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Bioprospecting and Biopiracy in the Caribbean

Challenges and Opportunities for the Region

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Abstract

The Caribbean is the seventh largest biodiversity hotspot (36 are recognized worldwide). This biodiversity is under myriad of threats including biopiracy, inertia, inequitable land use, and climate change. The loss of potential income due to biopiracy has made the Caribbean poorer as it has only benefitted countries outside of the region while leaving the Caribbean footing the bill for maintenance of its bioresource. The Convention on Biological Diversity (CBD) entered into force in 1993 and the Nagoya Protocol (NP) in 2014. The CBD, ratified by all UN members except the US, affirms that conservation of biodiversity is a common concern, reaffirms States have sovereign rights over their bioresources, while recognizing the close and traditional dependence of indigenous and local communities to this bioresource and the desirability of sharing benefits equitably with them for conservation and developmental purposes. The Nagoya Protocol provides a legal framework for access and benefit sharing when biodiversity, with or without associated traditional knowledge, from one party is sold as commercial products by another. As part of a recent UNEP project, which identified issues Caribbean nations face in ratifying and utilizing the NP, reported here are bioprospecting cases that have, or have not, benefitted the region. Included are biopiracy cases which had not but are now providing benefits to the Caribbean. Besides the obvious need for the Caribbean to invest more in valuing our own biodiversity and ratifying the NP, opportunities for the region include

keeping more of the bioprospecting value-chain in the Caribbean, converting value-chains into value-rings, and developing regional registries and databases.

Keywords: Traditional Knowledge, Indigenous and Local Communities, Taino, Kalinago, Maroon, Bioresource, Nagoya Protocol, Benefit Sharing, Ethnobioprospecting, Ethnobiology, Ecopharmacognosy, Ethnobiotechnology

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ABBREVIATIONS

ABS = access and benefit sharing
ACP = African, Caribbean and Pacific Group of States
CBD = Convention on Biological Diversity
CIBH = Caribbean Islands Biodiversity Hotspot
GEF = Global Environmental Facility
GIZ = Deutsche Gesellschaft für Internationale Zusammenarbeit
GR = genetic resources
ILCs = Indigenous and Local Communities
IPR = Intellectual Property Rights
IUCN = International Union for the Conservation of Nature
MAT = mutually agreed terms
MTA = Material Transfer Agreement
NP = Nagoya Protocol
PIC = prior informed content
SIDS = Small Island Developing States
TK = traditional knowledge
UNEP = United Nations Environment Programme

Introduction

The Caribbean is of critical importance for global biodiversity survival due to its high percentage of global plant and animal endemics and the high level of threats. Of particular concern are concentrated areas of endemism (e.g. the Blue & John Crow Mountains which have 50% endemicity in the flowering plants at elevations above 900–1000 m asl with between 30–40% of these species found only within this region, https://whc.unesco.org/en/list/1356/). There is a cost in taking care of this biodiversity, to ensure it will still be here for future generations.

Caribbean Island Biodiversity Hotspot

The Caribbean Region encompasses 30 diverse nations and territories in over 7,000 islands, islets, reefs and cays with 230,000 km² total land area in ~4 million km² of ocean (CEPF 2019). The Caribbean contains the seventh largest of 36 recognized 'biodiversity hotspots' in the world (Myers 2000). This is referred to as the Caribbean Islands Biodiversity Hotspot (CIBH). To qualify as a biodiversity hotspot according to Myers (2000), a region must contain >1,500 species of endemic vascular plants (>0.5% of world's total) and have lost >70% of its primary vegetation (Myers 2000,). The CIBH has ~12,000 known plant species, of which 7,000 are endemic to the hotspot, 2.3% of global plants, and 779 endemic vertebrates while endemics are still being found (Figure 1; Anadón-Irizarry et al., 2010; Mitchell et al., 2019; https://ec.europa.eu/environment/nature/biodiversity/best/regions/caribbean_en.htm).

