Articles

Anthropogenic activities contributing to the degradation of Miombo Forest surrounding Mount Unango, Mozambique

Atividades antrópicas que contribuem para a degradação da Floresta de Miombo na envolvente do Monte Unango, em Moçambique

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ABSTRACT

The Miombo is a forest formation characteristic of northern Mozambique, suffering from intense deforestation that contributes to its degradation. This study aimed to identify the main anthropogenic activities that contribute to the degradation of a Miombo forest around Mount Unango, Mozambique. Data collection included direct observation, questionnaires, and measurement of species growth and the size of degraded areas. Data were processed using Excel 2016, and the Tukey test compared the means at 5% significance. The results indicate that agriculture contributes most to forest degradation, with 174.5 ha of deforested area, representing 61.7% of the total area. This activity involves the felling of forest species protected by law; therefore, community awareness and the introduction of environmental education policies are recommended, as well as disseminating information on the importance of sustainable forest use.

Keywords: Agriculture; Forest deforestation; Miombo forest

RESUMO

O Miombo é uma formação florestal característica da região norte de Moçambique e que sofre desmatamento intenso, contribuindo para sua degradação. Este estudo teve por objetivo identificar as principais atividades antrópicas que contribuem para a degradação de uma floresta de Miombo em torno do Monte Unango, em Moçambique. A coleta de dados incluiu a observação direta, questionário e mensuração do crescimento das espécies e do tamanho das áreas degradadas. Os dados foram processados no pacote estatístico Excel 2016 e as médias foram comparadas pelo teste de Tukey a 5% de significância. Os resultados indicam que a agricultura é a atividade que mais contribui para a degradação da floresta, com 174,5 ha de área desmatada, que correspondem a 61,7% do total da área. A prática dessa atividade inclui o abate de espécies florestais protegidas por lei, assim, recomenda-se a sensibilização da comunidade e a introdução de políticas de educação ambiental, bem como a disseminação de informações relacionadas à importância do uso sustentável da floresta.

Palavras-chave: Agricultura; Desmatamento florestal; Floresta de Miombo

1 INTRODUCTION

In sub-Saharan Africa, forests are essential in providing goods and services to rural households, offering food, medicinal plants, shade, fuel, and income. It is estimated that around 15 million people in this region earn their livelihoods from firewood and charcoal sales, small-scale wood processing, and honey trading. However, deforestation, coupled with increasing population density in the area, is a critical factor in the degradation of this forest formation (Margulis, 2003; Falcão, 2013; Ministry of Land, Environment, and Rural Development – MITADER, 2016).

Mozambique is located in Southern Africa and has an area of 799,380 km², of which natural forests cover 51%. It is one of the few countries in the region that still maintains a considerable proportion of natural forest cover; however, it has a high deforestation rate, estimated at 219,000 hectares per year (Marzoli, 2007; Sitoe; Salomão; Wertz-Kanounnikoff, 2012). According to Nube (2013), deforestation in Mozambique is associated with the population's strong dependence on natural resources, as about 80% of the total population relies on forest resources for subsistence. This dependency is tied to the slow growth of natural forests, which could soon lead to forest resource scarcity if this trend continues (Uetela, 2014). Thus, studies need to understand land-use and land-cover change processes related to forest degradation.

The factors associated with the unsustainable use of natural resources are complex, and understanding them is essential for implementing practical actions. Martins *et al*. (2002) highlighted that ecosystems and landscapes change over time and space due to vegetation characteristics and disturbance regimes. The causes and extent of deforestation and degradation vary across regions, but human activity is the main factor (Lima *et al*., 2017). Additionally, natural characteristics, including demographic aspects, forest types, agroecological conditions (Lopes *et al*., 2022), and social and political aspects are also influential. From a socioeconomic perspective, replacing natural landscapes with various forms of land use, especially under extractive economic models (Cerqueira *et al*., 2021), results in rural populations becoming small-scale exploiters with a total dependency on the forest. Following the felling of forest species, they continue to exploit the land irrationally with various types of traditional and unsustainable agricultural practices (Margulis, 2003; Ceagre, 2015).

In Mozambique, the annual consumption of wood fuels was estimated at 16 million m³, with the Miombo forest contributing 85% of the total domestic energy needs (Falcão, 2008). The annual area deforested by the family farming sector is estimated at 26 million hectares, with logging responsible for 21% of the total productive forest deforestation and forest exploitation for other purposes, accounting for 11% (Sitoe, 2005).

