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Introduction

The main objective of this assessment is to support the valorization of genetic resources (GR) and to inform the development of national access and benefit sharing (ABS) frameworks. With a view to increasing the potential benefits arising from the utilization of GR, there is a need to bridge the gap between providers of GR and their potential users in foreign countries. For this purpose, the following key elements are examined.

Section one examines developments related to the development of a national ABS regulatory framework.

In section two, an overview of the Malagasy actors potentially using or involved in R&D on GR is presented. It seeks to answer the following questions: Which actors are valorising and/ or utilising GR in Madagascar? How are they connected to each other and to foreign users? Are they capable to meet the users R&D requirements? What are the gaps?

In section three, an overview of the economic potential of the species is drawn from the separate study "Biodiversity in the Patent System: Madagascar". The main question addressed in this study is: what can patent information teach us about the range of potential economic uses of African GRand traditional knowledge (TK)?

In section four, the link between patent documents, value chains and markets is presented. Examples were selected to illustrate different types of commercialisation and to highlight the economic potential of the species. Analysis of the value or profits that have been derived from the commercialization of products based on these GR/species is beyond the scope of this assessment.

Finally, conclusions and recommendations are provided with a view to inform the development or revision of the national ABS framework and create an enabling environment for the valorization of GR. This approach seeks to answer the following questions: What are the practical steps to improve the valorization of GR within the ABS framework? What kind of business, legislative and regulatory environment is favourable for this purpose?

1. National ABS framework

Since the year 2000, Madagascar has been working on the development of a draft bill on ABS. In the absence of ABS legislative, administrative or policy measures, requests by foreign institutions to carry out bioprospecting activities in Madagascar have been addressed on a case-by-case basis.

There is no valorization strategy for GR and TK. However there are national strategies on R&D and for the valorisation of biodiversity. Other strategic processes on ABS were under development when this assessment was carried (e.g. decree on ABS).

2. Overview of Malagasy actors potentially using or involved in R&D on GR

An identification of the relevant actors for the valorization of biodiversity, including GR, has not yet been carried out at the country level. Overall, there was limited information available on the R&D

activities when this valorisation assessment was carried. This analysis is based on publicly available information that could be identified through internet research, which limits its depth, and a few interviews with resource persons.

Relevant actors are often technical intermediaries in long and complex R&D processes and hence have a limited public profile. Finally, actors that do not have an internet website could not be identified and are therefore not taken into account in the assessment.

2.1 Methodology

The methodology used to identify the actors that are potentially using or involved in R&D on GR in Madagascar was based on the following steps:

- The characteristic of the country's economy was first examined to identify the key players that could be involved in the utilization of GR (e.g. biodiversity conservation, main actors of the principal economic sectors)
- An internet search based on key words was carried out. The key words used are presented in annex one.
- When possible, interviews were realized with individuals having a good knowledge of the actors related to the utilisation of GR, R&D and the valorization of biodiversity in the country[1].
- Specific internet research for each actor was carried out to identify: area(s) of R&D, maintenance of collections (e.g. genes), potential uses of GR and any collaborations with foreign actors (as a basis for potential exchanges of genetic material). For the last two categories, a basic Yes / No / Unclear categorisation was used.
- Based on the facts compiled, 39 institutions stood out as potentially relevant for ABS as their activities are related to the utilisation of GR.

While a total of 61 actors were identified (listed in the annex two[2]), the most 39 relevant actors are examined in this assessment (and listed in annex three). This subset includes foreigners and nationals that are potentially relevant to the economic valorization of GR in Madagascar due to their activity. They are categorised as follow:

- **Actors providing GR**: they are officially designated under national legislation as institutions with mandate to provide GR

- **Actors which may utilize GR in the context of their broader activity:** it is unclear if they specifically use GR, but it is a possibility in consideration of their mission statement, activities and area of expertise. Based on very limited information available, it is not possible to formally confirm this. There are two sub-categories: public researcher institutions and other institutions (e.g. NGOs, private sector).

[1] In the case of Madagascar, Ms Naritiana Rakotomala (ABS focal point) and Ms Claudine Ramiarison (Director General for scientific research, Ministry of higher education)
[2] Considering the limited information available, further analysis may indicate that they should be integrated into the core actors concerned by ABS and the economic valorisation of GR.

- **Actors of the support environment**: they do not directly use GR but they contribute to a conducive valorization environment by providing financial, technical and organizational support to potential providers, users and other actors.

