to be a priority to 68% of the community. We conclude that applying the AHP to the data collected in Bié province was a clear indication that future researches on local communities priorities will be conducted when it comes to take decisions for the entire forest community.

AHP, forest management, decision support methods

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## INTRODUCTION

Scientific knowledge of forestry arose in Europe in the mid-18th century and forests were a legal category of resource management. From the etymological point of view, the word 'forest' appeared first in Merovingian laws in the 7th century and was derived from Latin *foris* (*en dehor des demaines*) essentially meaning tribunal, indicating the dependency of forest from public treasury and courts (Paletto et al., 2008). Forest management planning (FMP) emerged due to conflicts between present and future. The main structure of forest management was always a top-dawn management in which the knowledge and wisdom were posed by foresters or agencies generally working for governments or timber industry (Jonsson et al., 1993; Gilmour et al., 2007; Delgado-Matas, 2015). In Angola, the history of forest management is linked with European colonisation (Portuguese) in the late 19th century. European settlers developed the cultivation of many plantations as oil palm, rubber, pines, and eucalypts that were distributed in highlands of the central plateau of Angola. From the total natural forest, 45.2% is constituted by miombo forest. The term 'miombo' originates from Bantu languages 'muombo'. Miombo forest covers countries such as Angola, Malawi, Mozambique, Zambia, Zimbabwe, Tanzania, and southern part of the Democratic Republic of Congo, altogether comprising about 2.7 million km$^2$ (Huntley, Matos, 1994; Campbell, 1996; Abdallah, Monela, 2007). Miombo is a closed deciduous forest within the spectrum of savannah ecosystems grading into seasonal dry forest with a mean annual rainfall between 800 and 1400 mm with a canopy height not greater than 15 m. The main timber species are *Pterocarpus angololensis* (girassonde), *Guibourtia coleosperma* (mussibi), *Afzelia cuanzensis* (ovala or muvala), *Brachystegia spiciformis* (omanda), *Julbernardia paniculata*, *Copaifera baumiana,* and *Marquesia macroura* (Diniz, 1991; Huntley, Matos, 1994; Romeiras et al., 2014)..

Miombo forests were studied mainly in countries like Zambia (Chidumayo, Gumbo, 2013), Malawi (Abbot et al., 1997; Abbot, Lowore, 1999; Kachamba et al., 2016), Tanzania (Abdallah, Monela, 2007; Jew et al., 2016) and Mozambique

(Williams et al., 2008; Mapanda et al., 2013). In Angola, the past assessments on miombo forests were on species distribution and special dynamics of the central-plateau forests where the observations of land cover by remote sensing illustrated the complexity of deforestation due to charcoal and firewood production (Huntley, Matos, 1994; Cabral et al., 2011; Romeiras et al., 2014; Schneibel et al., 2016, 2017). The resources of miombo forests in Angola are the source of livelihood for rural population and also a place for meeting spiritual needs of local people (Campbell et al., 2007). About 80% of population in Angola rely on charcoal and firewood from miombo forest for residential energy needs (IEA, 2006).

To understand which resource is priority to local population, the utilisation of decision suport methods for multiple criteria preponderates (Barrow, Nhantumbo, 2008; Lund, Treue, 2008). The problem comes when we want to manage forest for multiple purposes due to trade-offs which come from managing with a specific objective in mind (Lupala et al., 2014). The idea of creating a better management plan for miombo is addressed by many scholars (Tanz, Howard, 1991; Campbell, 1996; OECD/IEA, 2006; Campbell et al., 2007; Michon et al., 2007; Khan, 2010; Parrotta et al., 2016) . The involvement of local communities in management planning increases the trust between governmental agencies and local communities. The use of different interrelated knowledge (traditional knowledge) to protect and manage ecosystem services has been highly recommended (Toft, 2013; Toft et al., 2015).

There are three types of models of decision-making process that govern the forest planning: (1) rational, (2) irrational, and something in-between called (3) 'the garbage can model' (Bettinger et al., 2017; Grabner et al., 2013). The first model is based on the idea that all information is gathered, and we base the analysis on selection of the best possible scenario from the complete data set. The second model is based on assessing limited data alternatives (Abbot et al., 1997; Nhantumbo et al., 2001). The third model is applied to situations where the goals and objectives are unclear, which is sometimes problematic and misunderstanding. However, management plans must start from somewhere – good data, bad or no data. The second model will be the focus of this paper. The aim of this paper is to assess the predominant forest management policies of miombo forests and interlink it with new knowledge of decision support methods for future management plans.

