



ACIAR PROJECT FST/2019/128

Determining wood quality of 'other' Fijian forest resources with potential suitability for EWP

*Coconut and other non-traditional forest
resources for the manufacture of
Engineered Wood Products (EWP)*

Prepared by
Iliesa Koro
Ministry of Forestry

Table of Contents

1.0	Introduction	1
2.0	Methodology.....	1
3.0	Results & Discussion	1
3.1	Forest Resources in Fiji	1
3.2	Fiji’s Plantation Forests	3
3.3	Properties & Potential Uses of Selected LKS.....	6
5.0	Conclusion.....	7
6.0	References	8

1.0 Introduction

Fiji's forest resources are categorically classified into two main classes; native forests of mainly indigenous species, and plantation forests of exotic softwood and hardwood species (Leslie & Tuinivanua, 2010). In the 1950 to the early 1960s, the Forestry Department currently known as the Ministry of Forestry; administratively managed native forests whilst establishing softwood plantations on grassland areas, and hardwood plantations on logged-over native forests (GoF, 2007). Fiji Pine Limited and Fiji Hardwood Corporation Limited have since being established to manage pine and mahogany plantations respectively in Fiji (Leslie & Tuinivanua, 2010).

The last forest outlook study in Fiji indicated that native forests predominantly supplied wood for almost half a century (from the 1950s), but the decreasing supply of native species and subsequent maturity of softwood and hardwood plantations in the turn of the new century provided a seamless transition from the supply of native to exotic wood for the Forestry Sector (Leslie & Tuinivanua, 2010).

Furthermore, market trends reveal that the exploitation of commercially valuable timber species such as *Swietenia macrophyllum*, *Pinus caribaea*, *Albizia saman*, *Endospermum macrophyllum*, *Agathis macrophyllum* etc., due to the insatiable demand from domestic and international consumer markets, has meant that many of the plantation, native forests, and even private woodlots are being exploited unsustainably (FAO, 2010). Lesser Known Species (LKS) in Fiji merit attention because of the growing appreciation of their importance in the sustainable management of tropical forests, and of their potential for forest plantations (Barany *et al.*, 2003).

The Timber Utilization Division under the Ministry of Forestry was tasked with determining the properties and potential uses of about 31 LKS that are made up of all native species. Similar work had been implemented over the course of a decade in Bolivia and Peru whereby lesser known species were studied and marketed (Padulosi *et al.*, 2014).

Many forest concessions in the tropics can contain various timber species, yet only a handful are ever harvested commercially, due to their being no current market demand for the LKS (Padulosi *et al.*, 2014). Many of these LKS species characteristics are simply not even known, and could perform just as well as many of the traditionally harvested species (Ogle & Nhantumbo, 2006).

The aim of this report is to establish the knowledge and understanding of wood properties such as density, heartwood/sapwood proportion, and mechanical properties, etc. of LKS in Fiji.

2.0 Methodology

This report was consolidated from the results of wood property studies (sawmilling, natural durability, treatment, wood-working, etc.) on nine select Lesser Known Species (LKS), inventory & production data's from the National Forest Inventory (2007), Fiji Hardwood Corporation Limited (2021) & Fiji Pine Limited (2021) respectively. Also, sawmill returns of mahogany from all licensed sawmillers in 2020-2021 and export data on mahogany gathered by the Ministry of Forestry's online licensing system were also used in the compilation of this report.

3.0 Results & Discussion

3.1 Forest Resources in Fiji

The National Forest Inventory of 2006 and Permanent Sample Plot Measurements from 2010-2018 showed that there were 899,398 ha of natural forest, of which 670,300 ha were lowland (below 600 m altitude) and 229,098 ha upland forest (Alder, 2020). Native forests make up about 75% of Fiji's forest cover while pine

and mahogany plantations make up 11% and 8% respectively; and mangroves make up 6% of the forest cover (Figure 1).

