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Pacific Patent Landscaping

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1. Introduction

The Access and Benefit-Sharing Capacity Development Initiative ('ABS Initiative') has been supporting capacity development work in the Pacific region, specifically the independent Pacific Island states, since approximately 2011. This has involved a collaboration with University of New South Wales ('UNSW') researcher, Professor Daniel F. Robinson, and has been supported also by UNSW small grant funds and by an Australian Government AusAID/Department of Environment grant in 2012-2013. Much of the focus of this capacity development work has been towards the ratification and implementation of the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization* (2010) ('Nagoya Protocol'). The Nagoya Protocol was adopted by the Conference of the Parties (COP) to the *United Nations Convention on Biological Diversity (*1992) ('CBD') at its tenth meeting on 29 October 2010 in Nagoya, Japan. The Protocol entered into force on 12 October 2014. At the time of writing there are 10 Pacific Island Countries that have ratified the Nagoya Protocol: Fiji, Vanuatu, Tonga, Federated States of Micronesia (FSM), Palau, Solomon Islands, Tuvalu, Samoa, Marshall Islands, and Kiribati most recently (9 February 2021).[1]

In addition to support for ratification and implementation, the ABS Initiative has supported research that informs the implementation of better regulatory and governance outcomes for ABS, analysis of ABS-compliant supply chains, and also engagement processes with Indigenous peoples and local communities ('IPLCs') – which includes work developing 'bio-cultural' community protocols.

One area of research undertaken has been 'patent landscaping', also known as 'patent mapping'. This has been a useful tool to identify commercial and academic research and development on 'genetic resources' and their derivates, such as oils from medicinal plants and DNA sequencing and isolation of microbial or animal genes or biochemicals. The results highlight the extent and scope of patenting of these resources and emphasise the relevance of ABS systems to Pacific Island nations that have ratified, or are considering ratification of, the Nagoya Protocol. This, in turn, informs fair and equitable processes and policymaking.

2. Method: Patent Landscaping

Over several years, researchers have been mapping, or scoping the landscape of technical and legal information, used to assert monopoly rights for innovations. Bubela et al. (2013, p.202) state that, as a type of methodology, "a landscape is an analysis of the relationships between multiple sets of indicators measured against temporal, technical or spatial dimensions" and can be applied to patents, scientific articles, clinical trials, and other indicators. While they vary greatly in scale and scope, the notion of a patent landscape is increasingly used to map trends in science and technology, as industries become more knowledge-intensive or as the 'value-added' component of their production expands (see also Robinson & Raven 2017). Patent landscaping examines the filing for legal rights of monopoly by patent-holders and inventors and provides a 'map' or an array of the results. This patent mapping work is particularly interested in identifying trends in patenting 'nature' – in other words, who is filing patents on extracts or uses of plants or animals. The results provide a snapshot of legal assemblages, which highlights claims over 'innovations' and the rights allocated to them, which change temporally and spatially (Valverde 2015). While it is a quantitative methodology, our approach is to use the patent results to identify specific case studies, in order to do additional qualitative analysis about the use of particular plant species.

The research team and our collaborators have been undertaking patent landscaping as a research methodology because there is limited quantitative evidence about the scale of the problem of biopiracy, except for a limited number of case studies (see Dutfield 2004; Blakeney 2004; Robinson 2010), and reports from NGOs (see RAFI 1995), and governments (see Peruvian submissions to the World Trade Organization 2005a; 2005b; 2007). The results can have significant impacts, supporting Indigenous peoples' claims surrounding Indigenous knowledge and innovations, and influencing policymaking in several forums. With the Nagoya Protocol entering into force in 2014 and being gradually implemented around the world, it is timely to monitor and evaluate the operation of patent systems, laws, policies and regulations as they relate to genetic resources and Indigenous knowledge. Focused and purposive patent analysis can be used to identify where there is commercial use of plant species known to have associated Indigenous knowledge. Tracking patent applications over biological resources provides empirical evidence that can be used to determine how ABS standards could be implemented in nations, and if the system governing intellectual property rights ('IPR') is failing to prevent biopiracy under 'business as usual' scenarios.

Patent landscape analysis is an established methodology used by researchers examining the utilisation of biological resources in innovations registered and/or protected by a patent (Oldham 2006; Bubela et al. 2013; Oldham, Hall & Forero 2013). The most comprehensive quantitative studies relating to patents and biodiversity have been conducted at the global level by Oldham (2006; Oldham, Hall & Forero 2013). Additional relevant patent landscaping has been conducted by Lai and Robinson et al. (2019) in an extensive study of Maori Indigenous knowledge of plants endemic or near endemic to New Zealand (Aotearoa). As industries become more knowledge-intensive, and the 'value-added' component of their production expands, it is increasingly likely that commercial enterprises will invest in patents and other IPR protections in agri-food, medicines, cosmetics, and related fields that use biological resources. As has been argued elsewhere (Robinson & Raven 2017), patent landscaping analysis offers one of the primary methods to quantitatively or qualitatively understand the scope of this expansion. It is a method which allows us to look at the socio-legal and spatial aspects of specific plant species, as they transition from being traditionally used species on a relatively small scale, to being commercially used in many countries and in global supply chains for foods, cosmetics, medicines and other products.

For this patent landscaping, the scientific names (and some synonyms of those names) were then searched in a patent search tool: The Lens (previously known as Patent Lens).[2] The Lens provides a meta-search tool which can identify keywords in the main national and global patent databases. We specifically searched these species names by 'Title, Abstract and Claims' to narrow down cases where the species are specifically germane to the claims of the patent. Species were searched using the simple binomial species name in inverted commas to avoid, as far as possible, spurious 'hits' of a particle of the species name. Without access to the high-end-computing and linguistics software packages utilised by Oldham, Hall and Forero (2013), manual searches were conducted. This involved laborious visual inspection of patent search results but allowed greater qualitative analysis and interpretation of the relevance of specific results and 'hits' where a patent acknowledged use of Indigenous knowledge (as per Robinson & Raven 2017). By doing a 'structured search' in Lens, we limited the possibility of spurious mentions of the species in the patent documents or cases where it is not critical to the patent. While some of these patents may be on processes or methods of producing a product for different uses, some of them are explicitly on extracts derived from the plant biological material itself. The patents vary in terms of the field of use, the part of the plant used, the purpose of intended use, as well as many other variables. Where there are patents identified, it is noted that this does not explicitly indicate biopiracy, but it does provide an indication of commercial interest in a species. Then further detailed analysis on each patent and the claims therein is required to make further inferences about the researcher's activity. In many cases, it is impossible to identify where a researcher obtained the genetic resources and any associated knowledge. This highlights one of the gaps in the international and national regulatory regimes existing surrounding biological resources and IPR.