2.2 Main results: the most relevant actors related to GR

The following examines the actors that seem of particular relevance to the utilisation and valorization of GR. However, due to the lack of information, it was not possible to examine the specific areas of research, projects and the technical capabilities of these actors. Hence, although all these actors are involved in activities related to the valorization of biological resources (BR), it is unclear if and how they utilize GR.

2.2.1 National actors

- **Actor providing GR**

No institutions are designated as official provider of GR.

- **Actors which may utilize GR in the context of their broader activity**

Public Research Institutions

Since the assessment was carried, the Public Research has been structured to facilitate research on the conservation and valorisation of Biodiversity. This assessment has not been updated in this regard, but the main developments include the creation of:

- Competence center on biodiversity that gather all national research institutions

- Doctoral programs have been created (e.g. sustainable management of natural resources, agro-management). This includes the publication of a directory[3].

Three national public institutions were involved in the bioprospecting of GR as national partners to an **International Cooperative Biodiversity Groups**[4] (ICBG) project. The **Centre National d'Application de la Recherche Pharmaceutique**[5] (CNARP) carries out bioprospecting and has research departments in areas such as ethnobotany and biological chemistry. The **Centre National de Recherches Oceanographiques** (CNRO) and the **Centre National de Recherches sur l'Environnement**[6] (CNRE) collects marine organisms.

A range of national public institutions are potentially utilizing GR:

- The **FIMANOR** (Centre de Développement Rural et de Recherche Appliquée) and **FOFIFA**[7] (Centre National de la Recherche Appliquée au Développement Rural) work on applied research related to rural development. Their specificity is to develop improved varieties based

[3] www.mesupres.gov.mg

[4] The ICBG is in Madagascar since 1993. It focuses the issues of drug discovery, biodiversity conservation and sustainable economic growth. It examines through bioprospection the medicinal potential of biodiversity, including plants, animals and microorganisms. 1) www.wlbcenter.org/icbg.htm 2) www.icbg.org/groups/madagascar.php

[5] http://cnarp.recherches.gov.mg

[6] http://cnre.recherches.gov.mg

[7] http://www.fofifa.mg/

on their wild parents. They both contributed to the production of a best practice guide for ABS for non-commercial research (see details below).

- The **IHSM** (Institut Halieutique des Sciences Marines) focuses on the valorisation of marine ressource (e.g algae, marine cucumber).

- The **Centre National de la Recherche sur l'Environnement** does reseach on biodiversity conservation issues.

- The **Institut Pasteur de Madagascar**[8] does research on health issues.

- The **Silo National de Graines Forestières**[9] (SNGF) produces seeds for agriculture, forest and horticulture.

- Finally, the Ministry of Health has a **Department for Traditional Medicine** that, amongst other activities, supports traditional healers associations.

At the University level, a range of laboratories doing R&D on GR from Madagascar in the capital and in the rest of the country were identified. The departments of pharmacology and cosmetology of the **University of Antananarivo**[10] indicate that they have international collaborations with the private sector, however no further information was found regarding these partnerships. Some research departments (e.g. biochemistry, ecology, organic chemistry, entomology) also work on BR and potentially use GR. There is also the **Botanical Garden of Tsimbazaza**[11], which recently had a scientific partnership with the French consortium Sud Expert Plantes[12]. The focus of this project was the creation of a traditional botanical garden. In this case, it is possible that GR were exchanged for conservation purposes. There are also a few laboratories of relevance in the rest of the country, such as one working on the valorization of medicinal plants in Antsiranana, the laboratory of Health and Development in Fianarantsoa or the laboratory of vegetal biology in Tolianaro.

Other institutions

There are a few private actors and NGOs of particular relevance to this study. There is limited information available on private sector actors in Madagascar which may be involved in the utilization of GR. However, of particular relevance to this study, one institute and seven Malagasy companies doing R&D on Malagasy medicinal and agricultural plants were identified: **Bionnexx** [13] **,**

[8] www.pasteur.mg
[9] www.sngf-madagascar.mg
[10] http://www.univ-antananarivo.mg/Departements-Laboratoires
[11] www.sud-expert-plantes.ird.fr/writable/plugins/sep/files/85_239_JARDIN_BOTANIQUE_DE_TSIMBAZAZA.doc.
[12] The first phase of Sud expert plante (SEP) focused on taxonomy and fundamental research. The current and second phase Sud expert plante development durable (SEP2D) concentrates on operational implementation including the Nagoya Protocol. Partnerships will be developed with the private sector. www.sud-expert-plantes.ird.fr/
[13] www.bionexx.com

Homeopharma [14] **, Soamadina, Aroma forest** [15] **, LFL MADAGASCAR** [16] **,** and **TAF** [17] **.** Most have international partners and may be involved in the utilization of GR. Furthermore**, Sotramex**[18] does bioprospecting / R&D with high CSR standards as it is a member of the Union for Ethical BioTrade association[19]. Finally, the **Institut Malgache de Recherche Appliquée Fondation Albert et Suzanne Rakoto-Ratsimamanga**[20], does R&D on BR and GR.