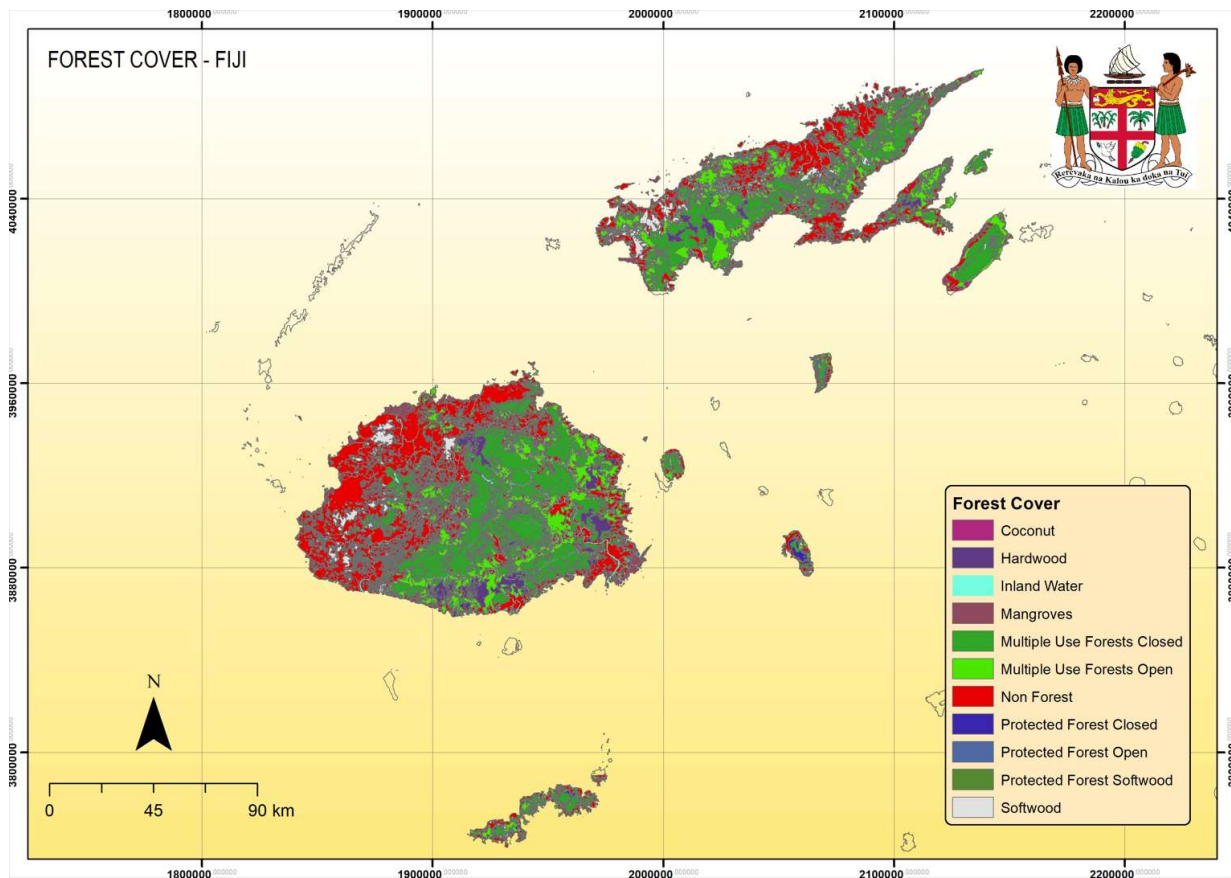


Figure 1: 2021 Forest Cover Map for the Fiji Islands

Close to 85% of the production forest in Fiji is accounted for by the 34 indigenous softwood and hardwood commercial timber species (Alston, 1982). The table below (Table 1) shows the national log production of native, and a few exotic species that include mahogany, pine and rain tree from 2009 to 2019.

Table 1. National Log Production Statistics (2009-2019)

Timber Species	2009 (m ³)	2010 (m ³)	2011 (m ³)	2012 (m ³)	2013 (m ³)	2014 (m ³)	2015 (m ³)	2016* (m ³)	2017+ (m ³)	2018** (m ³)	2019++ (m ³)
Native timbers	56614	48814	34349	30516	38052	46775	54350	25520	43191	26771	14765
Rain tree										6312	8782
Mahogany – P										1518	2339
Mahogany – G										-	-
Pine – P										1197	32409
Pine – G										51027	-
Mahogany (FHCL)	63758	92283	93748	53202	61513	59319	57463	27017	15646	11283	19802
Pine (FPL)	249769	256040	311011	266844	382673	539069	410272	172473	192386	432058	400419
Total	373141	398137	439098	350560	482238	645163	522085	225011	251223	530066	478516

* January – July '16 + Aug '16 – July '17 **Prov Aug-July '18 ++Prov Aug-July '19

Source: MoF (2020), Note: P – private plantation; G – natural regeneration

The Timber Utilization Division (TUD) under the Ministry of Forestry started looking into the wood properties of select non-traditional forest resources or lesser known timber species (LKS) since 2012 to compliment the traditional commercial timber species. Table 2 depicts the volume of selected timber species that were recorded in the 2007 National Forest Inventory (NFI) and had consequently been included in wood properties studies at TUD.