Thus, studies to understand the processes of land use and cover change related to forest degradation are essential. Given this, the objective is to quantify the area degraded by anthropogenic activity in a Miombo forest surrounding Mount Unango in Mozambique.

2 MATERIALS AND METHODS

The study was conducted on Mount Unango, located in the Sanga district north of Niassa Province, Mozambique (Figure 1). In the region, agriculture is the dominant activity and involves nearly all households. It is practiced manually in small family farms

under intercropping systems using local varieties (National Institute of Statistics—INE, 2011; Ministry of State Administration—MAE, 2014; Muhate, 2016).

Figure 1 – Geographic location of the study area
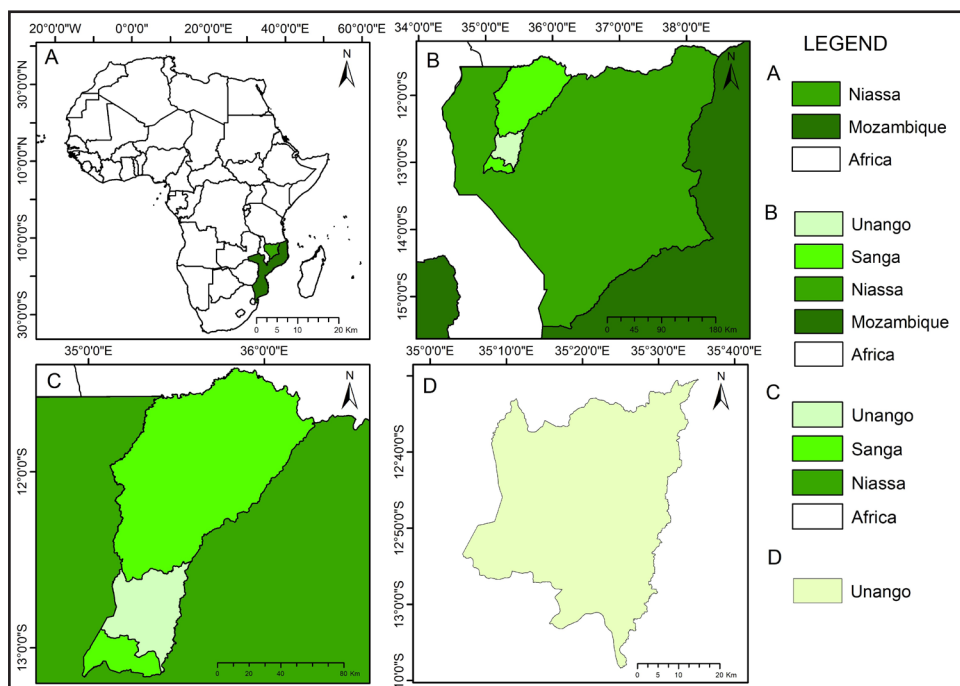
Source: Authors (2024)

Sixty sample areas were selected using non-probability sampling by convenience. During data collection, the sample units for each activity were defined in the field. The collected parameters were: i) main activities practiced; ii) main species exploited; iii) size of exploited trees; iv) number of individuals cut down for each activity; v) area degraded by activity. The degraded area size was estimated based on the extent of the forest area cleared for each operator. In assessing tree growth, only areas with a single practice were considered; in this case, logging was not considered as the activity had already occurred. Species in locations or areas where exploitation was ongoing were measured for all activities. In cases where tree felling or cutting activities had been completed, the stumps were counted. Finally, the area was divided by the number of occurrences.

The data were analyzed using SPSS and Microsoft Excel, where the mean values of the degraded plots, DBH (Diameter at 1.30 m above ground level), the total height of felled species, and species occurrence frequency were determined. An analysis of variance was conducted, with the means compared using Tukey's test at a 5% probability level.

3 RESULTS

3.1 Main activities and species involved

In the 60 areas studied, 21 forest species were identified for various activities (Table 1).