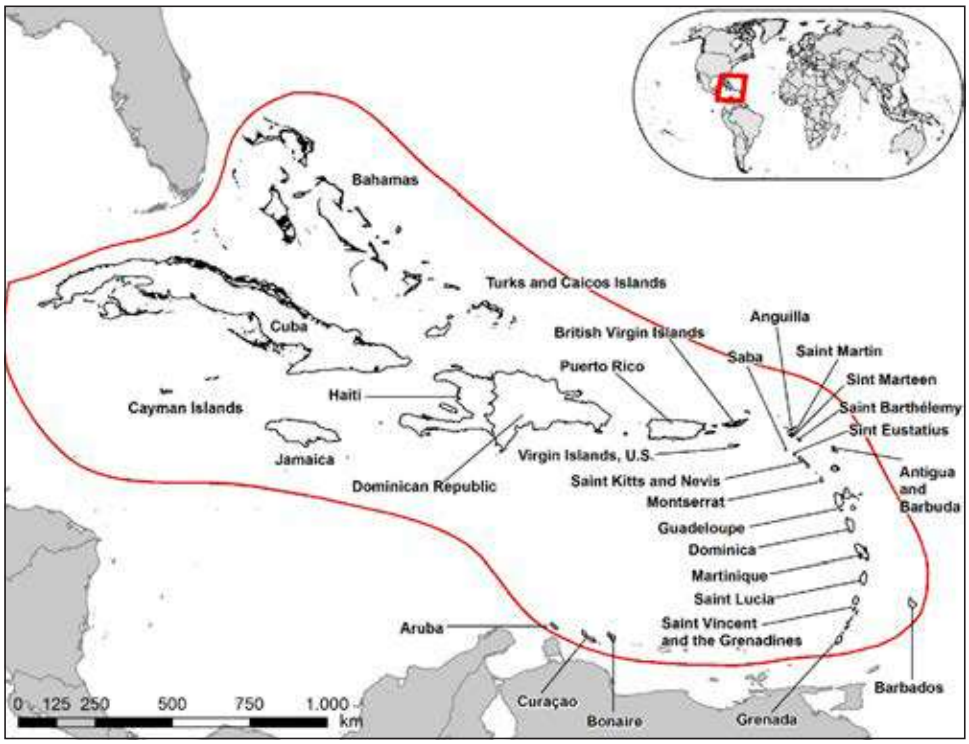

Figure 1: Caribbean Island Biodiversity Hotspot (CIBH)

Source: https://www.cepf.net/sites/default/files/cepf-caribbean-islands-ecosystem-profile-summary-2020-english.pdf

Threats to Caribbean Biodiversity

The highly valued genetic resources in the CIBH are under myriad threats due to the historically extractive nature of the plantationocene and its aftermath, which includes forest clearance, biopiracy, ignorance; inertia, unsustainable use, undervaluation of biodiversity; land degradation, pollution from nutrients, inequitable land planning, urbanization and climate change (Mitchell et al., 2007, 2008, 2019). These threats challenge the very existence of the CIBH endemics (Oleas et al., 2013). Endemics (plants and animals) have been found only in the CIBH; restricted to a few or one island; or even, only to one part of an island (Anadón-Irizarry et al., 2010). Endemic organisms are also still being discovered. The Caribbean is thus of critical importance for global biodiversity survival. While a lot of research has taken place (Oleas et al. 2013, Mitchell et al., 2019, CEPF 2019, 2022), a lot more research and development are needed. For example, Jamaica's only flora reference book lacks illustrations (Adams, 1972) and some forest plants are still unknown to science (Mitchell, 2011). Those that live in the Caribbean need to value its biodiversity and sustainably use it for health and wealth (Mitchell et al., 2018a). Corporations who still practice extractive research, leading to unequitable benefit sharing with the Caribbean, continue to threaten the sustainability of Caribbean biodiversity. In this paper, we will draw attention to the threat of biopiracy.

The Caribbean is the only major biodiversity hotspot comprised of many nations with varied affiliations (Table 1, Mitchell, 2019). This makes regional conservation and sustainable use management difficult but essential. How should the Caribbean sustainably manage its biodiversity given the challenges and opportunities of bioprospecting? When bioprospecting returns no returns to the country of origin, it is called biopiracy. To determine the threat of biopiracy to Caribbean biodiversity, it was necessary to evaluate for the Caribbean the present status of biodiversity knowledge, biodiversity threats due to biopiracy, and international biodiversity agreements including legal instruments such as the Nagoya Protocol which aim to share the benefits of commercialization of bioresources back to source countries for conservation purposes, and then consider what should be the Caribbean's response.

Conservation Conventions

Convention on Biological Diversity (CBD)

The United Nations Environment Programme (UNEP) tasked experts to prepare a legal internationally recognized instrument for conservation and sustainable use of biological diversity. They were to consider "the need to share costs and benefits between developed and developing countries" as well as "ways and means to support innovations by local people". The result was the Convention on Biological Diversity (CBD) which entered into force in 1993. The CBD is an international legal instrument for "*conservation of biological diversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the utilization of genetic resources*". The CBD *affirms* that conservation of biodiversity is a common concern; r*eaffirms* States have sovereign rights over their biological resources and for using them in a sustainable manner, *recognizes* the close and traditional dependence of many indigenous and local communities on local biodiversity and *desirability* of sharing equitably benefits arising from use of this traditional knowledge relevant to the conservation of biological diversity and its sustainable use. For the full CBD agreement, see (https://www.cbd.int/doc/legal/cbd-en.pdf). The CBD has been signed by all UN members except the US. All Caribbean nations, except for the US-affiliated islands of Puerto Rico and US Virgin Islands, ratified the CBD between 1994 and 1997.

Nagoya Protocol (NP)

The NP was introduced in 2010 and entered into force in 2014 thus providing a legal framework for the Access and Benefit Sharing (ABS) aspect of the CBD. The NP framework requires prior informed consent (PIC) and mutually agreed terms (MAT) to include any Indigenous or local community (ILCs) that provided any associated traditional knowledge [TK]), between the country where the biodiversity was accessed (*country of origin*) and the party that produced derived commercial products from this genetic resource (*user*), resulting in agreed access and benefit sharing (ABS) terms. It obliges the user to share benefits with the country of origin. It was the first international instrument of particular relevance to ILCs since adoption of the UN Declaration on the Rights of Indigenous Peoples in September 2007 (Mauro and Hardison, 2000). Prior to the Nagoya Protocol there, were no legal mechanisms in place to ensure that countries, communities and

individuals were properly compensated for the use of their genetic resources (GR) and associated TK. The NP offers an important opportunity for the Caribbean to ensure that use of its GR and associated TK benefits the region. This will help with management of the CIBH and development of the Caribbean countries with the accessed bioresources.