- **Actors of the support environment**

A few actors were identified which seem to contribute and/or support the valorization of BR and possibly GR.

Two NGOs of particular relevance include: **L'Homme et l'environnement** [21] that promotes the development of extracts based on Malagasy BR, and **Jardins du monde**[22] that promotes the use of TK on local species to improve households pharmacopeia. They have partnerships with foreign cosmetic companies**.**

Furthermore, a few conservation NGOs promoting economic development based on biodiversity conservation were identified (i.e. **Fondation Tany meva** [23] **, Service d'Appui à la Gestion de l'Environnement**[24] **(SAGE), Association malgache d'ethnopharmacologie (AME),** and **L'Association AVUPMA pour la valorization et l'usage des plantes médicinales à Antsiranana**). Most of these NGO work in partnership with the private sector.

Certain actors could potentiality contribute to the valorization of GR, including the following:

- A **business association** for natural products **PRONABIO** [25] (Produits naturels et agro-biologiques) and a syndicate of the producers of extracts **SYPEAM** (Syndicat des producteurs d'extraits aromatiques, alimentaires et médicinaux).

- A **group of Organic and Fairtrade producers** [26] (Cooperation Bio Fair trade Ravinala Madagascar)

- A range of business associations that are supporting economic development : **Chambre de commerce et d'industrie d'Antananarivo** [27] **, Fédération des Chambre de Commerce et d'Industrie de Madagascar** [28] **, Fédération des Chambres de Commerce, d'Industrie,**

[14] www.homeopharma.mg
[15] www.huiles-essentielles-madagascar.com
[16] www.food-allied.com/en/
[17] www.madacamp.com/Produits_TAF_Madagascar
[18] ethicalbiotrade.org/our-members/trading-members/sotramex-sarl
[19] A non-profit association promoting the sustainable sourcing of ingredients that come from biodiversity. http://ethicalbiotrade.org/
[20] www.imra-ratsimamanga.org
[21] www.environnement-madagascar.com
[22] http://jardinsdumonde.org/?option=com_content&view=article&id=37:jardins-du-monde-a-madagascar&catid=5:madagascar&Itemid=27
[23] tanymeva.org.mg
[24] www.madagascarsage.org/
[25] http://www.sim.mg/index.php?option=com_sobi2&sobi2Task=sobi2Details&catid=8&sobi2Id=60&Itemid=16
[26] www.ravinala.mg
[27] www.cci.mg
[28] www.cci-madagascar.org

d'Agriculture et de l'Artisanat de Madagascar (FCCIAA), and **Chambre de Commerce, de l'Industrie, de l'Agriculture et de l'Artisanat** (CCIAA) **d'Antananarivo.**

- There is also the **Centre d'Information Technique et Economique**[29] (CITE) that can provide pertinent information on technical and economic issues.

No further information was found on these actors with respect to potential activities of relevance to the valorization of GR.

2.2.2 Foreign researchers that operate in Madagascar which may utilize GR

Foreign actors play a key role in Madagascar with respect to the valorization of biological diversity. There are international research institutions such as **Africa Rice**[30] and **Bioversity International**[31] which conduct R&D on food species such Rice and Banana.

The **Centre International de Recherche Agronomique pour le Développement**[32] **(CIRAD)** is actively involved in research on BR and GR. It works in partnership with national research and development institutions. In order to comply with ABS requirements, it has recently contributed with FOFIFA and FIMANOR to the development of an ABS code of good conduct for non-commercial research[33].

This document establishes various procedures for accessing GR depending on the specific circumstances of the research (e.g. access to species in local communities, access to wild / cultivated species, exportation for research purposes and material transfer agreements). It also provides a general framework for benefit sharing with the State and research partners in order to contribute to the national development. There is also a model Material Transfer Agreement. In addition, the code of conduct establishes priorities for purposes of conservation and traceability (e.g. information, communication and reporting requirements for national and foreign research partners, databases). This document has not been adopted at the national level.