#### Multiple criteria decision for forest management (MCDFM)

Multiple criteria decision analysis is defined as an umbrella term that accounts of to help communities or groups explore decisions that matter to all. The MCDFM defines objectives, criteria to measure the objectives, specfies the alternatives and more, it transforms the criteria scales into measurable units and reflects their results into mathematical algorithms for ranking alternatives and choices (Tanz, Howard, 1991; Saaty, 2008; Ananda, Herath, 2009). The utilisation of MCDFM is a trend of the 21$^{th}$ century as the forest is now calling for sustainability (Janssen et al., 2005; Hajkowicz, Collins, 2007). European legislation has increasingly recognised the importance of preserving wetland ecosystems. The Water Framework Directive (WFD. However, few studies have supported the use of MCDFM to create management planning. The most theorical approaches used are Multi-Objective Programming (MOP), Goal Programming (GP), Muiti-Attribute Utility Theory (MAUT), Fuzzy Multi-Criteria Programming (FMCP), Analytic Hierarchy Process (AHP), Other Discrete Methods (ODM), Data Envelopment Analysis (DEA), and Group Decision Making techniques (GDM) (Pukkala, 1998; Kangas et al., 2005; Diaz-Balteiro, Romero, 2008;Ananda, Herath, 2009; Acosta, Corral, 2015; Fotakis, 2015). From the methods mentioned, the application of AHP showed successful results on forest management planning using MCDFM. The AHP is a theory of measurements through pairwise comparisons and depends on the judgement of experts to drive the priority scale (Saaty, 1987; Kangas, 1992; Ananda, Herath, 2003; Lepetu, 2012).

## METHODS

This study is a combination of literature review from different scientific fields and annual reports from the Institute for Forest Development (IDF) in Angola (Appendix A). To enrich the content of the review we made a questionnaire survey in one province of Angola to support the background of this paper. The questionnaire was done in 2010 and 96 respondents, mainly farmers living around miombo forests, were addressed. The questionnaire was designed to answer questions on the forest products and rank the importance of these products (Appendix B). The respondents' answers were divided into two groups according to their education level. Consequently, we made a preliminary exploratory analysis of qualitative data to link to the research questions.

Collected data (questionnaire survey) were processed using the Analytic Hierarchy Process (AHP) method. In general, everything we do consciously or unconsciously is the result of some decision. In forest management, the decisions are supported by information and measurements data that, for the purpose of analysis, need to be converted into numerical values. Therefore, the AHP method was applied to process the preferences of local people on the main products that communities gain from the forest. We translated the preferences of the stakeholder into measurable weights by making pair-wise comparisons using a 5-point scale (1, 3, 5, 7 and 9), reflected into equal, weak, strong, very strong (see Fig. 1).

The preferences of community on management objectives were firewood, charcoal, and timber. To apply the AHP, the letters were translated into numeric values; if the judgement value is located on the left side of 1 on the scale, it is presented as an entire value; however, if it is located on the right side of 1, a reciprocal value is used (Fig. 1, Table 1).

All the values of the matrix were summed up and each element divided by its column total, while the highest number under the priority column indicated the highest preference. Each element of the row was divided by the corresponding value in the column. The normalization was the sum of the column where the results were equal to one. Then each element of the matrix was multiplied by the reciprocal of the matrix size.

The consistency index and consistency ratio were calculated using models 1 and 2. The component to be considered for comparison (n) were timber, charcoal, and firewood (indicated as C1, …, Cn) and represents the relative weight of $C_i$ and $C_j$ by $a_{ij}$ to form a matrix $\mathbf{A} = (a_{ij})$. The conditions are that $a_{ij} = 1/a_{ij}$, where $i \neq j$ and $a_{ij} = 1$ (see Appendix C).

To find vector ω, we used the model:

$\mathbf{A}\ \omega = \lambda\ \omega$

where:

ω = the eigenvector (of order n)

λ = the eigenvalue.

