



Indigenous versus exotic tree species used in silviculture and agroforestry: An overview from Burundi Seed Centre data.

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Abstract

In Burundi, natural ecosystems are found mainly in protected areas and indigenous species seem to be scarce in silvicultural and agroforestry programs. The indisputable enthusiasm of the population to use Eucalyptus has already completely transformed the Burundian landscape. The present study aims at analyzing the extent of the exotic species use versus indigenous by different stakeholders, among them the Government of Burundi. Sales statistics (2012-2021) from the Burundian Office for the Protection of the Environment seed bank were analyzed. The study revealed that out of 23 species, seeds of only three indigenous tree species are sold. The latter corresponds to 27% of the total seed weight, representing only 0.11% of the total seed number. Eucalyptus div. sp. are the most dedicated to silvicultural programs with 99.63% of total seeds; no indigenous tree species is known for silviculture in Burundi. Concerning agroforestry, indigenous species are represented by *Maesopsis emenii*, *Markhamia lutea* and *Polycias fulva* totaling 29.03 % of total seed weight, equivalent to only 1.17 % of the total seed number. The most used species are exotic, namely *Grevillea robusta*, *Calliandra calothyrsus* and *Cedrella serrulata*, representing 57%, 25.43% and 11.36% of total seed number respectively. Likewise, the Government programs as well as other stakeholders are choosing seed species in the same way. This study showed the exclusive use of exotic species in silvicultural where Eucalyptus div. sp. have won over foresters and the general population due to their rapid growth, high productivity and regeneration regardless soil quality. The present study confirms the quasi-exclusive use of exotic tree species in silvicultural and agroforestry programs by different actors. Our findings suggest the need to seek for alternative indigenous tree species to promote. Relevant policies should be revised and implemented accordingly for the soil conservation and ecosystem restoration as well as reforestation.

Keywords: Burundi; agroforestry; silviculture; exotic species; indigenous species

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Introduction

In Burundi, the species used in reforestation are quasi exclusively exotic. However, this does not

reflect global trends, with indigenous species accounting for three quarters of the species used in artificial reforestation (FAO, 2010). Leakey and

Newton (1992) believe that "*Cinderella species*" are being ignored by researchers and farmers in developed countries who have only mastered a handful of exotic species that they have domesticated for decades (even centuries). It is thought that the relatively low level of domestication of tropical species can be explained by the high tropical biodiversity, allowing to satisfy the needs without great efforts to invest in production (Palmer, 1992).

Obviously, this is not the case in Burundi even though the domestication is also very low. Since the 1930s, forestry research in the Great Lakes region (of which Burundi is) by the colonial administration was guided by the urgent need to meet the country's timber requirements. Exotic species were chosen instead of dense forest indigenous species considered as expensive for artificial reforestation in the ecological conditions of the Great Lakes region (Pouilloux, 1992; Hicintuka, 2009). The slow growth of these indigenous species constitutes the major challenge for their use in plantations (DELigne, 1992) . Thus, the choice was made to use exotic species, which are considered to grow more quickly. The colonial administration opted for several species but according to literature, *Eucalyptus* quickly seduced the foresters and the whole population (DELigne, 1992). *Eucalyptus* species were chosen for their rapid growth, their high productivity and their less demanding in terms of soil quality and maintenance (DELigne, 1992 ; Hicintuka, 2009). Henceforth, the *Eucalyptus* became and remains the first choice and the first aspiration of the population (MEEATU, 2012; OBPE, 2020). A status quo was then established: exclusive use of exotic species whose seedlings are easy to produce in nurseries and whose behaviour in reforestation is mastered. However, recent studies have already elucidated that *Eucalyptus* trees such as *E. grandis* have a huge impact on soil acidification and the decrease of exchangeable soil phosphorus stock (Guedes, 2016). This would explain why Burundi has just banned the use of *Eucalyptus* in swamps and areas near water sources (Ministère de l'Environnement de l'Agriculture et de l'Élevage, 2018).

The purpose of this study was to investigate the use of exotic versus indigenous species in

reforestation programs in Burundi. The proportions of exotic species were analysed in the agroforestry system which should be relatively different as some indigenous tree species like *Ficus div. sp.*, *Dracaena.*, *Polycias fulva*, etc. are encountered in agro-systems. Also, in this study, the seed sales statistics of the Seed Centre from the Office Burundais pour la Protection de l'Environnement (OBPE), which is the only formal structure that sells silvicultural and agroforestry seeds in Burundi were analysed. It was acknowledged that other sources of seed supply from individual collectors exist but are expected to be of minimal importance. This study analyzes the extent to which different actors, including the Government of Burundi, use exotic versus indigenous species. Specifically, this study seeks to (i) identify the different tree species whose seeds are sold by OBPE's Seed Centre with a focus on (ii) the proportions of exotic versus indigenous seeds, (iii) determine the choices of exotic versus indigenous seeds by the different actors (buyers). The study is based on the hypothesis that the seed species available and sold are essentially exotic.