Because patents are often filed in multiple jurisdictions, they can be described in 'families'. The figures reported below in terms of 'patents' need to be understood as meaning all unique patents identified in all jurisdictions, whereas the term 'patent families' gives an indication of the number of discrete inventions filed. From each family there might be filings in multiple jurisdictions, for which the patent documents contain the same information. The patents and patent families might be considered 'assemblages' and expressions of 'innovation' as they bundle socio-technical information with rights and must be assessed in national phases with different jurisdictional results, with changing results over time (Valverde 2015).

In previous research, the patent landscaping results have led to case studies of particular species, whereby there may be patents 'of concern' (see Robinson & Raven 2017). In some cases, there have been opportunities to challenge these using administrative provisions in the patent laws of the countries in question. As is discussed in Robinson, Raven and Hunter (2018), an administrative challenge was previously filed by some of this research team in relation to a patent application on uses of Kakadu Plum as a cosmetic cream. This submission of evidence was successful in generating a negative report for novelty and obviousness from IP Australia, and the subsequent withdrawal of the patent application (Robinson, Raven & Hunter 2018). Provisions such as these may allow a simple challenge process for Indigenous knowledge-holders, those involved in local industries, and other concerned stakeholders that want to challenge a patent or application, either pre-grant or post-grant. In other jurisdictions there may not be these same provisions, meaning that concerned third parties must challenge patents through the courts at considerable expense and risk of counterclaim.

3. Vanuatu Patent Landscape Results

Figure 1: Butmas Village, Espiritu Santo and Matantas Village, Big Bay, Espiritu Santo, where an earlier biodiversity expedition had studied local species.
(Source: Robinson 2012)

The specific approach taken in this first patent landscape study involved identifying a number of species that are reputedly native and endemic to the South Pacific nation of Vanuatu. In total, 44 species were identified from a recent publication by Bradacs, Heilmann and Weckerle (2011) 'Medicinal Plant Use in Vanuatu: A Comparative Ethnobotanical Study of Three Islands' in the *Journal of Ethnopharmacology*. This article was chosen as an indicative (not exhaustive) review of Vanuatu's medicinal plants – one of very few that has been recently published. Our inference from using this article is not that these researchers may have triggered biopiracy, but rather that more generally the disclosure of knowledge of the traditional uses of plants by other authors, researchers or even tourists can then lead to further research and the patenting of different uses of those plants, for a range of products or methods. Of relevance to the discussion in this paper, Bradacs and colleagues acknowledge that they were given permission to conduct the research by a number of departments and ministries in Vanuatu, as required by the government (Bradacs, Heilmann & Weckerle 2011, p.447). Some of this research has been published separately in a book chapter, which was edited by the main author here (Robinson et al. 2020).

3.1 Overview of results

Table 1 below represents a new dataset from the patent landscape sample described above, using species keywords from Bradacs, Heilmann and Weckerle (2011) and by searching native and endemic species only. The research team has sorted the data to present those at the top of the table with the most patent families and has excluded species from the table that have a zero-patent count.

Table 1: Patent Landscape Results from our Sample of Traditional Medicines Identified in Vanuatu

Species Name	Local Name (approx.)	Patents	Patent Families	Known distribution (approx.)
Centella asiatica (L.) Urb. (n.c)	Gotu kola	2017	1305	Global tropics
Achyranthes aspera L.	nabudschata, nokorin	398	379	Native to Asia, now Global tropics
Morinda citrifolia L.	yalatri, yelawud, nouras	613	316	Tropical Asia, Australia and Pacific and now Global tropics
Cocos nucifera L.	lihol, natora, kau(u)ra, navara, samsam, kokonas	494	233	Global tropics
Piper methysticum	Kava, kava kava	200	132	Pacific
Vitex trifolia ssp. Trifolia L.	Limadnobnob	64	59	Southeast Asia, Melanesia
Zingiber zerumbet (L.) Roscoe ex Sm.	liwolängdob, billo	87	52	Southeast Asia, Melanesia, Polynesia and Tropical Australia
Crinum asiaticum L.	lili, naha, wael, litainbop, mamwenlake	59	41	Tropical Asia and the Pacific
Cassytha filiformis L.	(love vine)	44	40	Global tropics
Casuarina equisetifolia L.	na(m)bangura, tamanu blong, solwota, nambakura, nepugre, inmobolhat	46	36	Global coastal tropics and temperate regions
Cordyline fruticosa (L.) A. Chev.	nitschatimi, neggurrie, nara, nangaria	39	36	Eastern Asia, East Indies and South Pacific Islands to Hawai'i, now Global tropics
Macaranga tanarius (L.) Muell. Arg.	navenu, livinu, leviunu tahor, nehivaing, nevingne	54	31	Tropical Asia to Northern Australia and Polynesia
Epipremnum pinnatum (L.) Engl.	rop blong pik, nekamuro, nekaumro	14	12	Tropical Asia to Northern Australia and Polynesia
Saccharum robustum Brand. & Jesw. Ex	tschib, sugaken, pitpit	14	7	Indonesia and Melanesia
Trema orientalis (L.) Bl.	Lirpilu	6	5	Global tropics
Barringtonia asiatica (L.) Kurz	fis posentri, navele blong, solwota, nűt, neteng	5	5	Tropical Asia and the Pacific
Ficus septica var. cauliflora Burm. F.	libäla, nälmaha	6	5	Tropical Asia and the Pacific