Lambda max ($\lambda_{max}$) represents the total size of the matrix λ = n. However, to satisfy the vector ω and avoid human judgement we used the equation:

$\mathbf{A}\ \omega = \lambda_{max}\ \omega;\ \lambda_{max} \geq n$

The difference between n and $\lambda_{max}$ is that if the $\lambda_{max}$ = n, then the judgements of the responds are inconsistent (for explanation of the Analytic Hierarchy theory see Mu & Pereyra-Rojas 2017).

For the final step, the consistency ratio (CR) was calculated to analyse how consistent were the responses of the participants. If the CR exceeds 0.1, the judgements may be considered inconsistent. The value for the ratio index was obtained from the table of values suggested by Saaty (1987).

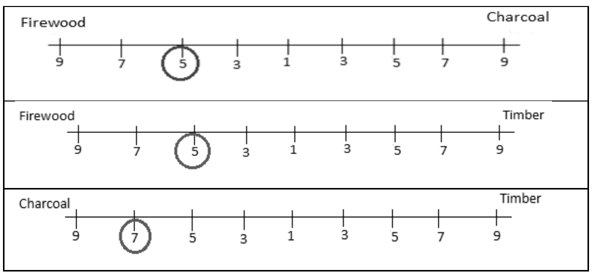


Fig. 1. Simulated scale of preferences of the priority resources of the stakeholder surveyed

Table 1. Simulated preferences of the stakeholders

| Values | Charcoal | Firewood | Timber |
|---|---|---|---|
| Firewood | 1 | 1/5 | 5 |
| Charcoal | 5 | 1 | 7 |
| Timber | 1/5 | 1/7 | 1 |
| Total | 31/5 | 47/35 | 13 |

$$CI = \frac{\lambda\, max - n}{n - 1} \tag{1}$$

where:

*CI* = Coeficiente index

$\lambda_{max}$ = Lambda max

n= represents the total size of the matrix

$$CR = \frac{CI}{RI} \tag{2}$$

where:

*CR* = consistency ration

*RI*= consistency index of a random-like matrix

## RESULTS

The dynamic of miombo forest in Angola has been less studied or demonstrated (Romeiras et al., 2014; Delgado-Matas, 2015; Goncalves, Goyder, 2016; Goncalves et al., 2017) and discussions on the optimization and management priorities for forest products harvesting are missing. The present survey found out that a majority of respondents rely on charcoal to satisfy their basic energy needs and data collected from reports indicate that the production of charcoal has been increasing every year since 2008 (Fig. 2). Similar studies that show the increase of production and commercialization of charcoal come from Mozambique and Malawi (Feuerbacher et al., 2016; Smith et al., 2017; Vollmer et al., 2017; Zorrilla-Miras et al., 2018). However, as the source of domestic energy people tend to use rather a combination of gas (LPG) and charcoal than charcoal alone (Fig. 3).

By using normal calculation of percentages, from the total number of respondents, 43.3% prefered to manage for firewood claiming that firewood is the main source of energy in the village, while 35% prefered charcoal. Timber represented 17.54% of the preferences. The rest (4.06%) were undicided in their answers if charcoal or firewood. However, by using AHP, charcoal was 68.64%, firewood 20.98%, and timber 6.41% on the

Table 2. Priority vector normalised relative weight

| Value | Firewood | Charcoal | Timber | Priority values |
|---|---|---|---|---|
| Firewood | 0.1613 | 0.1489 | 0.3846 | 0.2098 |
| Charcoal | 0.8065 | 0.7447 | 0.5385 | 0.6864 |
| Timber | 0.0323 | 0.1064 | 0.0769 | 0.0641 |

λmax (Lambda max) = 3.057; CI (consistency index) = 0.0283; CR (consistency ratio) = 4.88%

preferences scale (Table 2). The rest (about 3.96%) was for undecided answers/unclear answers on the respondents' priority choice. Based on the priority scale, it can be seen that timber is not the first priority of people living around miombo area. The preferences of the respondents were not directly proportional to gender. However, the consistency index (0.028) of the respondents was quite low which means higher consistency in respondents' answers. It is important to note that consistency index does not mean getting an answer closer to the 'real' life solution. It only means that the ratio estimated in the matrix is closer to respondents' answers.