Caribbean Initiatives for Biodiversity Access and Benefit Sharing (ABS)

Two collaborative initiatives, led by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) between 2012 and 2015 (Period A) and UNEP between 2015 and 2019 (Period B) have helped Caribbean countries to understand, ratify and use the NP for biodiversity conservation and development. Many Caribbean countries, due to these initiatives and others, have ratified the NP, either on their own or by virtue of their relationship to a ratifying country (Table 1). For example, the Netherlands signed the protocol in 2016 so its overseas territories and special municipalities in the Caribbean, are also considered to have ratified the protocol.

Initiative 1 – ABS Capacity Development Initiative

The *ABS Capacity Development Initiative* (a multi-donor initiative hosted by the German Federal Ministry for Economic Cooperation and Development), has been implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH since 2006. Following the adoption of the Nagoya Protocol in 2010, the European Union tasked GIZ to expand the ABS Initiative beyond Africa to include Caribbean and Pacific countries of the ACP (https://www.acpsec.org/). Between 2012 and 2015, GIZ hosted Caribbean meetings in Trinidad and Tobago, Dominica, Jamaica, St Lucia and Suriname (other island representatives were present) to discuss issues pertaining to the NP: its potential, challenges and opportunities while providing training in areas such as analysis of existing laws and developing drafting instructions for new laws necessary for its ratification (https://www.abs-biotrade.info). As a result of this effort and others, several Caribbean countries ratified the NP (Table 1, period A, https://www.cbd.int/abs/nagoya-protocol/signatories/).

Initiative 2 – UNEP 2015 Caribbean Project

A United Nations Environment Program (UNEP) project approved in 2015 entitled '*Advancing the Nagoya Protocol in Countries of the Caribbean Region*' (GEF ID

5774), was implemented between Febuary 2016 and March 2019 and continued this process. This project included ten countries (Antigua and Barbuda, Barbados, Dominica, Grenada, Guyana, Jamaica, St Kitts and Nevis, Saint Lucia, St Vincent and the Grenadines, and Trinidad and Tobago) with UNEP as Implementing Agency, the Global Environmental Facility (GEF) as funder, and the International Union for the Conservation of Nature (IUCN) as Executing Agency[1]. In the Caribbean, this GEF project financed at USD 1.826 million was supported by GEF-5 STAR funding of USD 1.900 million accessed by the Bahamas, to put in place the legal-, regulatory-, institutional- and administrative-systems needed to comply with the basic provisions of the Protocol. As a result of these initiatives and others, four more Caribbean nations ratified the NP (Table 1, Period B).

Table 1: Nagoya Protocol ratification status by Caribbean countries at December, 2022

	Country ratifying the NP	Date of ratification	Caribbean nation states covered by ratification
Period A	Guyana*	2014.10.12	
	Mexico*	2014.10.12	
	Dominican Republic*	2015.02.11	
	Cuba*	2015.12.16	
	Netherlands*	2016.11.17	Bonaire, Saba, Sint Eustatius (special municipalities); Curacao, Aruba, Sint Maarten (OCT)
	UK*	2016.05.22	Anguilla, Bermuda, British Virgin Islands, Turks and Caicos Islands, Cayman Islands, Montserrat
	France*	2016.11.29	French Guiana, Guadeloupe, Martinique, St Barthelemy, St Martin
Period B	Antigua and Barbuda*	2017.03.12	
	St Kitts & Nevis*	2018.12.04	
	Bahamas*	2022.03.30	
	St Lucia*	2022.06.12	
Nations that ratified the CBD between 1994 and 1997 are marked with an asterisk* The nation states in the Caribbean Region that have not yet ratified the Nagoya Protocol up to December 31, 2022 are Barbados*, Belize*, Dominica*, Grenada*, Haiti*, Jamaica*, St Vincent and the Grenadines*, Suriname*, Trinidad and Tobago* and the United States (Puerto Rico and US Virgin Islands).[2,3]			

OCT = EU Overseas Countries and Territories

1. See https://www.gefieo.org/data-ratings/projects/project-id-5774 and https://www.gefieo.org/sites/default/files/documents/projects/tes/5774-terminal-evaluation.pdf
2. https://www.cbd.int/abs/nagoya-protocol/signatories/
3. https://en.wikipedia.org/wiki/Caribbean_Netherlands

Initiative 3 – UNEP 2015 Caribbean Project Sub-component

As part of the UNEP project, a 3-member scientific team from the Caribbean (authors of this paper) carried out a component entitled '*Access & Benefit Sharing (ABS) – Bioprospecting in the Caribbean Region*'. This component explored Caribbean bioprospecting in relation to the Nagoya Protocol (NP). Other components of the UNEP project addressed capacity building for the development of legislation, information technology management, the engagement of policy makers, and ensured the participation of indigenous and local communities (ILCs).