Species Name	Local Name (approx.)	Patents	Patent Families	Known distribution (approx.)
Syzygium malaccense (L.) Merr. & Perry	nahabika, (na)kavika, negebige, hawei	5	5	Global tropics
Micromelum minutum (Forst. f) Wight & Arn.	wael pima, nerrenärre	4	4	Tropical Asia, Australia and the Pacific
Tabernaemontana pandacaqui Lam.	newawedäl, litschi, inmathethi	1	1	Southeast Asia, Tropical Australia and the Pacific islands
Garuga floribunda Decne	namalaos, neradou, namalaus	1	1	Tropical Asia to Northern Australia and Polynesia
Terminalia catappa L.	mataboa, natapoa, natalie	1	1	Tropical Asia to Northern Australia and Polynesia, now Global tropics
Ficus wassa Roxb.	Newua	1	1	Melanesia and Indonesia
Drynaria rigidula (Sw.) Bedd.	Nässäi	1	1	Tropical Asia, Australia and Pacific

From these results, some of the most commonly patented species are those that have a wide bio-geographic distribution in the global tropics and parts of Asia, as well as Vanuatu (which is part of Melanesia) and the Pacific. The research team searched native species, but this does not preclude these species (e.g. *Cocos nucifera* – the common coconut palm) being found in other countries. The research team did, however, search for endemic species and none of those species that appears to be endemic to Vanuatu appears to have been patented yet. This may be due in part to the limited biochemical research undertaken in the Pacific region to date, when compared to the extensive research being undertaken in parts of East and Southeast Asia on native species. As such, it is understandable that *Centella asiatica* – commonly known in Asia as *Gotu kola* – has been widely studied to determine its effectiveness, following its traditional use in parts of Asia as a medicinal herb. Similarly, it has been noted previously (Robinson & Raven 2017) that *Morinda citrifolia* – commonly known in the Pacific as *Noni* or *Nono*, and in Asia as Indian mulberry or cheese fruit – has been heavily researched in Asia for a range of medicinal and 'health beverage' purposes where traditional knowledge also exists. Across parts of East and Southeast Asia and the Pacific islands, there seems to be similar traditional knowledge about the use of *Noni* and this could have occurred through trade in the region or through simultaneous experimentation by traditional medicines practitioners (see for example, Whistler 1992, for a discussion of the range and variation of uses of *Noni* in Polynesia).

The closest patent 'hits' to endemic species that were searched for are the near endemic plants *Ficus wassa* and *Saccharum robustum*. These are examined in more detail below to provide examples of the scope of patent claims in relation to the species.

3.2 Analysis of near endemic species patents

The *Ficus wassa* patent identified is a World Intellectual Property Organization ('WIPO') patent with application number WO 2012/032494 A1 for a "Composition Comprising a Fig Plant Material Extract and Use Thereof in The Treatment of Benign Prostatic Hyperplasia". The applicants appear to be Swiss researchers from Geneva, and they have sought patent protection in many countries through the 1970 WIPO Patent Cooperation Treaty ('PCT'). The patent claims "a composition comprising an extract of fig plant material, preferably extract of fig leaves, and the use thereof in a method of preventing and/or treating benign prostatic hyperplasia and/or symptoms of benign prostatic hyperplasia" and lists 221 *Ficus* species which could be used in the invention. This sort of broad-range listing of species names has become a strategy by patent attorneys to widen the potential scope of the patent and to give the inventor flexibility in the way they formulate their composition. It also highlights an absurdity of the patent system - that such a broadening of the inventor's interest may occur when, in all likelihood, the real interest would be in a small number of *Ficus* species. In any case, by listing *Ficus wassa* in such a long list the patentee has diluted any real monopoly claim over-use of this species, which may be seen positively by those who utilise it currently for other purposes. In Vanuatu, Ficus wassa is reputedly used to stimulate fruiting of a watermelon plant (Bradacs, Heilmann & Weckerle 2011, p.443), which is a completely different use. However, Bradacs, Heilmann and Weckerle (2011) do note that other Ficus species more generally may include use of the inner-bark or leaf in a cold maceration taken internally for "postpartum abdominal pain", "taken internally for childhood diseases caused by spirits" and for other treatments. Despite some internal uses, there are no other commonalities between the patent and traditional uses, and so there is little likelihood of this patent impacting upon other users or other uses of Ficus species in Vanuatu (Robinson et al., 2020).

A search for *Saccharum robustum* provides 14 hits from seven patent families for this near endemic species found only in Melanesia and Indonesia, according to the Global Biodiversity Information Facility ('GBIF'). Bradacs, Heilmann and Weckerle (2011, p.443) note that a variety of *Saccharum robustum* can be used by chewing the stalk as a remedy against Ciguatera, a food-borne illness caused by eating contaminated fish. None of the filed patents resemble this use, and the majority of patents are for very specific methods and genetic manipulations of a broad range of *Saccharum* species. For example, one targets the "Isolation and Targeted Suppression of Lignin Biosynthetic Genes from Sugarcane",3 and another focuses on "Transgenic Plants for Nitrogen Fixation" in which the species is mentioned as one of many possible species to be used. It seems likely that *Saccharum robustum* – which is an isolated Melanesian species of sugarcane – has been 'lumped together' with other *Saccharum* species. It is hard to know if these patents would be problematic for any producers in Vanuatu or Melanesia, but given the narrow specificity of the patents, they seem unlikely to be problematic in terms of limiting any 'freedom to operate' in Melanesia.

The next species analysed was *Macaranga tanarius*. Some other species that are more widely distributed in Southeast Asia, Australia and the Pacific Islands have patents that show similarities with the uses described in Bradacs, Heilmann and Weckerle (2011). For example, there are a number of patents filed by the Pokka Corporation in Japan which relate to "Periodontal Bacterial Growth Inhibitor, Oral Hygiene Product, and Food and Drink"4 as well as other similar and alternative uses, all citing the use of *Macaranga tanarius*. The abstract of this above-titled patent indicates:

A periodontal bacterial growth inhibitor contains as an active ingredient Macaranga tanarius extract extracted from Macaranga tanarius with an extraction solvent including at least an organic solvent. Alternatively, the periodontal bacterial growth inhibitor contains as an active ingredient at least one selected from nymphaeol-A, nymphaeol-B, and nymphaeol-C. The periodontal bacterial growth inhibitor is used by being blended to, for example, an oral hygiene product or a food and drink.[5]