The respondents' age was not related to the preferences of households on the management of forest resources (mean = 42, standard deviation (SD) = 10.8). After dividing the respondents into two groups: (1) those with 0–1 years of schooling ($n$ = 17) and (2) those with 2–5 years of schooling ($n$ = 77), we found a significant difference between the two groups ($P$ < 0.010). The respondents with 2–5 years of schooling preferred charcoal and were better informed about the charcoal market in the cities.

**DISCUSSION**

Knowing the preferences of local population on the resources, forest management planning in which the main interest of the stakeholders is included can be established. The application of AHP to the data collected from Bié province showed that charcoal is more important than firewood and timber. The local government has failed to eradicate charcoal production and our results clearly indicate how miombo forests should be managed. The judgement of the actual situation on charcoal production is an unacceptable and the dramatic degradation of miombo forest cannot be stopped unless we find alternative sources for domestic energy and good management systems. In the long term, creation of reserve areas like communal forest for charcoal and timber production, where government can support local communities through subsidies to forest owners who are willing to conserve these areas, can be a good strategy for future management planning.

The involvement of people living around the miombo area into the management planning has frequently been practiced (Yolasıgmaz, Keles, 2009; Larsen, 2012; Mutune, Lund, 2016). The evidence of participatory forest management (PFM) policies is widespread in India and Nepal. In Africa, the most relevant studies were done in Tanzania, Kenya, and Ethiopia (Gilmour et al., 2007; Mbwambo et al., 2008, 2012; Ameha et al., 2014; Frank et al., 2017; Vollmer et al., 2017). Our results showed that property right is one of the key incentives for participatory forest management because people are only willing to conserve what belongs to them. Agrawal, Gupta (2005) on another hand argued that communities only participate in decisions on forest resources management when property rights are well-defined in the country. The participatory management planning (PMP) in Angola has not yet been applied and the combination of PMP with MCDM represents a poten-

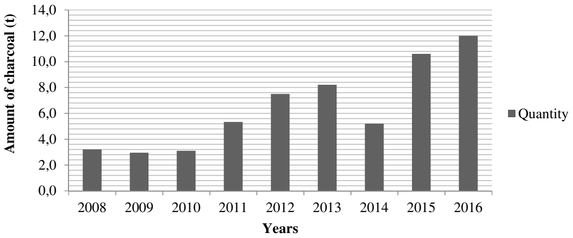


Fig. 2. Production of charcoal in Bié province in 2008–2016 source: IDF reports

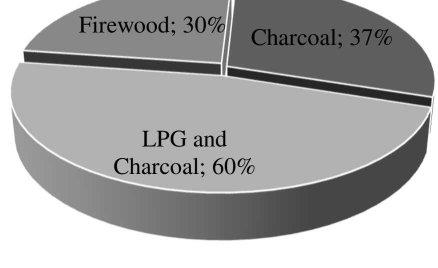


Fig. 3. Response of the local population over the main source of cooking energy

tial method for future studies because we now know the preferences of local people on what resource to manage for. Households in these miombo woodlands depend on a mixture of activities to meet livelihood needs while timber is not the main concern.

## CONCLUSION

No matter which management method you take, one has to realise that miombo must be managed for multiple purposes and there will always be conflicts in setting priorities for communities. The application of the AHP to the data collected in Bie province clearly indicated that researches on local communities should be prioritised when it comes to take decisions for the entire forest community. Most of Angola's environmental policies and forestry law were adapted from other countries and based on colonial-era legislation. Currently the forestry sector has no clear policy for forest management though conservation and proper management of forest ecosystems in Angola is a moral responsibility for future generations. To change the perception of local communities concerning their participation in resources management, elevating the education level of local population is of utmost importance.