Outputs of the *ABS – Bioprospecting in the Caribbean Region* component included a summary of the bioresource of each of the eight contributing nations (Mitchell et al., 2018a), its inter-connectivity with indigenous & local communities (ILCs), including Amerindians and Maroons (Mitchell et al., 2018b), mapped Caribbean ABS institutions (Mitchell et al., 2018c), recommended standardized methodology for Caribbean national registers of their biological resources (Mitchell et al., 2018d), valued Caribbean biodiversity knowledge (Mitchell et al., 2019), developed a roster of regional ABS experts, initiated a Caribbean medicinal plant database and produced ABS info-sheets for tour operations, policy makers and biosafety officials while collecting and discussing Caribbean bioprospecting cases (Mitchell and Richards, 2022).

This paper reports on cases of terrestrial and marine bioprospecting unearthed during the UNEP 2015 project which were initiated in the Caribbean, any known associated traditional knowledge, and any identifiable derived benefits for the Caribbean. Included are biopiracy cases that have only recently produced a benefit for the Caribbean. From analyzing these cases, we have identified challenges to be overcome and opportunities to be realized for the Caribbean Region. In forecasting for the future, besides the obvious need for the Caribbean to invest more in increasing knowledge about our own biodiversity and ratifying the NP, opportunities include developing more links in the bioprospecting value-chain in the Caribbean, converting the value-chains into value-rings, and developing regional registries and databases.

Methodology

An important aim of the *ABS–Bioprospecting in the Caribbean Region* component was to identify bioprospecting issues which could affect ratification and use of the NP in the region. The methodology included collection of desk and field data

(from country visits, questionnaires, internet searches, government offices and data sources, academic institutions, and patent repositories), which were then discussed during seven project workshops (in Trinidad & Tobago, Jamaica, Barbados, St Kitts), During the workshops, validated findings of each project component were presented, the implications of ratifying the NP shared, and training carried out. The workshop participants included government environmental officers, academics, lawyers, patent officers, ILC representatives and representatives of CARICOM and IUCN. The outputs developed by each component were used by the larger project to assist Caribbean nations understand, prepare, ratify and use the Nagoya Protocol. Some of these findings relevant to bioprospecting and biopiracy in the Caribbean will be given in this paper.

Results

This section begins by defining bioprospecting and associated terms. We then describe historical Caribbean bioprospecting and the present status of terrestrial and marine Caribbean bioresource including identification of areas with special potential for bioprospecting. The section ends with a typology of bioprospecting cases, and a short review of three Caribbean IPR patent systems.

Defining Bioprospecting and Biopiracy

As the team delved into the literature and talked with governments, academia, regional conservation groups and indigenous leaders, it was clear that terminology needed to be mutually understood so the key terms are defined here. Bioprospecting is the exploration of biological material for its commercially valuable biochemical properties. When bioprospecting includes how indigenous and local communities (ILCs) use the local biodiversity (called ethnobiology, folk knowledge, or traditional knowledge = TK), the correct term to use is ethnobioprospecting. The bioprospecting value-chain begins with access to genetic resources and any associated TK, through research that usually includes patenting, and ends with its derived commercialization. Patents are usually sought to protect the claim for the user. Though bioprospecting began as a search for drugs to cure new diseases, bioactive compound research has verified many pharmaceutical, cosmetic, biotechnological, agrochemical, and food applications (Mateo et al., 2001 and Santana et al., 2021). Consider turmeric, exploring its biochemicals for use as an anti-inflammatory agent or for COVID (Lantz et al., 2005 and Babei

et al., 2020) would be considered bioprospecting but using it to make curry for supper would not. This is lucrative business, more than half of developed drugs approved by the US FDA are derived or bioinspired from compounds obtained from living organisms (Santana et al., 2021).

Biopiracy is a purposefully contentious term, used to describe bioprospecting cases where biological material is accessed from a country without payment or returning any benefit. Of special concern is biopiracy of local folk knowledge (TK) without reward or benefit to the communities where the TK was accessed (Roht-Arriaza, 1996, Robinson, 2012, Mauro and Hardison, 2000). The loss of potential income due to biopiracy has made the Caribbean poorer as it benefits only countries outside of the region, leaving the Caribbean footing the bill for upkeep of its bioresource. Many authors have tried to define biopiracy, to determine its degree of occurrence, and why it is still happening (Crosby, 1986, 2003; Shiva, 1999, 2007; Mulligan et al., 2000; Merson, 2000; Mateo, 2000). However, no literature could be found from Caribbean scholars about bioprospecting or biopiracy as experienced by the region. The authors of this paper therefore started to explore the topic by asking a simple question: 'In cases where users accessed biodiversity in the Caribbean, have the region's communities derived any commercial or non-commercial benefit?' Based on the cases unearthed, another question was asked, 'What should be the Caribbean response given the history of biopiracy in the Caribbean and the opportunities possible through the Nagoya Protocol for conservation and developmental purposes?'

Caribbean Bioprospecting

Historical Caribbean bioprospecting

There is evidence that Amerindians (such as the Ciboney, Taino and Kalinago)) were in the Caribbean since at least 2,500 BC (referred to as Indigenous people due to how long they were present) and while sizeable populations occupied the islands, the natural vegetation was still described as luxurious centuries later[4]. When Europeans arrived, who did not know the Caribbean existed before 1492, they cleared the forests of many Caribbean islands to establish mono-crop plantations; this initiated a period referred to as the plantationocene (Wolford, 2021).