Table 2. Lesser known Species inventory data (NFI Data)

Species	Basal Area (m ² /hac)	Volume (m ³)
<i>Spathodea campanulata</i>	49.4	239.9
<i>Dillenia biflora</i>	51.6	82.2
<i>Maesopsis eminii</i>	2.8	3.7
<i>Pagiantha thurstonii</i>	42.9	107.4
<i>Xylopia pacifica</i>	24.3	61.8
<i>Parinari insularum</i>	208.4	1040.9

3.2 Fiji's Plantation Forests

3.2.1 Fiji Hardwood Corporation Limited – Mahogany Plantations

Fiji Hardwood Cooperation Ltd (FHCL) has a total leased area of 75,223.5 ha that is located in Tailevu, Galoa, Naboutini, Baravi, Nausori Highlands, Nadarivatu and Sawakasa in Viti Levu, whilst on Vanua Levu it is located in Wainunu, Dreketi, Nararo, Seqaqa, Saqani, Korotari and Navonu (FHCL, 2021). Out of the total leased area only 41,324.9 ha was planted with mahogany, while 10,850.5 ha with other species, besides mahogany, and the rest of the 23,048.2 ha are natural forests. The table below (Table 3) shows the different tree species, excluding mahogany that is found within the different FHCL leased areas. This table accounts for major and minor (marked with *) tree species that were planted within FHCL leased areas.

Table 3. Tree species within FHCL leased areas

Species	Area (ha)
<i>Swietenia macrophylla</i>	41,324.9
<i>Anthocephylus cadamba</i>	1,960.0
<i>Cordia alliodora</i>	1,158.6
<i>Agathis vitiensis</i>	125.5
<i>Ecalyptus delglupta</i>	121.2
<i>Endospermum mycrophylum</i>	76.8
<i>Maesopsis emnii</i>	715.1
<i>Pinus caribaea</i>	790.9
Mixed hardwood	5,864.4
* <i>Araucaria</i> sp.	0.5
* <i>Corymbia citriodora</i>	0.4
* <i>Syzygium</i> sp.	1.3
* <i>Elaeocarpus grandis</i>	28.5
* <i>Tectona grandis</i>	3.4
	52,171.5 ha

The table above depicts tree species that were planted with mahogany, however, there are other tree species within these planted areas and also in the un-stocked areas, with the majority being native species. A few of these species are Aumunu (*Dacrycarpus imbricatus*), Bauvudi (*Palaquium porphyreum*), Damanu (*Calophyllum vitiensis*), Kaudamu (*Myristica castaneifolia*), Kaunicina (*Canarium harveyi*), Kuasi (*Podocarpus neriifolius*), Laubu (*Garcinia myrtifolia*), Rosarosa (*Heritiera ornithocephala*), Sacau (*Palaquium hornei*), Sa (*Parinari insularum*), Waciwaci (*Sterculia vitiensis*), Vesi (*Intsia bijuga*), Yaka (*Dacrydium nidulum*), and Buabua (*Fagraea gracilipes*).

From August 2020 to July 2021, 20,387.1m³ of mahogany logs were processed from the Central, Western & Northern Divisions in which 10,150.2m³ of sawn timbers were produced at an average recovery rate of 50% (Figure 2). Consequently in the same period, 4,155.4m³ of mahogany sawn timbers were exported while the

remaining sawn timbers (5,994.9m³) were traded locally (Figure 2). Mahogany are mainly exported for decking, guitar production and general sawn timber to the United States of America, and a few countries in South America, and Oceania Region (Timber Utilisation Division, 2021).