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## Appendix A. Reports used in the study

| Title | Author | Year | Type of document* | Content of the report |
|---|---|---|---|---|
| Report of activities related to year 2010 | IDF/Bié | 2011 | report | records of data on charcoal production |
| Report of activities related to year 2009 | IDF/Bié | 2010 | report | records of data on charcoal production |
| Report of activities related to year 2008 | IDF/Bié | 2009 | report | records of data on charcoal production |
| Report of activities related to year 2011 | IDF/Bié | 2012 | report | records of data on charcoal and firewood production |
| Report of activities related to year 2012 | IDF/Bié | 2013 | report | records of data on charcoal production |
| Report of activities related to year 2013 | IDF/Bié | 2014 | report | records of data on charcoal production |
| Report of activities related to year 2015 | IDF/Bié | 2016 | report | records of data on charcoal production |
| Angola: NEPAD-CAADP Bankable Investment project profile | FAO/NEPAD | 2005 | project report | revitalization of forestry sector |

*documents are accessible in the Institute for Forest Development in Bié province

Appendix B. Questionnaire survey directed to local people living in a radius of 4 km from the forest

Village______________ Age ______________ Gender ______________________________

**General aspects**

1. How long do you live in this village?

______________________________________________________________

2. What is your level of education? Mark the option below

◯ Primary education

◯ Secondary education

◯ High School

◯ University education

◯ Others

3. What is the distance from your village to the forest?

◯ Less the 1 hour

◯ 1–3 hours

◯ 4–6 hours

◯ Others

4. What do you use as domestic energy to cook your meals?

◯ Charcoal

◯ Firewood

◯ Electricity

◯ Gas

◯ Others

**Forest aspects**

5. How often do you go to the forest?

______________________________________________________________

6. How is the owner of the forest where you normally go and collect forest products?

______________________________________________________________

7. Mark, which forest products you gain from forest

a) Hunting, mushrooms, honey and fruits

b) Charcoal and firewood

c) Timber, charcoal, firewoo

d) Hunting, mushrooms, honey, fruits and timber, charcoal, firewood

e) Others

8. If you chose at least one of the following options (b, c, and d), then please consider ranging according to their importance to you (note that the scale goes from 1 to 9, and 9 being the highest preference)

| Preferences for comparison | 1 | 3 | 5 | 7 | 9 | 1 | 3 | 5 | 7 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Firewood vs charcoal | | | | | | | | | | |
| Charcoal vs timber | | | | | | | | | | |
| Timber vs Firewood | | | | | | | | | | |
| Others | | | | | | | | | | |

9. Could you specify in few words the reasons of your preferences?

| Items | 1 | 3 | 5 | 7 | 9 | 1 | 3 | 5 | 7 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Firewood vs charcoal | | | | | | | | | | |
| Charcoal vs timber | | | | | | | | | | |
| Timber vs firewood | | | | | | | | | | |
| Others | | | | | | | | | | |

10. What do you know about the charcoal market?

____________________________________________________

11. What would you like to manage the forest for?

◯ Charcoal

◯ Firewood

◯ Timber

◯ Others

Appendix C. Theoretical approach of Analytic Hierarchy Process (AHP)

The main theoretical approach of AHP was developed by S a t t y in 1972 (S a a t y , 1987). The description of this method can be found in springer (an introduction to the AHP) and described by Mu & P e r e y r a - R o j a s , 2017. The application of AHP is based on the analysis of preferences of the respondents and responses, which are the decision elements we compared by using a matrix of pair-wise comparisons as follows:

| | | $C_1$ | $C_2$ | … | $C_n$ |
|---|---|---|---|---|---|
| A = | $C_1$ | $\omega_1/\omega_1$ | $\omega_1/\omega_2$ | … | $\omega_1/\omega_n$ |
| | $C_2$ | $\omega_2/\omega_1$ | $\omega_2/\omega_2$ | … | $\omega_2/\omega_n$ |
| | . | . | . | | . |
| | . | . | . | | . |
| | . | . | . | | . |
| | $C_n$ | $\omega_n$ | $\omega_n$ | … | $\omega_n/\omega_n$ |

The equation 1 constitutes the importance of the attributes i and j. The matrices should contain only positive values to satisfy the reciprocal property $a_{ij} = 1/a_{ij}$, the so called reciprocal matrix **A**. Multiplying this matrix by the transpose vector $\omega^T$ $(\omega_1, \ldots, \omega_n)$, the result is nω: A ω = n ω, where **A** is the n × n comparison matrix and $\omega = (\omega_1, \omega_2, \ldots, \omega_n)_T$, A = (aij) for estimated matrix and ω for the eigenvector. The matrix **A** is consistent only if the max = a. The solution ω of this problem is any column of **A**. However, it is necessary to normalise the solutions, which is the component sum to unity.

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