The **Institut de Recherche pour le Développement**[34] (IRD) also carries R&D on BR and GR related, amongst others, to health, agricultural, nutrition and ecological issues.

Finally, since 1993 the **ICBG** has been bioprospecting in Madagascar in order to identify BR that may be of interest to drug discovery. It examines the medicinal potential of BR, including plants, animals and microorganisms. There is a new ICBG project for 2014 – 2018[35] and the most recent one was from 2009 to 2013[36]. There is limited information for the new project. Members of the previous ICBG project included:

- **Missouri Botanical Garden**[37] (MBG) **Conservation International** (CI) for on-site plant collection

[29] www.cite.mg
[30] www.africarice.org
[31] https://www.bioversityinternational.org/about-us/latest-news/news/tag-news/madagascar/
32 https://madagascar.cirad.fr
33 Code de bonnes pratiques sur l'accès aux ressources génétiques et le partage juste et équitable des avantages tirés de leur utilisation en matière de recherche dans le cadre du DP Forêts et Biodiversité à Madagascar. 2014. FIMANOR, FOFIFA and CIRAD.
34 Madagascar.ird.fr
[35] http://projectreporter.nih.gov/project_info_description.cfm?aid=7538540&icde=6660918
[36] http://projectreporter.nih.gov/project_info_history.cfm?aid=8731173&icde=6660918
[37] http://www.missouribotanicalgarden.org/plant-science/plant-science/africa/madagascar.aspx

- **Dow AgroSciences** for training CNARP for microbial strain isolation from soil samples

- **Eisai Research Institute** (ERI) and **Virginia Polytechnic Institute and State University** (VPISU) for subsequent bioassays, fractionation studies, and chemistry.

Phytotrade Africa[38], a continental business organisation, is exploring opportunities to open a branch in Madagascar. Its members make products using the species that are harvested by African rural producers. Members can access Phytotrade's expertise on R&D, market opportunities, ABS and regulatory knowledge.

2.3 Key findings

The key findings arising from the identification of actors related to R&D which may utilize GR are:

- The presence of the ICBG and their work with domestic research actors (e.g. CNARP, CNRE and CNRO) has led to the development of a national bioprospecting expertise

- A range of Malagasy private actors carrying out R&D on wild and agricultural plants may be involved in the utilization of GR. Considering the importance of the spices and medicinal plant sectors in Madagascar, there may be more companies of relevance to ABS which were not identified in this study

- A range of national NGOs with relevant experience in the valorization of BR and GR

- Presence of international institutions carrying R&D in Madagascar in collaboration with national institutions. For Instance a best practice guide on non-commercial research for ABS was published, although it is not officially adopted at national level.

A few experienced actors on the valorization and R&D on GR do arise across public research institutions, companies and NGOs. However, further analysis regarding their R&D capacity and their relationship with foreign users would help to clarify the key actors involved in activities related to the utilisation of GR.

Furthermore, the support environment seems rather limited, with only two organisations of potential relevance to the valorization of GR. A few actors identified demonstrate some potential to improve the business environment for the valorization of GR (five business associations, one group of producers). However, as overall limited information was found, it is difficult to draw any conclusions regarding their potential effectiveness in promoting the valorization of GR from Madagascar.

3. Biodiversity in the patent system for Madagascar: overview of the economic potential of the species

The separate study 'Biodiversity in the patent system: Madagascar available at: http://www.abs-initiative.info/fileadmin/media/Knowledge_Center/Pulications/Patent_Studies/Madagascar_Country_Report_14072013_complete_SMALL.pd. It presents the results of the analysis of patent activity for the country's GR and TK. Key insights are drawn from this study, related to the economic potential of species.

[38] www.phytotradeafrica.com

3.1 Species that are known to be distributed in Madagascar and elsewhere

GBIF[39] indicates 23 220 record of species for Madagascar. In total, 6 764 species names that are known to occur in Madagascar were identified in the patent data from the major jurisdictions.

> *(…) patent activity typically involves research and development that targets particular organisms (i.e. pathogens), important agricultural crops or plants that are a source of approved pharmaceutical drugs or other medicines. (Biodiversity in the patent system: Madagascar, 2013)[40].*

3.2 Species that were directly sourced from, or potentially originate from, Madagascar based on distribution data.

In total, 73 species were identified as directly sourced from or potentially originating from Madagascar (amongst these, four were examined to identify links between the patent documents with the value chains or markets). The main technology areas are pharmaceuticals, biotechnology and peptides. Some species are the focus of activity for a range of different products, technology and markets.