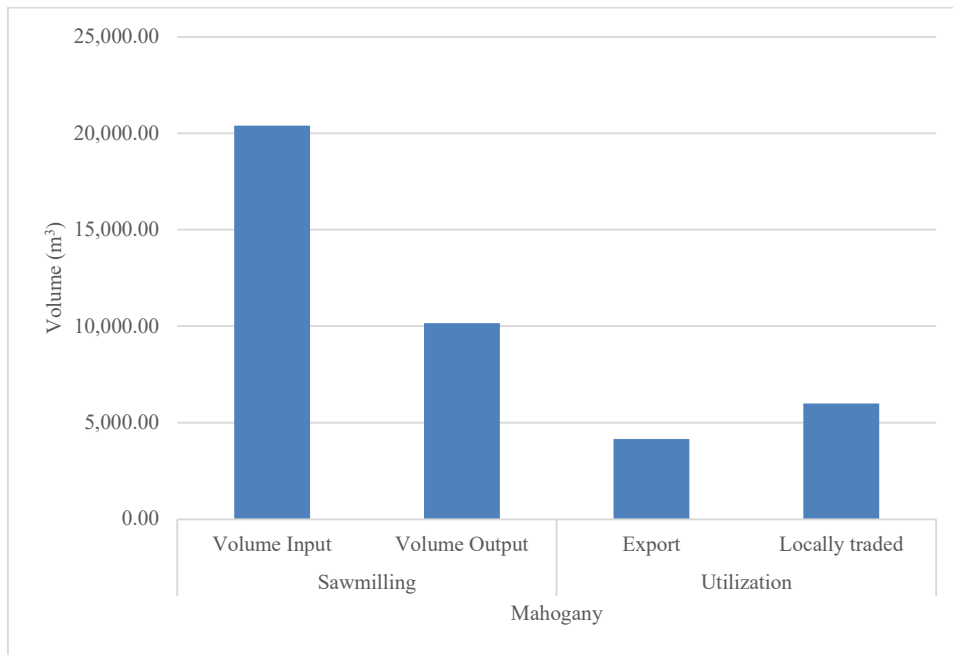


Figure 2: Mahogany sawmilling and utilization from August 2020 – July 2021 in Fiji

3.2.2 Fiji Pine Limited – Pine Plantations

Fiji Pine Group currently leases 83,545.7 ha for pine plantations and had attained FSC certification since 2013. In 2021, Fiji Pine Group produced products such as sawlogs, wood chips, posts, and poles from 551,998.8 tonnes of log supply (FPL unpublished production report). The two wood chippers in Tropik Wood Industries Limited (Drasa) and Tropik Wood Products Limited (Wairiki) produced a total of 589,283.2 tonnes of wood chips respectively but only exported 452,772.08 tonnes in 2021 to its markets in China (Hong Kong Paper Source) & Japan (OCM Fibre Trading Company Limited). The remaining 136,511.2 tonnes of wood chips were used to power the co-generation facility in Drasa (Figure 4). Sawlogs, posts, and poles contributed to 12,995.3 tonnes, 210.8 tonnes, and 849 tonnes respectively in the same period (Figure 3). Fiji Pine Limited not only exported wood chips, but also standard, F8 structural framing boards, industrial, decking, utility, mill run sawn timbers and even posts to a few islands in the South Pacific such as Kiribati, Samoa, Nauru, Vanuatu (Timber Utilisation Division, 2021).