4. See https://www.pitonbungalows.com/en/the-first-residents-of-the-archipelago-the-amerindians/

The felled trees and other forest products (mahogany, bitter wood, cocoa, herbs etc.) and later sugar, bananas, coffee etc. were exported as raw material to Europe where they were made into value-added products (white sugar, chocolates, furniture, pharmaceuticals). This restriction of Caribbean colonial trade to export of raw materials and import of finished goods was largely influenced by the British Navigation Acts. In operation between 1651 and 1849, these Acts restricted British colony exports to raw materials and only to Britain, local manufacturing was discouraged, and colonies could only purchase manufactured goods from or through Britain (Fernandez-Villaverde, 2022).

Bioprospecting was an integral part of European exploration as new areas brought new diseases and plants found in these areas were being used medicinally by local folks (Crosby, 1986, 2003). The earliest known medicinal plant compendium was written in 2,500 BC and it listed 366 plant drugs (Merson, 2000)[5]. In the Caribbean, the botanist who described the most plants (including medicinal ones) was Sir Hans Sloane (1660–1753). He collected Caribbean plants and associated folk knowledge without acknowledging his sources nor providing any benefit to any Caribbean source country. His plant collections form the basis of the Royal Botanic Gardens Kew collection in the UK (Nesbitt, 2018). The Kew collection and many others contain Caribbean plants and associated traditional knowledge (TK), but they are outside the Caribbean region (in databases, herbariums, botanical gardens, pictures and paintings) and are still largely inaccessible to the Region. The challenges and opportunities resulting from bioprospecting and biopiracy endeavours in the Caribbean will be discussed, including how this inequitable situation has, and still is, hindering Caribbean scientists (Mitchell et al., 2019).

Present status of Terrestrial and Marine Caribbean Bioresource

Though extensive research has adequately described Caribbean terrestrial and marine bioresource and endemics specifically, and the need for conservation is well appreciated (Maunder 2008; Mitchell et al., 2018a,c, 2019; CEPF 2019, 2022), there is still insufficient knowledge especially as it pertains to medicinal plants of the region, their folk use and their conservation needs. Caribbean bioresources suitable for bioprospecting and associated TK were reviewed in this project – for terrestrial, fresh-water and marine; for flora, fauna and microbes (Mitchell et al., 2018a,b, 2019). As an example, an ethnobotanical study in Montserrat alone

5. Written by Emperor Shen Nung, the Father of Chinese medicine, circa 2500 BC.

reported 256 medicinal and 24 poisonous plants (Brussel, 1997). A Caribbean medicinal plant database was developed for this project. This database presently includes 3,566 medicinal plant species in the Caribbean identified as having at least one ethnomedicinal use, for 17 countries, from 34 source documents (Mitchell et al, 2019). This project database, along with the TRAMIL database (https://tramil.net/en) and others (https://www.dcbd.nl/, https://dcnanature.org/caribbean-biodiversity-on-line/) point to Caribbean terrestrial plant biodiversity as being a shared resource.

The exploration of the Caribbean marine bioresource has been researched, in patches, and there are a lot more areas to explore. Representative data has been stored in an international and open database (https://obis.org/). The Caribbean marine bioresource which is shared among the Caribbean islands (Mitchell et al., 2019) is of increasing interest as a source of bioactive compounds. Pharmaceutical active agents obtained from marine sites include anti-neoplastic agents, cardio-vascular active drugs, marine toxins, antibiotic substances, anti-inflammatory and antispasmodic agents[6].

Caribbean Sites with Special Potential for Bioprospecting

Most bioprospecting in the Caribbean has taken place in accessible areas, such as lowland forests, wetlands and near-shore marine, mangrove, reef and sea grass beds. Less well explored environments include volcanic hot springs, pitch lakes, marine environments at extreme depths, specifically around submarine trenches, cold seeps, seamounts and deep-sea hydrothermal vents. The biological processes which enable 'extremophiles' to survive extreme temperatures, pressures, salinity and so on have great potential for commercial applications. Enzymes derived from extremophiles, for example, have been used in detergents, cleaning, dyeing, medical diagnosis, cosmeceuticals, and for forensics.

Types of Bioprospecting Cases Originating in the Caribbean

Several bioprospecting cases were unearthed where the biological materials were accessed from within the Caribbean Region. More drugs were identified that have been developed from Caribbean marine species than from terrestrial species. Research also appears to be shifting away from invertebrates (corals, sponges, tunicates) to the associated algal symbionts and bacteria. The focus of research

6.w See https://www.slideshare.net/SudheerKandibanda/marine-drugs-56601492

has been cancer treatment. Molecular biology techniques are increasingly used to explore these microbial communities (genomics, proteomics). Six types of bioprospecting cases originating in the Caribbean were identified. The cases given here are by no means exhaustive but are meant to be indicative.

Type 1: Bioprospecting R&D outside Caribbean leading to commercial products based on Caribbean Bioresources, which has no recorded benefit to the region.

This type of bioprospecting was difficult to unearth. Caribbean biodiversity might have been accessed illegally from the region, or legally by transfer between botanical gardens, or via research projects using material transfer agreements (MTA). The best-known case is the Madagascar periwinkle which was accessed from Jamaica then put into trials in the USA and Canada, first for diabetes then for cancer. Two Jamaican medical professionals in the 1950s sent parcels of periwinkle material to Florida and Canada for these trials. Eli Lily, who eventually obtained patents for anti-leukemia effects of vincristine and vinblastine extracted from the periwinkle acknowledge no wrongdoing and only admit to receiving their first sample from Jamaica (Desai, 2011). Other cases are given in Table 2.