The top three claims in the patent documents refer to methods of producing a plant, process for producing a desired product, composition (e.g. extracts, compounds, or combination of ingredients). However the interpretation of patent claims requires careful attention to the both the type and framing of patent claims as well as where and whether the patent is in force.

The analysis based on patent citations, revealed three species (*Euphorbia hedyotoides, Ravensara anisata* and *Cedrelopsis grevei*) with potential economic development related to the patented inventions. The analysis of the patent family allowed to identify two species of importance to the applicants (*Adandosia digitata* and *Theonella swinhoei*), where further R&D partnerships could be explored.

4. Links between patent documents, value chains and markets

Out of the 73 species identified, four species were selected to illustrate different types of commercialization and to further explore the economic potential of the species. The table in annex four presents the patent documents with all the information identified on the status of the R&D and linkages with value chains and markets. Based on this data, a summary table of the patent documents examined is presented below.

In some cases this analysis uncovered additional information on the current R&D and commercial developments that can be of interest for future exploration of the economic potential of the species or the specific GR, which are also presented below, with full details in the annex four.

Finally, the existence of TK related to the species was also reported. This information was either obtained from the patent document or incidentally found during the internet search. It is important to note that the information is only about the existence of TK on the species and it is not specifically

39 The Global Biodiversity Information Facility (GBIF) is an international open data infrastructure, funded by governments. It allows anyone to access data about all types of life on Earth, shared across national boundaries via the Internet.
40 Oldham P, et al. 2013. Biodiversity in the global patent system : Madagascar

related to the innovation. However, it can be of interest for future exploration of the economic potential of the TK associated to the species.

4.1 Methodology

An internet search was conducted in order to link patent documents to value chains and markets. This consisted of the following steps:

- The analysis of the country' biodiversity in the global patent systems provides a list of patent documents of potential economic interest as they directly relate to Madagascar (see separate study 'Biodiversity in the patent system: Madagascar')
- From this list, four species, found in 400 patent documents[41], were selected using the following criteria:
    - The species that were most referred to in the patent documents, or that had a high number of patent citations[42] or large patent families[43] were analyzed in priority
    - When there were too many patent documents to examine for a same species, either a focus was given to those held by the patent assignees that hold the majority of them or in some complex cases a random selection was realized
- Finally, 15 patent documents (spanning across the four species) were selected
- Each patent document was then analysed in two phases:
    - First, in order to understand what the innovation is about, a thorough understanding of the patent document was necessary. For this purpose the analysis focussed on some sections of the patent document: title, abstract, main claims and prior art.
    - Secondly, an internet search was conducted in order to identify the status of the R&D and the presence of the GR in a value chain or on a market. For this purpose, specific key words were used (e.g. the species name, the patent assignee, the inventor, the innovation patented and the targeted market)
- When no product, service, or ongoing R&D could be found, a second search was done by visiting the patent assignee's website to identify potential R&D hints
- Finally, the following classification, with a basic Yes / No / Unclear categorisation, was devised to indicate the degree of linkages with a value chain or a market :
    - Evidence that a product or service is marketed or under active R&D (code : yes)
    - Presumption that a product or a service is marketed or under active R&D but there is no clear evidence (code : unclear)
    - No information could be found about a product, a service or active R&D (code : no)

One limitation of this approach, is that it mostly allows to access information regarding marketing activities in the 'business to consumer' segment, as information is often publicly and readily available. Other types of commercialization protected through licenses and trade secrets for example in the 'business to business' segment are difficult to capture because they are seldom publicly available.

[41] Two reasons explain the difference between the number of species and the number of patent documents. First, different organisations can hold a patent on a same species. Secondly, an inventor generally seeks to protect its innovation at different points in time as its R&D progress and also diversifies (e.g. Leo Pharma has eight patents documents on *Euphorbia hedyotoides*). There are also 332 patent documents for *Euphorbia hedyotoides*.

[42] The number of citations of a patent document in subsequent patent documents is a measure of importance and impact of that cited patent document within the patent system.

[43] A patent family is a set of patent documents that links back to an original parent filing.

Furthermore, in many cases it was difficult to confirm the presence of a species in a product due to corporate marketing practices that rarely disclose such information (e.g. rebranding of species active molecule, trademarks). Also, in some jurisdictions companies are not legally required to disclose the product's list of ingredients.