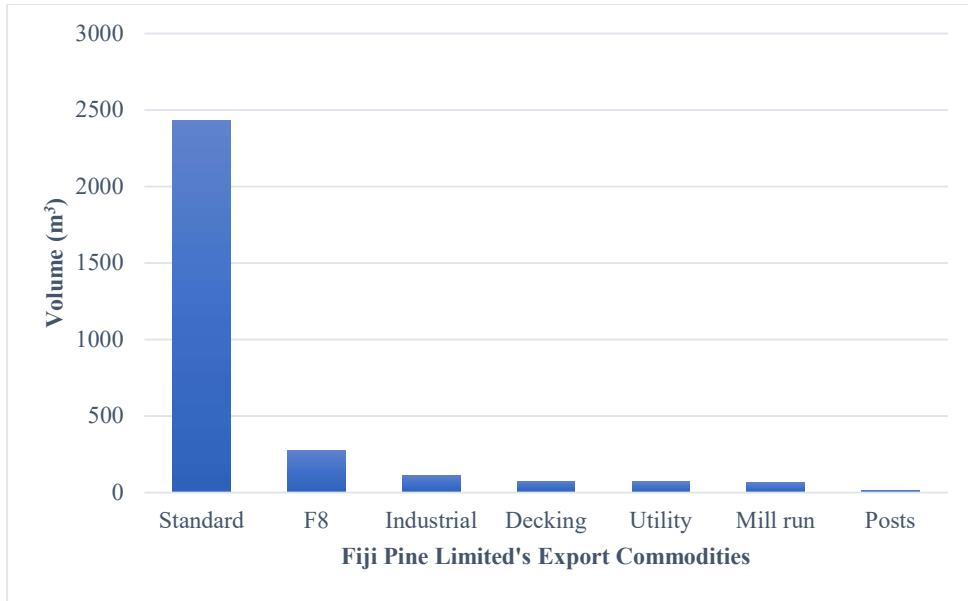


Figure 3: Fiji Pine Group of Companies Products Produced from August 2020 – July 2021 (wood chip product excluded).

Waste from Tropik Wood Industries Limited’s sawmill, post peelers, and de-barker are also used as fuel for the 27MW wood fired steam boiler (cogeneration facility) in Tropik Wood Industries to sustain its operation (Windsor Energy, 2021). The 27MW cogeneration facility also supplies 75 giga-watt hours per annum to Fiji’s national grid through a power purchase agreement with Energy Fiji Limited (Figure 4). Wood chips that were not exported, sawdust, and off-cuts are also used to fuel the cogeneration facility.



Figure 4: Tropik Wood Industries Limited Cogeneration Facility

It is not practical to specify a single timber for a particular end-use if that timber comprises only a very small percentage of the resource and is not readily available (Timber Utilisation Division & Fiji Sawmiller’s Association, 1989). Limited information on a selection of Fiji’s lesser known species that is available in Fiji Pine Limited or Fiji Hardwood Corporation Limited (FHCL, 2021) plantations is available including some fundamental wood properties data and potential uses (Dranibaka *et al.*, 2016; Dranibaka & Tabua, 2013, 2016; Kumar *et al.*, 2020; Tabua *et al.*, 2020).

3.3 Properties & Potential Uses of Selected LKS

Table 4. Selected LKS studied on its certain wood properties at the Ministry of Forestry's Timber Utilization Division & Timber Utilisation Division and Fiji Sawmiller's Association (1989)

Name	Heartwood color	Strength		Density (kg/m ³)	Shrinkage		Durability (heartwood)	Powder post beetle susceptibility (sapwood)	Suggested Building & other uses
		Green	Dry	Air dry	Radial	Tangential			
<i>Barringtonia edulis</i> (Timber Utilisation Division & Fiji Sawmiller's Association, 1989)	Pale brown to yellow brown (sapwood), or pink	S6	SD6	580	1.6	5.1	0	In trial	Building timber, moulding, dressed framing
<i>Spathodea campanulata</i> (Kumar et al., 2020)	White	-	-	605	-	-	0	Susceptible	Non-load bearing applications such as banana boxes, coffee table, artefacts
<i>Maesopsis eminii</i> (USDA Forest Service)	Bright yellow green	460-680 lbs	500-700lbs	507	2.5	4.0	1, 2	Susceptible	Flooring, exterior uses and construction of furniture
<i>Pagiantha thurstonii</i> (Tabua et al., 2020)	Light yellow wood	-	-	541	-	-	1, 2	In trial	Suitable for furniture and light construction applications
<i>Ecalyptus deglupta</i> (Dranibaka et al., 2016)	Pink to pale red-brown	S7	SD8	420	2.4	7.0	0	Susceptible	Furniture, interior joinery, paneling, etc.
<i>Tectona grandis</i> (Timber Utilisation Division & Fiji Sawmiller's Association, 1989)	Golden brown, can be grey-brown to red-brown	S6	SD6	670	1.2	2.2	1	Susceptible	Interior finishing, mouldings, photo frames, furniture etc.
<i>Dillenia biflora</i>	Pinkish brown	-	-	604	-	-	1, 2	In trial	Light construction, interior construction
<i>Xylopia pacifica</i> (Dranibaka & Tabua, 2013)	White yellowish	-	-	713	-	-	1, 2	In trial	Light construction, interior construction
<i>Parinari insularum</i> (Dranibaka & Tabua, 2016; ITTO)	Pink to red-brown	S4	SD4	751	3.0	2.0	1, 2, 3, 4	Not susceptible	Useful in high strength structural applications such as bearers and beams or decking

Barringtonia edulis, *Spathodea campanulata*, *Maesopsis eminii*, *Pagiantha thurstonii*, *Eucalyptus deglupta*, *Tectona grandis*, *Dillenia biflora*, *Xylopia pacifica*, and *Parinari insularum* were the nine LKS studied on its certain wood properties at the Ministry of Forestry's Timber Utilization Division (Table 4).