Table 2: Summary of unearthed Type 1 Caribbean bioprospecting cases

- *Tectitethya crypta*, is a marine sponge found in shallow water across the Caribbean. It was accessed first in 1945 by a young organic chemist, Werner Bergmann from the coastal waters of Florida. Scientists isolated two nucleosides from the sponge, spongothymidine and spongouridine, which were used as models for the development of anti-viral and anti-leukemia drugs. The first was approved by the FDA in 1969 and the latest, remdesivir, was found to be effective against SARS, MERS and COVID-19 (https://ocean.si.edu/ocean-life/invertebrates/sea-sponge-hiv-medicine).
- Ecteinascidin 743 was isolated in 1990 from the sea squirt *Ecteinascidia turbinate.* It can be found in shallow waters off the east coast of Florida, Bermuda and the Gulf of Mexico from the Caribbean Sea. Antitumor activity of *E.* turbinate extracts was reported since 1969 but exactly where it was first accessed and by whom is unclear. Ecteinascidinen is presently undergoing trials for use as an anti-cancer medication.
- Fer-de-lance venom, *Bothrops caribbaeus*, St Lucia (Gutierrez, 2008). The snakes *B. caribbaeus* and *B. lanceolatus* are endemic to the Lesser Antillean islands of St Lucia and Martinique. They are rare, highly venomous snakes. Venoms offer potential for new discoveries (https://edition.cnn.com/2015/07/15/health/deadly-venom-saves-lives/index.html). Although rare in the insular Caribbean, representatives of this genus of snakes can be found across tropical Americas, including CARICOM countries such as Trinidad & Tobago, Guyana, Suriname & Belize. The venom may have medical potential. Unauthorized access was obtained in the 1990s.

Table 2: Summary of unearthed Type 1 Caribbean bioprospecting cases *(cont'd)*

• Crassin acetate from Caribbean Gorgonian *Pseudoplexaura porosa.* Crassin acetate, a cyclic diterpenes observed to be comparatively inert to the mammalian system but extremely cytotoxic to human leukemic cells in vitro and mouse fibroblasts (https://www.slideshare.net/SudheerKandibanda/marine-drugs-56601492). Patent for use of crassin acetate as an analgesic was granted in 1972.
• In 2015, there was opposition to a patent awarded to French Institut de Recherche pour le Développement (IRD) for the antimalarial properties of simalikalactone E isolated from *Quassia amara*. The scientists interviewed members of Kali'na, Palikur and Creole communities in French Guiana (ILCs) and others then focused on that species. The IRD did not mention these ILCs as a TK source in its patent application filed 2010.06.17 and granted 2015.03.04. No certificate of compliance was filed. A 'First worldwide family litigation' was filed 2015.10.23. Presently the patent is not in force and anticipated expiration date is 2030.06.17. In 2016, IRD stated it will work out a protocol with FG to guarantee fair sharing of the scientific and economic benefits if the drug makes it to the market and ensure that people in French Guiana get it at an affordable price (https://patents.google.com/patent/EP2443126B1/en, Bourdy et al., 2017, https://www.science.org/content/article/french-institute-agrees-share-patent-benefits-after-biopiracy-accusations,).

Type 2: Bioprospecting R&D outside Caribbean leading to commercial products based on Caribbean bioresources, which has a recorded benefit to the region.

This type of bioprospecting was the most difficult to unearth. The only scenario under which this seems to have occurred is if a Caribbean national undertook research of a Caribbean plant outside of the Caribbean, then returned to patent and develop commercial products. Thus, that researcher would be the one benefiting the region as long as they stay in the region. The best example unearthed of this is Dr. Lawrence Williams who dedicated his life work to researching one plant, guinea hen weed (*Petiveria alliacea*). He received financial support from Caribbean business interests and in the process developed an anti-cancer drug. Two products on the market are *Guinea Hen Weed Tonic and Restorative* and the *Guinea Hen Weed Magic Relief pain ointment.*

Type 3: Caribbean Bioprospecting R&D begun in the Caribbean leading to commercial products, which has no recorded commercial benefit to the region.

This has been the most typical type of Caribbean bioprospecting. A review of medicinal plant research in the Caribbean indicated that 334 plant species grow-

ing in Jamaica had at least one folk medicinal use, 193 of these have been tested for their bioactivity, crude extracts from 80 plants had reasonable bioactivity and phytochemicals were being identified from 44 plants (Mitchell and Ahmad, 2006). This and other literature indicate ethnobioprospecting is being done by regional scientists (Cohall, 2010; Picking et al., 2011, 2015; Mitchell, 2019) but further research leading to patentable claims has been, and is still being, done outside the region leading to patents being assigned to external researchers. The larger islands, Cuba, Jamaica and Puerto Rico can carry out clinical trials but resources do not permit the whole value-chain to market to take place in the Caribbean. The one exception to this is Cuba, which has been able to complete the entire value-chain as seen under Type 4.

Type 4: R&D begun within region leads to products based on Caribbean Bioprospecting, which has recorded benefit to the region.