4.2 Main results

4.2.1 Linking patent documents to value chains and markets

The four species (covered in the 15 patent documents examined) were analyzed in order to identify linkages with value chains and markets. There are three plantae and one fungus. The research is mostly carried out in the pharmaceutical sector. There are also a few patent documents in the cosmetics, as well as for animal food and medicine sectors. The species are mostly used in the business to consumer segment but there are cases of business to business.

For one patent document (*Euphorbia hedyotoides*), the innovation was clearly linked to a market with a final product (a method for the treatment of chronologically-aged and/or photo-aged skin).

For nine patent documents spanning across three species the links were unclear:

- *Cedrelopsis grevei (four patent documents):* the assignee sells products in relation with the active molecules related to the patent document but the lists of ingredients are not disclosed

- *Erythroxylum pervillei* (two patent documents): a product was recently in pre-clinical studies but no further information is available. It is worth noting that Malagasy scientists were involved in the discovery process as they appear in a scientific publication related to the patent assignee. This species may be related to the ICBG activities. This could be confirmed as a next step.

- *Paecilomyces viridis* (three patent documents): The patent documents relate to a business to business application as it is a process to improve drug production. There is limited information available to confirm whether and how it is used.

For the other five patent documents no commercial outcome or ongoing R&D was found: Cedrelopsis grevei (one patent document*), Erythroxylum pervillei (one patent document), Paecilomyces viridis (three patent documents)*.

It is also interesting to note that for eight patent documents there is TK related to the species: *Cedrelopsis grevei, Euphorbia hedyotoides, Erythroxylum pervillei*. However, the link between the TK and the invention subject to the patent documents was not examined. For *Erythroxylum pervillei* there is a scientific publication on the TK.

Species	Geographical origin of the species[44]	Methodology to analyse the patent document	Kingdom	Link between the patent document and	Sector	Traditional knowledge on the species

[44] This column indicate if the patent document directly refer to the species as originating from the country (Malagasy origin) or if distribution data suggest that the species is distributed in other countries (Distributed in other countries).

				a value or a market		
Cedrelopsis grevei	Distributed in other countries	There are 23 patent documents; five were examined.	plantae	Unclear (four patent documents)	Animal food / Cosmetics	Yes
				No (one patent document)	Pharmaceutical	
Euphorbia hedyotoides	Distributed in other countries	There are 21 patent documents. One was examined.	plantae	Yes	Pharmaceutical	Yes
Erythroxylum pervillei	Malagasy origin	There are four patent documents; Three were examined.	plantae	Unclear (Two patent documents)	Pharmaceutical	Yes with scientific publication
				No (one patent document)	Animal medicine	No TK identified.
Paecilomyces viridis	Distributed in other countries	There are 13 patents documents. Six related to two patent assignees were examined.	fungi	No (one patent document)	Pharmaceutical	No TK identified.
				Unclear (3 patent documents)	Pharmaceutical	
				No (2 patent documents)	Pharmaceutical	

Table 1: links between species in the patent documents with value chains and markets

4.2.2 Wider industrial and scientific information related to the patent documents

Based on the internet research conducted it would seem that some species have economic potential beyond the value chain and markets identified in relation to the patent documents. As identified on the internet, some species are sold on-line as an ingredient part of various products. Others are potentially subject to on-going research, especially in the pharmaceutical sector.

No particular additional conclusions can be drawn from this information with regard to the valorization of GR, as it is unclear if these products or R&D are based on the GR. There is however a clear indication of the economic potential of the species. Hence, the following cases are of potential interest for further exploration:

- For *Paecilomyces viridis,* it is sold on-line: a company sells strains for biomedical research and development material on line (€428 the freeze dried strain).

- The species is potentially under active R&D

    - *Cedrelopsis grevei:* the chemical composition of the species leaves extracted in essential oil were tested for anticancer, anti-inflammatory, antioxidant and antimalarial activities[45]

    - *Euphorbia hedyotoides*: in 2012 scientists at the Scripps Research Institute have achieved the first efficient chemical synthesis of Ingenol[46]. In the same period, the

[45] Afoulous S., 2013
[46] Jørgensen L. et al, 2013

patent assignee also developed a chemical synthesis process to synthesize Ingenol[47] that is more efficient and cheaper than the extraction from the plants. The connection between these two R&D is unclear.

4.3 Key findings

Considering the small number of species analyzed, only preliminary conclusions can be drawn. Generally, these cases confirm that R&D is currently taking place on species found in Madagascar. In one case the patent document was linked to a marketed product (i.e. treatment of aged skin).