Table 1 – List of species involved in activities conducted on Mount Unango, Mozambique

| Species	Classification	Purpose
Afzelia quanzensis	1st Class	Timber exploitation
Amblygonocarpus andongensis	2nd Class	Charcoal production and stake production
Annona senegalensis	Non-Commercial	Agricultural exploitation
Berchemia zeyheri	Precious	Stake production
Brachystegia boehmii	2nd Class	Charcoal production and stake production
Brachystegia longifolia	2nd Class	Charcoal production and stake production
Brachystegia spiciformis	2nd Class	Charcoal production and stake production
Brachystegia utilis	2ª classe	Charcoal production and stake production
Brachystegias sp.	2nd Class	Agricultural exploitation
Cassipourea malosana	2nd Class	Charcoal production and stake production
Combretum imberbe	1st Class	Charcoal production and stake production
Khaya nyasica	1st Class	Timber exploitation
Mangifera indica	Non-Commercial	Agricultural exploitation
Protea sp.	2nd Class	Charcoal production and stake production
Pterocarpus angolensis	1st Class	Charcoal production and stake production
Rinorea ferrugínea	2nd Class	Charcoal production
Rinorea ferrugínea	2nd Class	Stake production
Sterculia quinqueloba	2nd Class	Charcoal production and stake production
Strychnos spinosa		Agricultural exploitation
Swartzia madagascariensis	1st Class	Charcoal production and stake production
Uapaca kirkiana	3rd class	Charcoal production and stake production

Source: Authors (2024)

The sole operator in the community utilizes species from the 1st class: *Pterocarpus angolensis*, *Afzelia quanzensis*, and *Khaya nyasica*, as stipulated by the Forestry and Wildlife Law (Law No. 10/99 of 7 July).

– Production of stakes (used for firewood, construction and housing rehabilitation, tobacco curing, and brick firing).

– Agricultural exploitation: The community cuts all species within the agricultural production area, except for certain fruit-bearing species such as *Annona senegalensis*, *Strychnos spinosa*, and *Mangifera indica*, and others used for shade, like *Brachystegia* spp.

Charcoal production and stake production for construction are the main activities carried out in the study area, and they involve the use of native forest species. Agricultural practices and logging for timber purposes complete the list of activities (Figure 2).

Figure 2 – Activities conducted around Mount Unango, Mozambique, involving the use of forest species
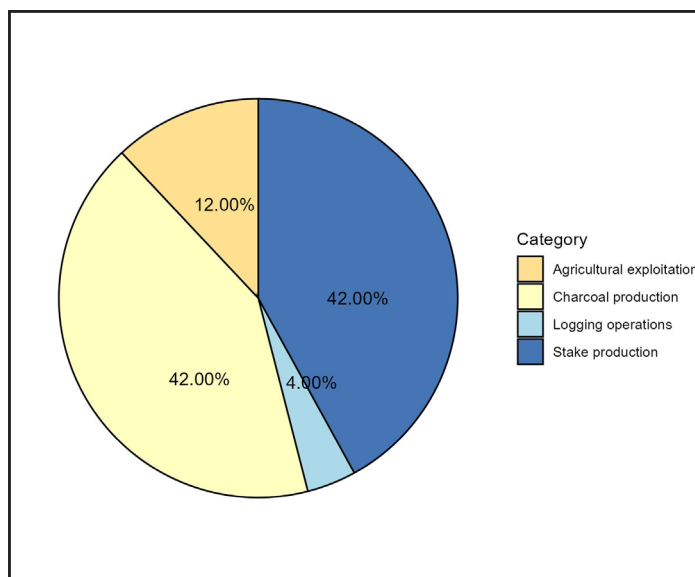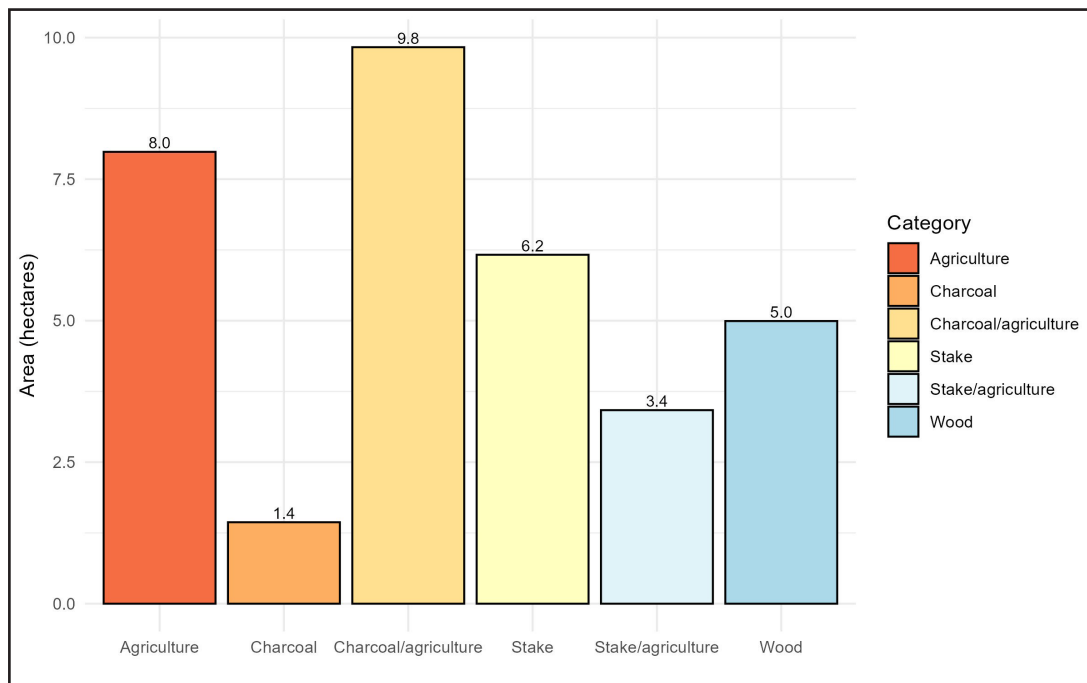