As with Type 2, only a few cases were found for this type of bioprospecting. In one case, all the research was carried out in the Caribbean, by Caribbean academics. The final product was registered but no patent applied for. This means the details of the innovation remain a tightly kept trade secret to this day. This is the story of Canasol (registered as a Drug in Jamaica in 1983) and Asmasol (registered in 1990) extracted from *Cannabis sativa* by two Jamaican scientists Drs West and Lockart. Canasol is used to treat glaucoma and Asmasol to treat coughs, colds and bronchial asthma. Neither are protected by patents. Both products are sold only in Jamaica.

In another case, research in Cuba led to a medical product from Blue or Red scorpion, *Rhopalurus junceus* which can be found in Cuba and Dominican Republic. Blue scorpion venom research done in Cuba resulted in Vidatox 30 CH, which has been described as Cuba's newest homeopathic medication (https://cubamedicos.com/products/vidatox).

Type 5: Bioprospecting, where eventually a benefit was realized for the Caribbean due to compliance with the Nagoya Protocol.

A Type 1 case was unearthed where a benefit was eventually secured by a Caribbean country (The Bahamas), from which the original material was accessed (Table 3). This story started off with an inequitable bioprospecting relationship: the University of California (UC) collected soft corals (*Pseudopterogorgia elisabethae*) in

Bahamian waters, discovered bioactive pseudopterosines and obtained a patent for a derived anti-inflammatory product all without a benefit-sharing arrangement with the country of origin (The Bahamas). UC declined in the 1990s to sign an access and benefit-sharing (ABS) agreement with the Bahamian government. However, The Bahamas later enforced benefit sharing in 2001 (Table 3), authoring only a single company to access (harvest) the soft coral. The limited benefits under this agreement has supported surveys, conservation education and resource management, which was needed for sustainability of the resource(http://wings.buffalo.edu/academic/department/fnsm/bio-sci/faculty/lasker.html). However, the relationship remains inequitable, as the Bahamas obtained no benefit from the value chain.

Table 3: Bahamas soft coral bioprospecting story

In a nutshell
• **1982**: Sampling of soft corals in The Bahamas by the University of California (UC)
• **1986**: Anti-inflammatory properties of pseudopterosines published by UC
• **1988**: U.S. patent on pseudopterosines and synthetic derivatives granted
• **1990s**: OsteoArthritis Sciences Inc. tested methopterosin in phase I and II clinical trials
• **1995**: Estée Lauder started to use coral extracts in cosmetics, licence fees for UC 750.000 USD per annum. More companies followed.
• **1990s**: University of California declined entering a benefit-sharing agreement with The Bahamas
• **2001**: Benefit-sharing agreement concluded between Government of the Commonwealth of The Bahamas, the local company Marsh Harbour Exporters and Importers Ltd. and the U.S. company Lipo Chemicals
• **2014**: Close to 1 mill USD paid into a fund for surveys, conservation education, and resource management
• **2014**: 145 cosmetic products use coral extract from The Bahamas, 50% of these products belong to Estée Lauder
• **2015**: The Bahamas started UNEP GEF ABS project
• **2022:** Bahamas acceded to the Nagoya Protocol

Type 6: Bioprospecting originating in the Caribbean with derived products still in the pipeline.

There are bioprospecting cases that begin with accessing a Caribbean bioresource which are still in development. It is unclear whether any of them have negotiated an ABS agreement between the country of origin and the user as required by the Nagoya Protocol. An example is plitidepsin (I-II) extracted from the anscidian *Tridemnum solidum*. This ascidian is present throughout the West Indies from Florida and Bahamas to Venezuela. The patent states that the bioresource was

accessed from Belize, Colombia, Honduras, Mexico, Nicaragua, and Panama. There are also several New Marine Natural Products from Invertebrates (NMNPI) accessed in the Caribbean. In 2015, the Total NMNPI identified in Bahama waters exceeded the total identified in the rest of CARICOM (MarinLit database http://pubs.rsc.org/marinlit/).

Intellectual Property Protection Levels in the Caribbean

Commercializing biodiversity-derived products usually involves obtaining a patent for the use claim. To be NP compliant, countries have to ensure their Patent Offices are informed about the origin of any genetic resource accessed and any ILC that provided TK, before a certificate of compliance is given from a competent country authority. Therefore, to determine if the Caribbean is ready for ratification of the NP, the status of national patent laws (Table 4) and the number of patents (Table 5) was reviewed. For the sake of this paper, only three countries are reported but the databases can be searched for other countries.