Overall, the patent documents are concentrated in the pharmaceutical sector and on plantae species. Based on the information available, linkages between species with value chains and markets have been identified in the 'business to consumer' segment. All the patent holders are foreign companies. There is no information available on Malagasy partners or providers of these GR with the exception of *Erythroxylum pervillei* where Malagasy scientists were involved in the discovery process as they are contributing authors to a scientific publication[48] with the patent assignee (University of Illinois, Chicago[49]) that is a member of an ICBG project[50]. Based on the information available, there does not seem to be a particular species, amongst the ones examined, that was the subject of an ABS agreement.

Finally, internet research provided evidence that beyond the innovation protected by patent documents, a product based on a GR is commercialized. Furthermore there is ongoing research on three species. Eventually, the TK for one species was scientifically confirmed. These research results could potentially offer economic valorization opportunities. However, it is unclear if there is utilization of GR and therefore if they should be considered as a raw material or as a GR under the ABS framework. In any case, this clearly indicates the economic potential of the species.

Conclusion and recommendations

This study shows that there is ongoing R&D on the country's biodiversity and that GR are of value for public and private actors doing R&D across different sectors. There are therefore potential economic opportunities to further valorize Malagasy GR.

Concretely, the analysis of the patent documents focussing on Malagasy species - where there is utilization of GR – enabled the identification of links with value chains, markets or on-going R&D. The analysis of actors provides a clearer picture of the institutions related to biodiversity conservation and to the valorization of BR and GR. However, due to the limited information available, it is not possible to determine with certainty: a) which Malagasy actors are clearly using GR and b) which actors provided the genetic material used for the R&D related to the patent documents. Hence, based on the information available, it is impossible to establish a link between identified users and potential providers. This could be the basis of further research.

[47] Ingenol is a highly complex, anticancer substance found in the Euphorbia genus of plant, whose milky sap has long been used in traditional medicine.
[48] Silva GL., et al., 2001. www.ncbi.nlm.nih.gov/pubmed/11754602
[49] www.uic.edu/pharmacy/depts/ICBG/index.php
[50] Soejarto DD., et al., 2004. www.ncbi.nlm.nih.gov/pubmed/14987071

In summary, an ABS framework is under development at national level. The analysis of the actors present in Madagascar that potentially use or carry R&D on GR shows that there is a unique valorization expertise among national actors (public research institutions, private actors and NGOs) and foreign actors based in Madagascar. This pool of experienced actors is a positive foundation to further explore market opportunities. In doing so, the exploration of how trust was built with the ICBG consortium and other international research collaborations could improve the understanding of users' R&D needs, challenges and requirements.

Overall, there are a few other actors involved in R&D and potentially utilizing GR. There are at least three experienced actors carrying R&D on GR as they have been involved an international bioprospecting program. However, the role and activities of the national institutions (i.e. public research, private sector, NGOs, and civil society) organisations is generally unclear. Apart from a few core strengths, the capacity to transit from the research to the development phase of the innovation and product development process seems limited. There is also a limited support system for actors carrying R&D on GR. This set up seems rather weak for the effective and efficient valorization of GR. It is however complex to come to any definite conclusion as limited information was found.

This however allows to draw a range of strengths and weaknesses with regard to R&D on GR and their economic valorization. While the specific threats were not in the scope of this research, a range of opportunities arise in order to progress in the valorization of its GR.

The table two below presents the country's strengths and weaknesses with regard to R&D on GR and their economic valorization. The strengths relate to features that were identified in this project. The weaknesses relate to characteristics that are clearly missing.

Strengths	**Weaknesses**
- High biodiversity with R&D carried out across a range of species (e.g. plantae, animalia) - A wide range of general and specialized technology areas and markets of relevance to the Malagasy biodiversity - A unique national expertise in bioprospecting and ABS. Some research taking place in public research institutions - Expertise in a few Malagasy private companies and NGOs for bioprospecting and the valorization of GR	- Limited research in universities - Absence of ABS procedures - Limited support to the business environment for the valorization of GR - Few civil society organisations
Opportunities	**Threats**
<u>Species opportunities:</u> <u>*Erythroxylum pervillei*</u>: The product that was recently in pre-clinical studies. Malagasy scientists were involved in the discovery process as they are contributing authors in a scientific publication along with the patent	*Not in the scope of this assessment.*

assignee. There may be lessons to learn and/or benefits to be shared. <u>General opportunities</u> 69 species identified in the patent studies were not covered in this country assessment. A similar exploration to the one carried for *Erythroxylum pervillei* regarding the links between patent documents, value chains and markets could uncover other economic opportunities.	