This patent is particularly interesting because the description from Bradacs, Heilmann and Weckerle (2011, p.442) indicates that a subspecies of *Macaranga tanarius* has been used as a "mouthwash with decoction" for toothache in Aneityum, Vanuatu, as well as for wounds and other treatments. The traditional healers of Aneityum had knowledge of the oral healing qualities of the plant, which is similar to the more technical "periodontal bacterial growth inhibitor" for oral hygiene concept being used in the patent. Given that this species is found in tropical Asia, Northeastern Australia, Melanesia and Polynesia, it is likely that the lead for investigation of the plant for these qualities had come from traditional uses in parts of Asia, possibly from Japan where the researchers are based. The patent document notes that the plant has a wide distribution across this region and also notes that the plants are found in Okinawa – the most southerly and tropical part of Japan. In this case, no specific inferences can be drawn except to assume that is quite possible that there might be similar traditional knowledge and uses of the plants across tropical Asia and the Pacific (Robinson et al. 2020).

This *Macaranga tanarius* example does highlight that it is not always possible to tell from a search of the patent document what the source or origin of the plant or genetic resource samples were for the research. This fact undermines ABS processes discussed earlier and has been one of the reasons that many nations have been calling for patent reform. In the WIPO Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore ('IGC'), many countries have debated the possibility of using a 'disclosure of origin' patent requirement for genetic resources and traditional knowledge, to help ensure that benefit-sharing occurs with the providers of the plant or genetic resource (see Robinson & Chiarolla 2017; Bagley 2017). However, these negotiations have been stalled for many years, with advanced economies unwilling to amend the global patent laws for fear of delays to patent filings and protections for their researchers and companies (Robinson & Chiarolla 2017).

3.3 Kava patents

It should be noted that this is not an exhaustive study of all medicinal species from Vanuatu. In another paper this research team has chosen to focus solely on the use of *Kava* (*Piper methysticum*), which has customary uses as a relaxant and has been used for a range of ceremonial purposes (Robinson et al, 2019). By searching the species name, the research team identified 200 patents (including current applications) from 132 patent families (see also in Table 2). *Kava* is thought to be endemic to Melanesia and parts of Polynesia, but Vanuatu particularly is seen as a centre of diversity, with approximately 44 local 'noble' varieties. There have been both economic and cultural concerns about the appropriation of *Kava* for decades, which have been raised by many stakeholders during our visits to countries in the Pacific Islands region. When the *Kava* patents were analysed, many of the patented uses were for very different purposes and may be related to new plant cultivars, or new uses of *Kava*. For example, there are some patents that apply *Kava* to cosmetic and skin-care applications. Other patents are more concerning, as they relate more closely to the traditional uses or the drink as a relaxant (see Robinson et al. 2019 and Figure 2).

Figure 2: Mature Kava Plants, Espiritu Santo, Vanuatu (Source: Daniel F. Robinson)

Through patent laws, one can see the transformation of *Kava* into the subject of a range of commodified inventions. Alternatively, traditional Vanuatu *Kava* origin myths and stories often speak to wider cultural notions in their customary laws and traditions (*Kastom*) about proper relations between men and women, leaders and followers, and between the living and the dead, in which Lindstrom (1997, p.129) refers to *Kava* as the "germinant corpse". *Kastom* sees *Kava* as embroiled in the linkage between death and life, fertility, and growth (Turner 2012) and was traditionally used to enhance communication with ancestral spirits (Taylor 2010; Robinson et al. 2019). Thus, as the plants travel and are traded in different places, they take on different meanings and uses. But this transformation can also potentially be culturally offensive to the original users and custodians, according to *Kastom* (Robinson et al. 2020).

4. Polynesia Patent Landscape Results

A similar patent landscape search was conducted for plant species with documented Indigenous traditional uses in the Polynesian countries. The main reference used was Art Whistler's *Polynesian Herbal Medicine,* and from that text 85 species were searched in Patent Lens using the same methods as described above. Of these 85, there were 20 species with no patent 'hits'. The total patent hits that were identified amounted to 8183 patents from 12114 patent families. The plant with the largest number of hits was *Curcuma longa* – commonly known as *Turmeric* - with 2231 patents from 2953 patent families. Clearly, *Turmeric* has widespread traditional uses throughout Asia especially and is native to India and many parts of Asia.

With such large numbers, we therefore narrowed down the search results to focus on species that were native or endemic (or near endemic to Polynesia) using the Whistler text and GBIF as reference points for native species, and these results appear below in Table 2.

Table 2: Polynesian Native and Endemic or Near Endemic Species

Species name	Patents	Patent Families	Known distribution (text)	Known distribution (GBIF/ Wiki)
Piper methysticum	200	132	Melanesia, Across Polynesia, Cook Islands, Fiji, Hawai'i, Tahiti, Tonga, Samoa	Pacific
Lagenaria siceraria	108	96	Cook Islands, Hawai'i, Tahiti	Pacific
Pandanus tectorius	71	63	Cook Islands, Hawai'i, Tahiti, Samoa	Malesia, eastern Australia, and the Pacific Islands
Cordyline fruticosa	36	33	Cook Islands, Hawai'i, New Guinea, Samoa, Tahiti, Tonga	Pacific, Asia, Australia etc
Solanum viride	35	26	Cook Islands, Melanesia, Marquesas, Hawai'i, Tonga	Australia, Pacific (tomato family)
Euodia hortensis	3	2	Futuna, Melanesia, Micronesia, Niue, Rotuma, Samoa, Tonga	Nil
Ficus prolixa	1	-	Australia, Cook Islands, Marquesas, New Caledonia, Niue, Samoa, Tahiti, Tonga	Pacific
Garcinia sessilis	1	-	Fiji, Santa Cruz Island, Samoa, Tonga	Pacific
Gardenia taitensis	1	-	America Samoa, Cook Islands, New Hebrides, Tahiti, Futuna	Pacific
Hoya australis	1	-	Australia, Futuna, New Hebrides, Samoa, Tonga	Australia, Pacific
Pipturus albidus	1		Hawai'i	Endemic, Hawai'i

Interest in species such as *Solanum viride* – a nightshade species sometimes called 'cannibal tomato' or 'necklace pepper' – has spiked in recent years, with 30 new patent applications being processed and 5 granted (see Figure 3). Of these, 14 are filed in China, 8 in Australia, 8 in the USA, and 5 through the WIPO PCT. It appears to be native to the Pacific and Australia, but there may have been occurrences in parts of Asia, or it may be introduced there. The patent applications being filed are for a wide range of medical uses, as well as for isolated useful molecules, and many of them noted multiple *Solanum* species – not just *Solanum viride*. Traditional uses in Polynesia included use of the fruit as a food, and use of the leaves for a range of skin ailments and taken internally for boils (Whistler 1994). These seem distinct from the patent claims generally, but the anti-cancer or anti-tumour activity is noted in some patents and also in some traditional Fijian uses noted by Cambie and Ash (1994).