Materials and Methods

The study was carried out at the Seed Centre of the Burundian Office for the Protection of the Environment (OBPE). The Seed Centre deals with the production, conservation, conditioning, distribution and management of silvicultural and agroforestry seeds in Burundi. Seeds of various silvicultural and agroforestry species are purchased from individual collectors, who generally own plantations. These seeds are sold by Seed centre to the various actors (among them farmers, associations and institutions, both public and private) throughout the year. These seeds are sold after being tested for germination rate as they are supplied by collectors from various parts of the country and under uncontrolled conditions. After the germination tests, these seeds are directly stored in the cold room to preserve their viability.

Data collection

To conduct this study, sales records from OBPE's Seed Centre were used. These data allowed the

determination of the different tree species whose seeds are sold, their quantity in terms of weight and number of seeds, the status of origin (exotic or indigenous) and the relative preferences of the buyers. A ten-year period was selected, from June 2012 to June 2021.

Data analysis

Seed sales data were recorded using an Excel spreadsheet before being subjected to analysis. The analyses made it possible (i) to determine different trees species whose seeds are sold by the Seed Centre, (ii) to evaluate the proportions of different species according to their origin status (indigenous or exotic) and their buyers (the different actors). The weight was estimated on the basis of records of sales for each species over the study period. The seed number was estimated based on the number of seeds per kg.

Results

Types of seeds of plant species sold

The results in Table 1 show the seeds of species available and sold by the OBPE's seed center over

the past ten years in terms of weight and number of seeds. Considering the weight of the seeds, the species most preferred by different actors are (in order of their importance): *Calliandra calothyrsus* (43.84%), *Maesopsis eminii* (26.33%), *Grevillea robusta* (13.09%), *Eucalyptus* div. sp. (7.78%) and *Cedrela serrulata* (1.78%) which total 92.85% of the total weight of seeds sold over the whole period of the year.

Considering the number of seeds (evaluated on the basis of the weight of seeds sold of each species), the different species of *Eucalyptus* div. sp. are largely dominant (90.54% seeds). The other relatively better represented species are: *Grevillea robusta* (5.19%), *Calliandra calothyrsus* (2.31%) and *Cedrella serrulata* (1.03%), which when added together do not even add up to 10%. Regarding exotic versus indigenous species, exotic species represent 73% of the weight (against 27% of indigenous species) while considering the number of seeds, exotic species take 99% of the seeds (Table 1)

Table 1. Weight and number of seeds per species sold by the Seed Centre of OBPE from June 2012 to June 2021

	Species	Total Weight	Weight (%)	Seeds (%)
Exotic species	<i>Eucalyptus</i> div. sp*	3083.785	7.78	90.55
	<i>Grevillea robusta</i>	5190.19	13.09	5.20
	<i>Calliandra calothyrsus</i>	17381.95	43.85	2.32
	<i>Cedrella serrulate</i>	706.07	1.78	1.04
	<i>Callitris calcarata</i> *	320.5	0.81	0.28
	<i>Cassia siamea</i>	690.4	1.74	0.17
	<i>Leucaena diversifolia</i>	356.35	0.90	0.15
	<i>Leucaena leucocephala</i>	414.45	1.05	0.06
	<i>Cupressus lusitanica</i> *	42.95	0.11	0.05
	<i>Cedrella odorata</i>	105.95	0.27	0.03
	<i>Passiflora edulis</i>	182.783	0.46	0.03
	<i>Moltinga oleifera</i>	639.14	1.61	0.02
	<i>Terminalia superba</i>	5.25	0.01	0.00
	<i>Pinus patula</i> *	0.04	0.00	0.00
	<i>Terminalia mentaly</i>	0.25	0.00	0.00
	<i>Macadamia integrifolia</i>	14	0.04	0.00
<i>Acrocarpus fraxinoli</i>	0	0.00	0.00	

	<i>Pinus oocarpa</i> *	0	0.00	0.00
	sub total	29134.058	73.49	99.89
	<i>Maesopsis eminii</i>	10438.8	26.33	0.07
	<i>Polycias fulva</i>	12.1	0.03	0.02
	<i>Markhamia lutea</i>	57.3	0.14	0.01
	<i>Acacia mangium</i>	0.8	0.00	0.00
Indigenous species	<i>Acacia mearnsii</i>	0.15	0.00	0.00
	<i>Acacia albida</i>	0	0.00	0.00
	<i>Acacia auriculiformis</i>	0	0.00	0.00
	<i>Acacia melanoxylon</i>	0	0.00	0.00
	sub total	10509.15	26.51	0.11
	TOT		100	100