Source: Authors (2024)

3.2 Degraded area size by activity

Of the 60 areas studied, 16 (equivalent to 9.83 ha) were cleared for charcoal production and later used for agricultural activity. In contrast, 7.62 ha (30 sample units) were used exclusively for this purpose, representing 61.7% of the total (Figure 3). On the other hand, only four sample areas, covering 1.44 ha, were used solely for charcoal production (Figure 2). In terms of the number of trees that felled per activity, agriculture resulted in the highest number of trees cut, with an average of 79 trees falling (ranging from 24 to 196 trees). On the other hand, charcoal production used an average of 13 trees per kiln, ranging from 4 to 29 depending on kiln size. For stake production, between 7 and 44 trees were used, with an average of 15 trees, while logging activities had a maximum of three trees felled per area.

Figure 3 – Area size by activity around Mount Unango, Mozambique

Source: Authors (2024)

Agricultural production is the activity practiced by the most significant number of families, occupying about 50% of the total area. Of this percentage, 27% refers to

charcoal production, converted into agricultural land. Following this, stake production (8%), charcoal production (7%), and logging (5%) are the activities occupying smaller areas, along with a stake production area (3%) that is later repurposed for agricultural use.

3.3 Growth of species used in forest degradation

The areas used for charcoal production showed the largest DBH (25.2 cm), followed by agricultural areas (21.4 cm) and stake production areas (10.3 cm). On the other hand, there was no significant difference in total height between the areas exploited for charcoal production (11 m) and agriculture (14 m); however, in areas exploited for stake production, the species had the lowest height (6 m).

3.4 Local population's awareness of changes in forest structure around Mount Unango

All 60 study participants stated they did not have authorization or a license for forest exploitation and had never attended meetings on disseminating the Forestry Law. Furthermore, they are not organized into groups or associations, hindering the authorities' support and monitoring.

The majority of respondents (66.7%) reported having observed changes in forest structure characteristics. They noted that trees are increasingly distant from the village due to deforestation. Despite acknowledging this, the community continues to clear the forest, citing a lack of alternatives for their subsistence.

3.5 Contribution of activities resulting from forest degradation to household income

The local community relies on the forest for their livelihood, collecting the following main products: medicinal plants, wild fruits, small wild animals, firewood and charcoal, construction materials, and engaging in agriculture. Family farming is

the activity that contributes the most to community income, at about 48.3% per year, followed by charcoal production (41.7%) and stake production (5%). A small proportion (5%) indicated they needed clarification on the most profitable activity, as it varies yearly depending on factors such as rainfall levels and pest and disease occurrences, among others (Figure 4).