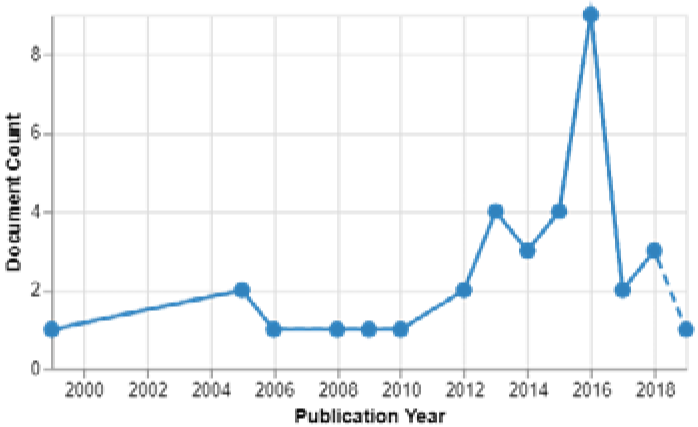

Figure 3: Solanum viride patents and applications by yearn
(Source: Patent Lens: www.lens.org)

Similarly, for *Pandanus tectorius,* which is common throughout the Pacific, and which has a range of traditional food and medicinal uses, there is a proliferation of patents and application since 2014 with 71 patents from 63 patent families found, most filed since that year. 62 patents are still at the application stage, and 68 (or 96%) were filings in China, mostly by Chinese companies and institutions. The tree can be found in tropical parts of Asia and many of the patents claim traditional medicinal uses. Whistler (1994) notes mostly traditional skin care and external malady applications, and as part of tonic mixtures as a laxative. The patent applications were for a wide range of medical uses, including some tonics claimed to be based on traditional Chinese medicines. Few, if any, seemed to accord to the Polynesian uses.

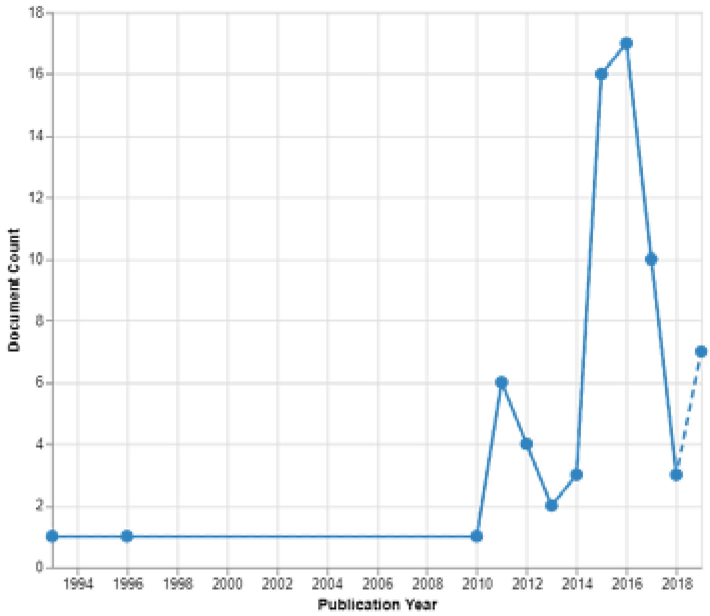

Figure 4: Pandanus tectorius patents and applications by year
(Source: Patent Lens: www.lens.org)

5. Fiji Patent Landscape Results

For the patent landscape of Fijian traditional plants, the research team used Cambie and Ash (1994) Fijian Medicinal Plants and identified 261 species from that text. The research team searched Patent Lens and identified some 2390 patents from 1720 families. For the species that were endemic or near endemic to Fiji (many of which were found to be across the Pacific, as is typically the case), a summary is set out in Table 3 below. Of these species, there are 270 patents across 196 patent families. The top hit was for *Hibiscus rosa-sinensis*, which has 193 patents from 168 patent families. The majority of these are patent applications yet to be granted (155), and the majority are filed in China (119). Typically, these patents are being filed as plant patents for new strains or varieties of ornamental Hibiscus, or for foods, drinks and other products which might use a Hibiscus extract. The plant is likely to have origins in tropical Southeast Asia, but is widespread in the Pacific, and is a well-known ornamental plant in many of the Pacific Islands and territories such as Hawai'i. It may have had traditional uses in warmer regions of China or Southeast Asia, and so traditional uses may have existed there as well.

Table 3: Fijian Traditionally used species, Native and Near Endemic to Fiji and the Pacific Region

Species name	Patents	Patent Families	Known distribution (GBIF and text)
Hibiscus rosa-sinensis	193	168	Fiji, New Guinea, New Caledonia, Niue, Polynesia, Tahiti, Tonga
Vigna marina	35	4	New Guinea, Samoa, Cook Islands, Fiji
Acalypha wilkesiana	19	12	Australia, Fiji, New Guinea
Cuscuta campestris	8	4	Fiji
Solanum uporo	5	2	New Caledonia, Rarotonga, Tahiti, Tonga
Euodia hortensis	2	1	Across Polynesia, Niue, Samoa, Solomon Islands
Commersonia bartramia	2	1	Fiji
Wedelia biflora	2	1	Malesia, South Asia, Samoa, Tonga
Pipturus argenteus	2	1	New Guinea, Solomon Islands, Tonga
Messerschmidia argentea	1	1	Funafuti Atoll, Polynesia, Samoa
Ficus obliqua	1	1	Tonga, Samoa, Fiji

Some of the plant species of interest include *Colocasia esculenta* – one of the commonly known species of *Taro* - which had 190 patent hits from 152 patent families. While *Taro* is found in much of the Pacific, including Fiji, Hawai'i, New Guinea, Samoa, and others, it is also found in Asia, and may have originated from Southeast Asia. *Taro* is a highly significant plant to Polynesians, and in Hawai'i there is a genealogical chant called the *Kumulipo* which explains the origins of people and considers *Taro* to be their 'big brother'. The crop is also highly significant as a staple food throughout the Pacific, and has an important role in subsistence farming, and as a crop that can be stored and eaten in times of food shortage (Robinson, Drozdzewski & Kiddell 2014).