Table 2: Strengths, weaknesses, and opportunities for R&D and to valorize GR under the ABS framework

Overall, this raises two key questions for the public policy on ABS and the economic valorization of GR. First, in practice, how to close the gap in order to take advantage of economic valorization opportunities related to GR. Second, what are the policy needs to create a favourable institutional and business environment in order to facilitate access to GR and share in fair and equitable manner the benefits arising from their utilization? For this purpose, general recommendations are presented in the synthesis "Economic potential and valorization opportunities for genetic resources in six African countries" for the 6 countries. However, for Madagascar a range of specific recommendations are put forward:

1. Clarify the needs of actors in Madagascar and constraints to valorize GR

- **Clarify the scope and the capacities of the relevant actors** using or involved in activities related to the utilization of GR (presented in annexes two and three) to complement the analysis of the country's strengths and weaknesses (e.g. research areas and the use of GR, R&D expertise, network at various level).

- **Gain a wider understanding of the links between patent documents, value chains and markets** by further exploring the patent documents related to the 69 species that were not examined in this project.

- **Lessons could be drawn from previous ABS cases** such as ICBG, and other well known cases such as *Prunus africana.*

2. Clarify users R&D requirements and how GR and TK are utilized by different users.

These elements are further presented in the synthesis report and in the sectoral analysis. Some initial steps could include:

- **Improve understanding of the markets needs and the requirements that positively qualify a Malagasy R&D actor** to enter in an R&D process in order to determine how to respond to specific demand. In this context, further engagement with foreign partners such as ICBG and CIRAD, as well as with experienced Malagasy actors, could improve the understanding of users' challenges.

3. **Encourage benefit-sharing requirements that improve the Malagasy actors capacity to move up the value chain** (e.g. training of local researchers to carry out additional research activities) as most GR only undergo the initial stages of the research phase (e.g. screening), where failure is high. For this purposes, consider reviewing and evaluating the benefit sharing gained from previous ABS cases (e.g. ICBG and other related experiences, especially with NGOs).

In light of the recommendations above and those contained in the synthesis "Economic potential and valorization opportunities for genetic resources in six African countries", policy makers may wish to consider the usefulness of developing a valorization strategy. This would take advantage of the economic, environmental and social opportunities related to the utilization of GR, while taking into account the existing gaps between users and providers in innovation and R&D processes.

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Annex 1: Key words used to identify actors relevant to R&D on GR

Note: traditional knowledge was not in the scope of this institutional analysis.

a. Generic websites
   - For all countries : World Bank : strategy for developing agriculture in the country, focusafrica.gov.in,
   - For English speaking countries : www.commonwealthofnations.org

b. Generic key words for key stakeholders
   - Chamber of commerce
   - Trade associations and business federation
   - University
   - Herbarium
   - Museum
   - Laboratory
   - Research institutes
   - Botanical gardens

c. Specific actors (mostly international actors likely to do R&D and use GR from the country)
   - Research (CIRAD, CIFOR, Kew, IRD (Sud Expert Plantes), CBI), MNHN, FOFIFA
   - Development (FAO, ITCSD, UNDP)
   - Development agencies (AFD, GIZ, USAID)

d. Types of genetic resource: forest, marine, animal, agricultural, plantae, microbe, microorganisms, bacteria, fungi

e. Sectors and R&D[51]:
   - Pharmaceutical
   - Biotechnology
   - Horticulture
   - Food : crop improvement, breeding, pest protection, stress resistance
   - Health food : nutraceutical, agro-biodiversity, plant for food and alimentations
   - Cosmetics: Oils, fats and waxes, gums, extracts and saps, colorants, formulation, anti-oxidant

f. R&D activities, processes and technologies: bioprospection, raw material, sample, valorization, extraction, metabolic processes, molecular technique, nanotechnology, liquid chromatography devices, nuclear magnetic resonance, spectometers.

[51] A focus was done on the health food and cosmetics sectors as they are thought to be the easiest targets for providers of GR to engage with in R&D processes.

Annex 2: List of all the actors found in the scope of the study related to R&D and the economic valorization of biodiversity, biological and genetic resources.

Click here to view annex 2.

Annex 3: List of the most relevant actors related to R&D and the economic valorization of biodiversity, biological and genetic resources

Click here to view annex 3.

Annex 4: List of the patent documents examined for linking species with markets and value chains

Click here to view annex 4.