Figure 4 – Contribution of activities to community income
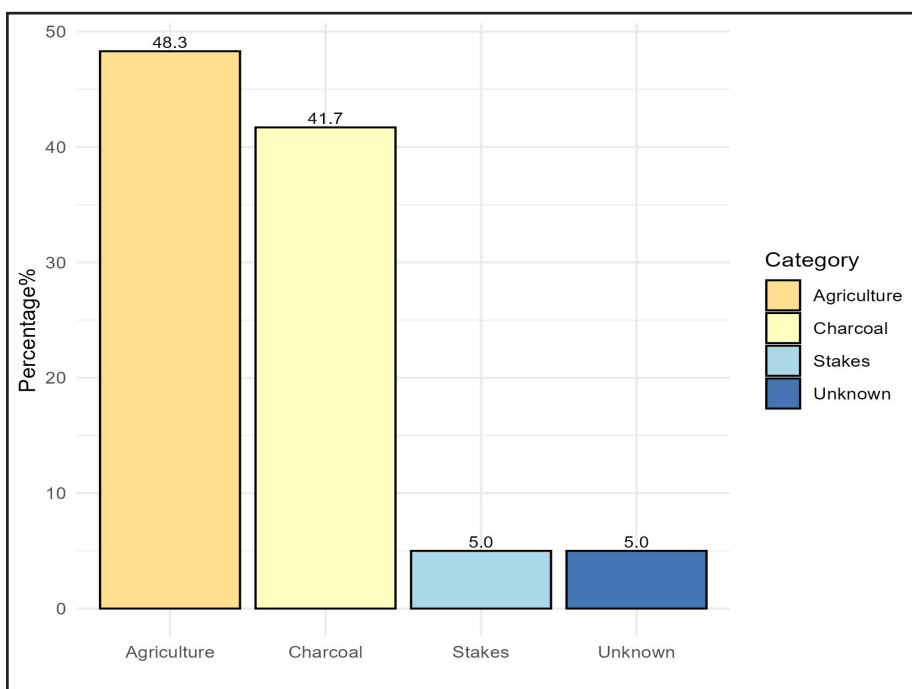
Source: Authors (2024)

5 DISCUSSIONS

This study observed violations of good natural forest management practices. Local communities use valuable species for charcoal production and stakes, as well as felling others to clear land for agriculture, contrary to national legislation and contributing to forest degradation. The Forestry and Wildlife Law (Law No. 10/99 of 7 July) stipulates that only 4th class species should be used for charcoal production. Individuals from other classes are permitted only for poorly shaped trunks that cannot be used for timber purposes.

Charcoal production and sales are among the most profitable activities in Mozambique. The study by Chidumayo and Frost (1996) shows that charcoal production provided an average income of $70 to $140 per month for each family involved in this activity. Therefore, there is a need to promote alternative income sources for rural communities to reduce pressure on forest resources.

Although practiced on smaller plots (below 0.5 ha), agriculture is the activity that contributes most to forest degradation. This is because it is practiced by nearly all families in the community. This result aligns with the study by Sitoe *et al*. (2012), which identifies logging, subsistence agriculture, uncontrolled burning, and mining as the activities that most contribute to forest degradation in Mozambique. Similarly, Ceagre (2015) points out that the shifting agriculture models practiced by the family sector are responsible for deforesting about 65% of the area annually.

Analyzing deforestation from 2003 to 2013, Muhate *et al*. (2016) found that the Miombo forest was highly pressured by shifting agriculture and forest exploitation for firewood and construction materials. Therefore, more effective policies are needed to raise local community awareness of the importance of forest preservation, thus ensuring the sustainability of this resource and conservation through use.

6 CONCLUSIONS

Agriculture is the activity that contributes most to forest degradation around Mount Unango, followed by charcoal production, stake production, and logging, which involve the felling of forest species protected by law. However, agriculture and charcoal production are the most profitable activities for the communities. Therefore, initiatives are needed to ensure alternative income sources for families to reduce pressure on forest resources. It is recommended that community awareness be raised on the use of legally recommended species, environmental education policies should be introduced, and information on the importance of sustainable forest use should be disseminated.

REFERENCES

CENTRO DE ESTUDOS DE AGRICULTURA E GESTÃO DE RECURSOS NATURAIS - CEAGRE. **Identificação e análise dos agentes e causas directas e indirectas de desmatamento e degradação florestal em Moçambique**. Relatório final. Maputo, 2015. 10 – 20p.

CERQUEIRA, M. C.; MATRICARDI, E. A. T.; SCARIOT, A. O.; OLIVEIRA, C. H. Fragmentação da paisagem no entorno e na Reserva de Desenvolvimento Sustentável Nascentes das Geraizeiras, Minas Gerais. **Ciência Florestal**, v. 31, p. 607-633, 2021.