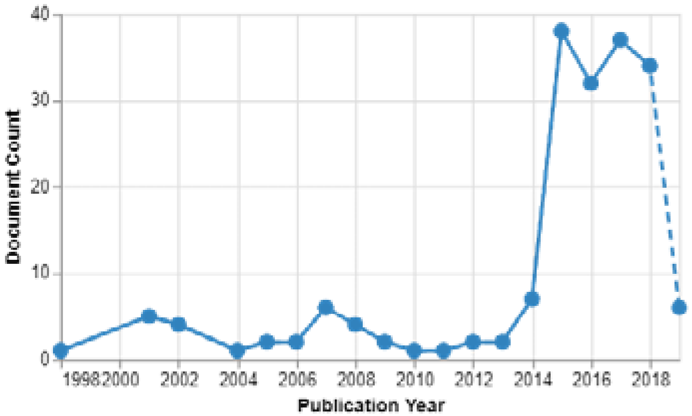

Figure 5: Taro (Colocasia esculenta) patents by year (Source: Patent Lens: www.lens.org)

Figure 5 highlights that patents and applications that mention *Taro* in their abstract, claims or title have jumped since 2014. These patents are dominated by applications from China (104), typically on food products that use *Taro* for various purposes, cultivation methods, and preservation methods, and the majority are still patent applications (133) that are not yet granted.

Another interesting species attracting significant research and development is Vigna marina, which is found in tropical coastal regions around the world, but which has some varieties that are native to the Pacific region. It has documented traditional uses in Polynesia as well as Fiji. The majority of filings are still patent applications (22). Many patent applications are attributed to Dr Graham Matheson and the company Cimtech Pty Ltd, which owns / has applied for a number of medical and cosmetic patents. This research is part of a now well-documented example, whereby the researcher, Dr Matheson, sought permissions from the Koutu Nui – a legally recognised Indigenous representative group (sub-district chiefs) – in the Cook Islands, where he learned about the traditional medicinal uses. The Koutu Nui were established as a shareholder in the company Cimtech Pty Ltd, as part of the benefit-sharing agreement, which was established to conduct the research on bone and wound healing, as well as for a cosmetic skin care product (see Robinson 2012; 2015)

6. Papua New Guinea (PNG) Patent Landscape Results

We searched 192 medicinal plant species, sourced primarily from the World Health Organisation (WHO, 2009) book, *Medicinal Plants in Papua New Guinea* and also from Woodley (1991) and other sources. We identified 24585 patent families relating to these species. However, the majority of these plant species are found in many countries throughout the tropics and parts of Asia. Many species identified were also found across the Pacific and have already been noted in the sections above. Therefore we used GBIF to narrow down to endemic and near endemic species. Of these species, there were very few that we were able to detect patents on (or relating to). The majority of these endemic or near endemic species had a zero patent hit.

A summary table of the results for endemic and near endemic species in PNG is shown below:

Table 4: PNG Traditional Medicinal Plant Patent Hits, Near Endemic to PNG.

Species name	Patent families	Patents	Known distribution (GBIF and text)
Canarium indicum	2	9	Var. indicum Papua New Guinea, Indonesia, Solomon Islands; Canarium indicum L. Indonesia, USA, Papua New Guinea, Cook Islands, Vanuatu, Singapore, French Polynesia, Solomon Islands
Pometia pinnata	2	2	P. pinnata Forst is dispersed throughout the Asia-Pacific; however, f. pinnata is found in Solomon Islands, Papua New Guinea, Samoa, Indonesia
Amomum aculeatum (Roxb)	1	1	Papua New Guinea, India, Indonesia, Malaysia, Thailand

* Ficus wassa was also identified and was reported earlier in the Vanuatu section.

The PNG patent landscape results were interesting because most of the endemic or near endemic species in PNG that have traditional medicinal uses have not been patented. This may suggest that PNG medicinal plants are under-researched by 'non-traditional' medical practitioners, scientists, universities and pharmaceutical companies. There are 47 species such as *Vaccinium keysseri* (var Schlechter) and *Solanum moszkowskii* which have no patent hits and which appear to endemic to PNG (or as is often the case PNG and West Papua province of Indonesia), or to the Melanesia region. Compare to other countries or sub-regions searched, PNG appears to have the highest degree of endemic or near endemic species that are not being patented. The 'under-researched' nature of the endemic genetic resources highlights the importance of establishing an ABS regime in PNG which could assist in ensuring that PNG has adequate systems in place the ensure permission and benefit sharing when biodiscovery R&D takes place.

7. Species of Biotrade Interest

In the most general sense 'biotrade' has come to be used to refer to trade in biological resource-based goods and commodities. These are typically plant or animal based goods that have been produced by Indigenous peoples and local communities from a range of different biomes and natural sources, and that have not been farmed on a wide scale. We use 'biotrade' here (in lower case) as a more general term than the specific uses of the United Nations Conference on Trade and Development (UNCTAD) BioTrade Initiative which follows a set of guidelines for fair and sustainable uses of the resources (also, see the Union for Ethical BioTrade or UEBT). Their capitalised use of the term 'BioTrade' is explained as:

> BioTrade is defined as "activities related to the collection or production, transformation, and commercialization of goods and services derived from biodiversity (genetic resources, species and ecosystems) according to a set of guidelines for environmental, social and economic sustainability, known as the BioTrade Principles and Criteria (P&C)" (UNCTAD, 2020, p1).