Choice of exotic versus indigenous seeds by the various actors

The actors in the field of forestry and agroforestry are mainly farmers, non-governmental organizations and government programs. For the latter, it is the National Reforestation Program which was replaced in 2018 by the *Ewe Burundi Urambaye* Project (meaning 'How forested is Burundi!'). Our results show that exotic species are almost the only ones used by all actors: 99.94% of seeds for the government and 99.90% for other actors. The Government mainly uses

exotic species such as *Eucalyptus* div.sp (90.31% of seeds number), *Callitris calcarata* (2.68%) and *Grevillea robusta* (2.28%), *Cedrella serrulata* (2.55% of seeds number). The figures are similar for the other actors: *Eucalyptus* div. sp (90.55% of seeds number), *Grevillea robusta* (5.20%) and *Calliandra calothyrsus* (2.32%).

In addition, indigenous trees species are under-represented among all stakeholders: they have only 0.06% of seeds number (Government) and 0.08% (other stakeholders) (Table 2).

Table 2. Weight and number of seeds per species sold according to the actors' preferences (* is specifying silvicultural species, remaining species are for agroforestry)

Species	Government		Other actors	
	Weight (%)	Seeds (%)	Weight (%)	Seeds (%)
Exotic				
<i>Eucalyptus</i> div.sp*	11,8	90,31	7,78	90,55
<i>Callitris calcarata</i> *	11,66	2,677	0,81	0,28
<i>Cedrella serrulata</i>	6,66	2,55	1,78	1,04
<i>Grevillea robusta</i>	8,73	2,28	13,1	5,2
<i>Cassia siamea</i>	10,8	0,69	1,74	0,17
<i>Cupressus lusitanica</i> *	2,01	0,62	0,11	0,05
<i>Leucaena diversifolia</i>	3,35	0,36	0,9	0,15
<i>Calliandra calothyrsus</i>	5,82	0,2	43,85	2,32
<i>Passiflora edulis</i>	2,8	0,11	0,46	0,03
<i>Cedrella odorata</i>	1,05	0,09	0,27	0,03
<i>Leucaena leucocephala</i>	0,97	0,04	1,04	0,06
<i>Terminalia superba</i>	0,37	0,005	0,01	0

<i>Pinus patula*</i>	0,01	0,004	0	0
<i>Macadamia integrifolia</i>	0	0	0,04	0
<i>Moringa oleifera</i>	0	0	1,61	0,02
<i>Terminalia mentaly</i>	0	0	0	0
Subtotal	66,03	99,936	73,5	99,9
Indigenous				
<i>Maesopsis eminii</i>	33,89	0,06	26,33	0,07
<i>Markhamia lutea</i>	0,08	0,004	0,14	0,01
<i>Polycias fulva</i>	0	0	0,03	0,02
Subtotal	33,97	0,064	26,47	0,08
Total	100	100	99,97	99,98

Choice of plant seeds used by the National Reforestation Program versus the Ewe Burundi Urumbaye project

The results in Table 3 show that the *Ewe Burundi Urumbaye* Project used the seeds of exotic trees species (99.91% of seeds almost in the same way as the National Reforestation Program (PNR,

99.9%). *Eucalyptus* has decreased: 97.15% of seeds for the PNR against 94.41% for the Project *Ewe Burundi Urumbaye* (Table 3). Despite the low proportions of their uses, there was a tendency of increased use of indigenous trees species, 0.01% of seeds for the PNR and 0.09% for the *Ewe Burundi Urumbaye* Project.

Table 3. Quantity (weight and number of seeds) of seeds purchased by the Government through the National Reforestation Program (2012 to 2017 and *Ewe Burundi Urumbaye* project (2018 to August 2021)

Species	NR Program		<i>Ewe Burundi Urumbaye</i> project	
	Weight (%)	Seeds (%)	Weight (%)	Seeds (%)
Exotic				
<i>Eucalyptus</i> div. Sp*	32.02	97.15	13.34	94.42
<i>Grevillea robusta</i>	12.74	1.32	5.03	1.21
<i>Cedrella serrulata</i>	4.14	0.63	0	0
<i>Calliandra calothyssus</i>	28.33	0.39	0.58	0.02
<i>Callitris calcarata*</i>	2.8	0.26	13.88	2.95
<i>Leucaena diversifolia</i>	2.04	0.09	0.12	0.01
<i>Cupressus lusitanica*</i>	0.43	0.05	1.13	0.32
<i>Leucaena leucocephala</i>	2.87	0.05	0.40	0.02
<i>Cedrella odorata</i>	1.00	0.03	0.40	0.03
<i>Passiflora edulis</i>	1.27	0.02	0	0
<i>Cassia siamea</i>	0.45	0.01	15.89	0.94
<i>Pinus patula*</i>	0.01	0.00	0	0
<i>Terminalia superba</i>	0.13	0	0	0
<i>Terminalia mentaly</i>	0.00	0	0	0
Sub total	88.22	99.99	50.76	99.91