Although Kumar *et al.* (2020)'s basic density of *Spathodea campanulata* was 605kg/m³, Bispo *et al.* (2021) reported its basic density at approximately 500kg/m³ and had values of 248, 238, 377 kgfcm² for the radial, tangential and traverse directions respectively. There have not been much studies focussed on the physical & mechanical properties of the selected lesser known or used species on Table 4 elsewhere probably be due to their minor commercial importance because of inferior properties than major commercial timbers (Ofori *et al.*, 2009a; Ofori *et al.*, 2009b).

The manufacture and utilization of EWPs from non-traditional forest resources such as LKS in Fiji is a field that requires further research and development to compliment and sustain the timber industry. The Ministry of Forestry and other regulatory government agencies (such as the Ministry of Environment, Ministry of Infrastructure & Meteorological Services, Ministry of Housing & Community Development, etc.) in collaboration with stakeholders (resource owners, timber industries, universities, funding agencies, etc.) and partners such as the ACIAR Future EWP Project provides such an opportunity to lay the foundation for the manufacture, utilization and marketing of EWP to the timber industry and also to policy decision makers.

To minimize pressure on the most sought after species while increasing the productivity of harvesting operations in forests, countries such as Mozambique have identified the need to explore the potential of lesser-known timber species (Ali *et al.*, 2008; Ogle & Nhantumbo, 2006). Benefits of using and promoting lesser known timber species (LKS) is that they can often act as a substitute for more traditionally used species in terms of performance and aesthetics in most applications, but they are generally most cost effective because they are often abundant and underutilized, many LKS species have rich colours and textures that can provide new design opportunities for many industry sectors, and the use of lesser known species can alleviate pressure on the over exploited commercial timber species while increasing the economic viability of sustainable forest management (WWF, 2013).

5.0 Conclusion

In summary, there were nine non-traditional forest resources that included LKS that were studied on its wood properties at the Timber Utilization & Research Division under the Ministry of Forestry with its available research capacity. With research on wood properties on these select non-traditional forest resources still in progress, opportunities to broaden the scope of the study to also include how this species can complement the manufacture of engineered wood products (EWPs) apart from conventional sawmilling to produce sawn timbers.

The following are a list of recommendations for future wood property studies on Fiji's non-traditional forest resources (including LKS) with a complimentary engineered wood products (EWPs) focus:

- Conduct veneer processing trials on other forest resources such as *Anthocephylus cadamba*, *Cordia alliodora*, *Spathodea campanulata*, *Parinari insularum*, *Maesopsis eminii*, *Eucalyptus delglupta*, *Dillenia biflora*, *Pagiantha thurstonii*, and *Xylopia pacifica* & sawmilling trials on *Anthocephylus cadamba*, *Cordia alliodora*, *Eucalyptus delglupta*, and *Dillenia biflora* given their available volumes;
- Develop suitable EWP products for all relevant commercial timber species like mahogany, pine, *Agathis sp.*, *Calophyllum sp.*, etc. and other forest resources above; and
- Conduct fundamental wood property studies (amenability, strength tests, stress grades, shrinkage, shrinkage, gluing, etc.) in non-traditional forest resources (and EWP products) for which there are sufficient stocking/resources in plantation and natural forests.