The ABS Capacity Development Initiative, and its aligned projects on ABS Compliant Biotrade in Southern Africa (ABIOSA) and BioInnovation Africa, have sought to highlight the potential importance and benefits of establishing fair and equitable ABS compliant value chains.

Value chains are inherently about linking local producers in the Global South (or 'developing countries') to international markets, from raw material producer to the final consumer (van Dijk and Trienekens, 2012). In the 'development context' the focus from researchers, development assistance and capacity building projects has often been on 'upgrading value chains' and 'progression up the value chain' (Gereffi, 2018; van Dijk and Trienekens, 2012). Gereffi (2018) explains that upgrading refers to how countries and firms try to create, capture and retain higher-value niches in the value chain through technology, product improvement, marketing and other mechanisms. In the biotrade context there can also be specific meanings for ensuring the resource is used sustainably and that workers are fairly involved and receive fair income. The UNCTAD BioTrade Initiative describe a value chain as:

> *"[r]elationships established between actors involved directly and indirectly in a productive activity with the aim of adding value in each stage of the value chain… A value chain involves alliances among producers, processors, distributors, traders, regulatory and support institutions, whose common starting point is the understanding that there is a market for their products and services. They then set out a joint vision to identify mutual needs and work cooperatively in the achievement of goals. They are willing to share the associated risks and benefits, and invest their time, energy, and resources into realizing these goals." (UNCTAD, 2020, p.2).*

From our fieldwork in the Pacific, there are several species where there is potential for biotrade value chains to develop and for 'upgrading' to enhance local community and producer benefits – indeed we saw local people value-adding plant extracts with coconut oils for the formulation of some skin-care oils/creams, for example. Coupled with potential ABS agreements, upgrading and ABS could potentially provide dual benefits for communities. Aside from Kava and several other species noted above, *Calophyllum inophyllum* and *Canarium indicum h*ave both been identified as species of biotrade interest in field studies during ABS consultations in the Pacific. *Calophyllum inophyllum* has attracted 137 patents and applications from 90 families. As noted in the PNG section there are 9 patents and 2 patent families relating to *Canarium indicum.* We case study these species with the aim of highlighting the potential importance and dual benefits of establishing fair and equitable ABS compliant value chains.

Calophyllum Inophyllum (Tamanu, Fetau, Dilo nut)

Calophyllum inophyllum is a large coastal tree that is ecologically important for coastal zone areas in the Pacific, particularly given the effects of climate change. The tree is also known as tamanu (Vanuatu), fetau (Samoa) or dilo (Fiji), and it has cultural importance in some parts of the Pacific, having been traditionally used for skin care and medicines, as well as having sacred significance and being used in *marae* (sacred communal places) in Polynesia (Whistler, 1992). The nuts of the tamanu tree are golf-ball sized spheres that propagate the tree along coastal zones and between islands in the Pacific and Southeast Asia, also making it easy for local communities to collect the nuts along beaches for use in the production of tamanu oil. It is found in the coastal tropics, native to the Pacific, Northern Australia and Southeast Asia (see GBIF 'occurrences' map below).

> The oil production process is as follows: ripe and non-germinating fruits are slightly crushed in order to crack the shells without damaging the kernels. The latter are quickly removed, arranged in thin layers and exposed to the sun. They must not be exposed to humidity in any case. In spite of these precautions, some kernels mould and must be eliminated.

Tamanu oil has been used traditionally in Polynesia for skin care and as an analgaesic and can be applied on skins and lesions. It heals small wounds such as cracks and chaps but is also reputedly effective on more serious cutaneous problems. Tamanu oil activity was studied in numerous clinical cases. Those healing, anti-inflammatory and antibiotic properties have made Tamanu oil an excellent raw material for cosmetics, and it has been studied now for some decades for use in regenerating and protective formulations (Muller, 1993).

Figure 6: Calophyllum Inophyllum L. (Tamanu) Occurrences. Source: https://www.gbif.org/species/9531830 accessed 29/6/21

Dweck and Meadows (2002, p342) explain that the:

> Tamanu kernels have a very high oil content (75%). It is obtained by cold expression and yields a refined, greenish yellow oil, similar to olive oil, with an aromatic odour and an insipid taste. Once grown, a Tamanu tree produces up to 100 kg fruits and about 18 kg oil…

Tamanu oil may also reputedly be used for different kinds of burns (sunburns or chemical burns), most dermatoses, certain skin allergies, acne, psoriasis, herpes, chilblains, skin cracks, diabetic sores, haemorrhoids, dry skin, insomnia, hair loss, and in the preparation of regenerative creams (Dweck and Meadows, 2002).

As research has progressed on this species, many companies have sought it out for use in their formulations, and indeed have filed patents relating to specific uses and formulations of Tamanu oil. In Vanuatu, we are aware of companies including reputedly Aveda (Europe), Concentrated Aloe Corporation (USA), Laboratories 220 (USA), and Pure Fiji (Fiji) researching and formulating cosmetics based on the use of tamanu oil. Smaller biotrade companies such as Tebacor Island Products (Vanuatu), the Summit (Vanuatu), Nuts and Oils Malekula (Vanuatu), and Women in Business Development (Samoa) produce and reputedly export the oil. These companies have undertaken basic value addition by extracting and distilling the oils, and mixing them to produce soaps, skin care oils and similar basic products. Given the research interest and low value-addition, there is a strong case to encourage the Pacific countries to ensure compliance with ABS regulations for these biotrade companies and their larger trading partners. Without ABS agreements in place, communities are not informed of the value chains and R&D, and they are not being made beneficiaries of high value goods. Rather, many of the producers are stuck at the basic production end of the supply chain, being paid very low rates for collection of the nuts despite being crucial to the value chain and contributing to the traditional knowledge of tamanu oil and to the conservation of the tamanu trees.

Canarium Indicum (Nangai, Galip or Nali Nut)

Canarium indicum is a large tree native and endemic to the coasts of islands and inland in Melanesia (Vanuatu, Solomon Islands and PNG) as well as Indonesia. It may be found in some other locations, or introduced, such as Hawaii (see distribution map below).