CHIDUMAYO, E. N.; FROST, P. G. Population biology of miombo trees. *In*: CAMPBELL, B. (Ed.). **The miombo in transition: woodlands and welfare in Africa**. CIFOR, Bogor, 1996. 59 – 71p.

FALCÃO, D. M. S. **Produção e Consumo Doméstico de Combustíveis Lenhosos em Moçambique**. Dissertação. Universidade Nova de Lisboa. 2013. 15 - 26p.

FALCÃO, M. P. Charcoal production and use in Mozambique, Malawi, Tanzania, and Zambia: historical overview, present situation and outlook. *In*: KWASCHIK, R. (Ed.) **Proceedings of the "conference on charcoal and communities in Arica"**, UEM, Maputo. 2008. 4-6p.

INSTITUTO NACIONAL DE ESTATÍSTICA (INE). **Censo Agro-pecuário 2009-2010: Resultados Definitivos – Moçambique**. INE, Maputo, 2011. 17-21p.

LEI DE FLORESTAS E FAUNA BRAVIA. Law n.º 10/99, of July 7th. Annex I, n. 1 of article 11. Maputo 1999. 22-24p. Available at: https://gazettes.africa/archive/mz/1999/mz-government-gazette-series-i-supplement-no-4-dated-1999-07-12-no-27.pdf

LIMA, B. C.; FRANCISCO, C. N.; BOHRER, C. B. A. Deslizamentos e fragmentação florestal na região serrana do Estado do Rio de Janeiro. **Ciência Florestal**, v. 27, n. 04, p. 1283-1295, 2017.

LOPES, R. V. R.; SILVA, M. D.; ALMEIDA, N. V.; FERREIRA, G. R. D. Supressão e fragilidade de remanescentes florestais em uma Unidade de Conservação, na região sul de Alagoas, Brasil. **Ciência Florestal**, v. 32, n. 3, p. 1479-1499, 2022.

MARGULIS, S. **Causas do desmatamento da Amazônia brasileira**. 1ª edition. Banco Mundial. Brasília, 2003. 22-36p.

MARTINS, S. V.; RIBEIRO, G. A.; SILVA JUNIOR, W. M.; NAPPO, M. E. Regeneração pós-fogo em um fragmento de floresta estacional semidecidual no município de Viçosa, MG. **Ciência Florestal**, v. 12, n. 1, p. 11-19, 2002.

MARZOLI, A. **Relatório do inventário florestal nacional**. Direcção Nacional de Terras e Florestas, Ministério da Agricultura. Maputo, Moçambique, 2007. 60-63p.

MINISTÉRIO DA ADMINISTRAÇÃO ESTATAL (MAE). **Perfil do distrito de Sanga província de Niassa.** 2014. 5p.

MINISTÉRIO DA TERRA, AMBIENTE E DESENVOLVIMENTO RURAL – MITADER. **Estratégia Nacional para a Redução de Emissões de Desmatamento e Degradação Florestal, Conservação de Florestas e Aumento de Reservas de Carbono Através de Florestas (REDD+) 2016-2030.** Maputo, 2016. 10-11p.

MUHATE, A. Coord. **Desmatamento em Moçambique (2003 – 2016)**. Direcção Nacional de Florestas. Maputo, 2016. 22p.

NUBE, T. G. **Impactos Socioeconômicos das Plantações Florestais em Moçambique: Um Estudo de Caso na Província do Niassa.** Dissertação, Universidade Federal do Paraná. Curitiba. 2013. 14p.

SITOE, A.; SALOMÃO, A. E.; WERTZ-KANOUNNIKOFF, S. **O contexto de REDD+ em Moçambique: causas, actores e instituições**. Publicação Ocasional. CIFOR, Bogor, Indonesia, 2012. 26 – 36p.

SITOE, T. A. **Agricultura familiar em Moçambique estratégias de desenvolvimento sustentável**. *In*: MINAG, Maputo, Moçambique. Normas Técnicas Agrícolas, 1ª edition. 2005. 25p.

UETELA, A. E. **Dinâmica e Prognose de Produção de uma Floresta de Miombo Utilizando Matriz de Transição**. Dissertação, Universidade Federal do Paraná. CURITIBA. 2014. 23-24p. Available from: http://www.floresta.ufpr.br/pos-graduacao/defesas/pdf_ms/2014/d687_0180-M.pdf

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