6.0 References

- Alder, D. (2020). *An analysis of the Fiji National Forest Inventory 2006 and Permanent Sample Plot measurements 2010-2018*. Retrieved from Suva, Fiji Islands:
- Ali, A. C., Uetimane, E., Lhate, I. A., & Terziev, N. (2008). Anatomical characteristics, properties and use of traditionally used and lesser-known wood species from Mozambique: a literature review. *Wood Science and Technology*, 42(6), 453-472.
- Alston, A. (1982). *Timbers of Fiji: properties and potential uses*. Suva, Fiji Islands: Department of Forestry.
- Barany, M., Hammett, A., & Araman, P. A. (2003). Lesser used species of Bolivia and their relevance to sustainable forest management. *Forest Products Journal*. 53 (7/8): 28-33.
- Bispo, L. F. P., Nolasco, A. M., de Souza, E. C., Klingenberg, D., & Júnior, A. F. D. (2021). Valorizing urban forestry waste through the manufacture of toys. *Waste Management*, 126, 351-359.
- Dranibaka, S., Kumar, S. D., Waqanibeqa, A., Naura, S., & Kotoilakeba, T. (2016). Sawmilling and density study of *Eucalyptus deglupta* (Blume). *Fiji Agriculture Journal*, 56(1), 41-45.
- Dranibaka, S., & Tabua, K. (2013). Properties and Potential Uses of *Xylopia pacifica* (Dulewa). *Fiji Agriculture Journal*, 53(1), 30-35.
- Dranibaka, S., & Tabua, K. (2016). Properties and Potential Uses of *Parinari insularum*. *Fiji Agriculture Journal*, 56(1), 26-30.
- FAO. (2010). *Global forest resources assessment 2010*. Retrieved from Rome:
- FHCL. (2021). *Minor Species Report*. Retrieved from Suva, Fiji Islands:
- GoF. (2007). *Fiji Forest Policy Statement*. Retrieved from Suva, Fiji Islands:
- ITTO. Sa (*Parinari insularum*). *ITTO Lesser Used Species*. Retrieved from <http://www.tropicaltimber.info/fr/specie/sa-parinari-insularum/?print=true>
- Kumar, S. D., Bulai, T., Kunadei, T., & Tabua, K. (2020). The properties and potential uses of African tulip (*Spathodea campanulata* P.Beauv) in Fiji. *Fiji Agriculture Journal*, 58(1), 22-25.
- Leslie, A., & Tuinivanua, O. (2010). *Fiji forestry outlook study*. Retrieved from FAO, Bangkok:
- Ofori, J., Brentuo, B., Mensah, M., Mohammed, A., & Boamah-Tawiah, R. (2009a). Properties of 10 Ghanaian high density lesser-used-species of importance to bridge construction—part 1: green moisture content, basic density and shrinkage characteristics. *Ghana Journal of Forestry*, 25, 67-77.
- Ofori, J., Brentuo, B., Mohammed, A., Mensah, M., & Boamah-Tawiah, R. (2009b). Properties of 10 Ghanaian high density lesser-used-species of importance to bridge construction—Part 2: mechanical strength properties.
- Ogle, A., & Nhantumbo, I. (2006). Improving the competitiveness of the timber and wood sector in Mozambique. *Report prepared for the Confederation of Mozambican Business Associations under the Mozambique Trade and Investment project*.
- Padulosi, S., Amaya, K., Jäger, M., Gotor, E., Rojas, W., & Valdivia, R. (2014). A holistic approach to enhance the use of neglected and underutilized species: the case of Andean grains in Bolivia and Peru. *Sustainability*, 6(3), 1283-1312.
- Tabua, K., Rawasoi, M., Kunadei, T., & Bulai, T. (2020). Properties and potential uses of Tadalo (*Pagiantha thurstonii*). *Fiji Agriculture Journal*, 58(1), 44-49.
- Timber Utilisation Division. (2021). *Annual Report (unpublished)*. Retrieved from Suva, Fiji Islands:
- Timber Utilisation Division, & Fiji Sawmiller's Association. (1989). *A guide to the specification of local timbers for building applications*. Suva, Fiji Islands: Department of Forestry.

- USDA Forest Service. *Maesopsis eminii* Wood Technical Fact Sheet Retrieved from https://www.fpl.fs.fed.us/documnts/TechSheets/Chudnoff/African/htmlDocs_africa/Maesopsiseminii.html
- Windsor Energy. (2021). *Project Review: 27MW_{th} Wood Fired Steam Boiler*. Retrieved from New Zealand: <https://www.windsorenergy.co.nz/wp-content/uploads/2021/07/Windsor-Energy-27MW-Biomass-Boiler-Tropik-Wood-Fiji.pdf>
- WWF. (2013). *A guide to lesser known tropical timber species*. United Kingdom: Global Forest & Trade Network.