Compared to Tamanu, *Canarium indicum which is known locally as nangai (Vanuatu), nali (Solomon Islands) or* galip (PNG) nut is relatively isolated to a few countries and has been harder to produce on a commercial scale. Currently, communities in Vanuatu, Solomon Islands and PNG collect the nut and process it for its oil mostly for domestic use as a skin care treatment and analgesic, as has been done traditionally (Nevenimo et al., 2007). It is also edible and is roasted to be used as an edible snack nut or in cereals, chocolates and muesli bars. Local companies such as Solagrow (food, Solomon Islands), the Summit (skin care, Vanuatu), and Nuts and Oils Vanuatu (skin care oil) are producing it for local markets and for export. Some companies such as Concentrated Aloe Corporation (USA), have been formulating and selling the oil for use in cosmetics with larger companies, and other large companies such as Chanel have filed patents for skin care products that use *Canarium* species including *Canarium indicum* (although it is unknown if they have established a benefit-sharing agreement).[1]

Figure 7: Canarium Indicum (Nangai/Nali/Galip Nut) Occurrences. Source: https://www.gbif.org/species/5421345 accessed 29/6/2021

1 See WO 2008/145692 A2 (which appears to be pending) and related patents in the USA and other jurisdictions (which appear to be discontinued or inactive).

An Australian Centre for International Agricultural Research (ACIAR) project has sought to increase production capacity and improve the supply chain of galip production in New Britain in PNG. Professor Wallace (University of Sunshine Coast) has argued there is strong consumer demand for galip in PNG, and great potential to expand the domestic markets and develop an export market (ACIAR, 2021). Their project helped develop solar drying technologies to improve shelf-life and have helped set up a factory with new processing facilities, helping upgrade their position in the value chain. In 2017 the new factory successfully bought and processed nearly 65 tonnes of nut-in-pulp, resulting in new sources of income for more than 1300 local farmers (ACIAR, 2021). While the production of the nut is still relatively small in scale, production is gradually increasing in these countries as the demand from both local and foreign buyers stimulates local interest and opportunities.

There is a significant opportunity to protect and promote nangai and galip, given its smaller endemic range and the limited R&D and patents filed to date. Establishing ABS systems and agreements that ensure biotrade of these nuts and their oil derivatives provide benefits back to local producer/provider communities is critical. This would enable the supporting of local livelihoods and respect the traditional uses and knowledge of the nuts and oils.

8. Conclusions

From the patent landscaping results, several key themes can be identified:

First, plant genetic resources found in the Pacific are often widespread across the region and are often transported by sea to other regions, or may be found in Australasia, Southeast Asia, East Asia, or the Pacific Rim. There are rarely entirely endemic species, but there may be some local centres of diversity and locally adapted varieties of many of these species found there (e.g. *Kava, Canarium indicum).*

Secondly, traditional knowledge is also often widespread in the Pacific and may overlap between 'subregions' of the Pacific, and with Australasia, Southeast Asia and the Pacific Rim in many cases. This could make it challenging for researchers to establish benefit-sharing with 'rightful knowledge-holders' in cases where there may be multiple. This suggests the need for regional coordination on both genetic resources and traditional knowledge.

Thirdly, patent application rates for many of these species have accelerated in recent years, and this is perhaps a result of new trends in these industries, a response to regulations like those required under the Nagoya Protocol, because of the way these patent tools keep or produce records, or for other reasons. This highlights the importance of quick ratification of the Nagoya Protocol and development of national systems, so that Pacific countries are able capture and maximise research partnerships benefits.

Fourthly, Chinese researchers and filings in China are proliferating, and many of the species found in the Pacific may also be found in China naturally or as introduced species. Some of these species may have overlapping or related traditional knowledge, or the knowledge may have been traded with plants between Pacific countries and Asian traders or researchers. Chinese traditional knowledge of medicines from plants and natural products is extensive, long recorded and prominent in public use, and it is also a huge market, so it should not be a surprise that there is interest in filing in China and by Chinese companies.

Last, there are some species such as kava, *Canarium indicum,* and *Calophyllum inophyllum* which have significant biotrade markets and potential. There is also evident R&D occurring on these species and they appear to mostly be sourced from the Pacific for the R&D and biotrade supply. This presents an opportunity for the establishment of ABS-compliant value chains. On the other hand, there is the risk that local providers and producers could miss the opportunity to be beneficiaries of fair and equitable agreements with overseas (and local) researchers and partners.

It is also important to note that further research is required to fully understand the research and development being undertaken with regards to each patent. Each of these patents or applications identified do not necessarily mean that 'biopiracy' has occurred. Rather, we hope that the data supports awareness surrounding the prolific use of biological/genetic resources that have associated traditional knowledge, and that it encourages researchers and companies to consider their processes. Are they obtaining permits and prior informed consent for access? Do they have legal / and or cultural permission for the use/development of the genetic resources in their possession and what will happen if they do not? Have they established a benefit-sharing agreement with an appropriate provider group?

The biotrade case studies highlight the potential for enhancement of benefits for local communities and producers. By upgrading their products from raw material inputs to more high quality (e.g. distilled, refined or clarified oils) and formulated or marketed (e.g. beneficial skin care creams from plant based extracts and coconut oil) they are likely to receive a greater income and reach wider markets (including international and tourist markets). For these unique species of interest, there is also already interest from researchers for further development of products, triggering the need to consider ABS agreements for access to the genetic resources. As such, there is potential for dual-enhancement of the benefits to communities, through value chain upgrading and through ABS agreement.

It is also hoped that this patent landscape and biotrade case study data helps Pacific Island countries as well as other governments to consider their status with regards to the Nagoya Protocol and the CBD. Are appropriate permit systems in place? Are there clear and transparent procedures for prior informed consent? Are IPLCs also sufficiently aware and empowered to provide local prior informed consent? Is there an effective system of monitoring and compliance in place, and are there mechanisms for regional collaboration where it may be relevant?

The research team will continue to work through these questions and challenges with Pacific Island Governments and Indigenous and local communities in the region, through their ABS Initiative (2017-2022) and ARC Discovery (2018-2023) projects.

For more information on the projects, visit: https://www.abs-biotrade.info)/ and https://www.arts.unsw.edu.au/our-people/daniel-robinson.

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