Indigenous

<i>Maesopsis eminii</i>	11.78	0.01	49.13	0.08
<i>Markamia lutea</i>	0	0	0.12	0.01
Sub total	11.78	0.008	49.24	0.09
TOT	100	100	100	100

Discussion

In this discussion, focus is on the % of seed number (instead of weight) because seeds are of more relevant to seedling production (Nkengurutse *et al.*, 2016). It is hypothesized that the seed species available and sold at Seed Centre of OBPE are essentially exotic. Our findings support this hypothesis. Out of 25 species available, only 8 are indigenous (and 17 exotic species). It was observed that even the eight indigenous species were sold in very small proportions (only 1.08% of the total number of seeds); the rest (99.89%) was represented by exotic species.

By linking the analysis of the origin status (indigenous versus exotic) and the vocation of the species (forestry versus agroforestry), the results revealed the almost exclusive use of *Eucalyptus* div. sp. With its 90.54% of seeds number being of *Eucalyptus*, the rest of the species represent only an infinitesimal fraction: *Callitris calcarata* (0.282% of the seeds) and *Cupressus lusitanica* (0.050%). While noting that all of these species are exotic, our findings confirmed the complete absence of indigenous species in silviculture (reforestation) programs in Burundi.

Concerning the agroforestry species, greater diversity of species used (20 species) among which *Grevillea robusta*, *Calliandra calothyrsus*, and *Cedrella serrulata* was noted. In the same way as for the silvicultural sector, the main agroforestry species were all exotic. However, it is important to note that all the indigenous species reported in this study are all agroforestry. *Maesopsis eminii* is the most represented although it is only 0.06% of the total seeds. In general, indigenous species account for less than one percent of the seeds sold at the Seed Center. We believe that this is probably underestimated, although indigenous species are still largely underutilized in both silviculture and agroforestry. For example, in January 2021, thousands of *Prunus africana*

seedlings were distributed to the local population around Kibira national park (Pers. Obser.). However, the seeds should have been obtained from local collectors and thus, escaped to the formal statistics from Seed Centre. This should be the case for some other seeds but the Seed Centre is still main source of the country.

When analyzing the evolution over the time of the Government through the National Reforestation Program (2012-2018) and the *Ewe Burundi Urambaye* Project (2018-2021), it was noted that the trends have not changed significantly. Nevertheless, *Ewe Burundi Urambaye* Project has tentatively decreased *Eucalyptus* div. sp (94.14% of the total seeds) when compared with the National Reforestation Program (97.15%).

Our findings support the previous studies reporting *Eucalyptus* species to be the first choice of Burundian farmers for reforestation (silviculture) (MEEATU, 2012;OBPE, 2020). The extension of *Eucalyptus* div. sp. cultivation has also been reported in several regions of the world such as Spain, Portugal and Morocco (Quezel *et al.*, 1990). Concerning agroforestry seed species, only *Maesopsis eminii*, *Malkamia lutea* and *Polycias fulva* were used in small proportions.

The slow growth rate of these indigenous species would have been a barrier to their use. These species could also have been underutilized because they are not well known (DELigne, 1992). It is important that research focused on domestication studies of indigenous species be undertaken and strengthened. These studies would to provide agronomically interesting species for silviculture and agroforestry. Moreover, the research should describe the seedling production and field monitoring techniques for better valorisation of these species.

Conclusion

The present study aimed to contribute to the sustainable conservation of natural ecosystems and indigenous species in Burundi through an analysis of the extent of the use of exotic species versus indigenous species by the various actors including the Government of Burundi. Our results have shown that there is an almost exclusive use of exotic species by various actors including the government of Burundi in national reforestation programs. Research should aim to reverse the covering of natural forest landscape from artificial landscape with exotic species to indigenous trees. The use of indigenous species is a lesser evil to safeguard the forest landscape while boosting the production of the wood that the country so badly needs. It would also reduce the harmful effects of exotic species on water, soil and biodiversity. It is recommended that researchers should get involved in promoting the use of indigenous trees species in agroforestry; research should also focus on multi-use agro-

forestry species (improving soil fertility, honey, food, medicine, etc.) and fast growing. The government should plan extension programs and use of local trees species in the creation of woodlands and indigenous agro-forestry species in the restoration of ecosystems and the general population should adhere to programs aimed at the sustainability of indigenous species and contribute to the conservation of biodiversity.

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