Patent level protection in the Caribbean is low but increasing (Table 4). Patent laws have been updated (e.g., the old Patent Act 1857 of Jamaica was replaced in 2020) but more legislation is needed especially to cover micro-organisms. In terms of the number of patents, which suggests the level of ongoing research, those filed by residents were much lower than those filed by non-residents

Table 4: Status of relevant Patent Laws

Country	Signatory to International Law
Barbados	Barbados *Patent Law* of 2001 was amended 2006. Barbados has been a signatory of the *Patent Cooperation Treaty (PCT)* since 1985 but not yet to the International Union for the Protection of New Varieties of Plants (UPOV).
Trinidad & Tobago	The Trinidad and Tobago (T&T) *Patent Law* of 1996 was amended in 2000. T&T is signatory to the *PCT* since 1994, the *Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure* since 1994, and the *Strasbourg Agreement Concerning the International Patent Classification* since 1996.
Jamaica	In Jamaica, the new *Patent and Design Act*, 2020 replaced the Patent Act, 1857 and the Designs Act, 1937. This allowed Jamaica to finally sign the PCT in 2022. The PCT makes it possible to seek patent protection for an invention simultaneously in numerous countries by filing an "international" patent application. The PCT now covers 153 contracting states. Jamaica is not yet signatory to UPOV nor the Budapest Treaty.

https://wipolex.wipo.int/en/members/profile/

Table 5: Number of Patents filed between 1960–2020 (World Bank database)

	1960–1979	1980–1999	2000–2009	2010–2020	TOTAL
Local residents[a]					
Barbados	0	3	6	33	42
Trinidad & Tobago	0	17	105	27	149
Jamaica	0	75	119	201	399
Non-residents[b]					
Barbados	0	185	771	389	1,345
Trinidad & Tobago	0	946	2,130	1,398	4,474
Jamaica	0	778	897	866	2,541

[a] https://data.worldbank.org/indicator/IP.PAT.RES
[b] https://data.worldbank.org/indicator/IP.PAT.NRES

(Table 5). A small but increasing number of drug-related patents have been awarded to Caribbean researchers (as suggested by the increase in local patents in more recent years in Barbados and Jamaica). In Jamaica, patents were awarded for products derived from terrestrial herbs used in traditional healthcare, achieved through collaboration with universities in North America.

Discussion

The authors of this paper asked a simple question: 'In cases in which users accessed biodiversity in the Caribbean, have the region's communities derived any commercial or non-commercial benefit?' We attempted to answer this question by exploring the types of bioprospecting cases that have occurred in the Caribbean and presented three types of cases (Types 1, 3, 6) where there is no recorded benefit, and three (Types 2, 4, 5) that had some recorded benefit to the region. However, none of the cases unearthed had an ABS agreement as envisaged by the Nagoya Protocol.

The second question we will attempt to answer in this section: 'What should be the Caribbean response given the history of biopiracy in the Caribbean and the opportunities possible through the Nagoya Protocol for Caribbean conservation and development?' We will attempt to answer this question by enumerating the challenges facing the Caribbean in utilizing the Nagoya Protocol and suggest some opportunities that should lessen or eliminate biopiracy by enabling sharing of benefits derived from bioprospecting. We will explore how the Nagoya

Protocol and other initiatives can help the region. Given the possibility for access and benefit sharing under the Nagoya Protocol, this is where our discussion will primarily be based.

Challenges of Providing Access to Caribbean Genetic Resources and Traditional Knowledge and Realizing Benefits of this Bioprospecting via Utilization of the Nagoya Protocol

There were many challenges identified that have been slowing the process of ratification of the Nagoya Protocol in the Caribbean (Table 1). Challenges were also identified which will hinder or slow the use of the Nagoya Protocol. During project discussions, a general lack of understanding of, and belief in, the potential of the Nagoya Protocol was expressed by several Caribbean nations. A challenge identified, which happened on more than one occasion, was that officials vested with such understanding through the GIZ and UNEP projects from 2012 to 2019, had since left critical government posts, resulting in the process towards ratification being stalled or having to be restarted. A clear message needs to be conveyed and understood – that biodiversity-rich countries become relatively poorer when they provide access to their GR and TK and do not secure a reward but still spend on conservation, while at the same time other countries benefit from selling products derived from said GR/TK without the conservation bill. This is an ongoing process due to the entrenched plantationocene systems. Genetic resources (GR), with or without TK, from the Caribbean are still being developed into manufactured products by extra-regional companies without sharing benefits with the Caribbean (biopiracy).

Even with understanding the potential of the Nagoya Protocol, there are several requirements a country needs to ensure they are compatible with the Nagoya Protocol before ratification is possible. These include reviewing existing laws, training people to provide drafting instructions of any required new laws, training in writing agreements with mutually agreed terms (MAT) and prior informed consent (PIC), possibly updating patent laws, carrying out stakeholder meetings while developing a system for issuing certificates of compliance with the Nagoya Protocol. This process takes time and human resources for which there are many other competing matters. Governments need to be convinced of the benefits of ratifying the NP before they will allocate time and energy in the process (even if external funds and expertise is available).

Challenges encountered with using the Nagoya Protocol in the Caribbean

- Accessing a bioresource in the Caribbean is problematic for benefit sharing because the same genetic resource (say a plant) may be on different islands governed by a different country. Access is not about where a plant or animal is endemic (originally found) but where it is was first accessed. However, a researcher may have an ABS agreement with the country where the genetic resources (GR) was first accessed, but when needing it again further along the value chain, may access it from another Caribbean country with whom they do not have an ABS agreement.
- Challenges exist with identifying Indigenous and local communities (ILCs) in the Caribbean. It is generally agreed that ILCs in the Caribbean include the Taino, Kalingo and Maroons but this term can also include any community that holds folk knowledge in common.
- Indigenous and local community members expressed challenges with prior informed consent (PIC) and mutually agreed terms (PIC) required by the NP. Ethics bodies require of researchers only individual PIC. Since this project, knowledgeable researchers have begun to obtain PIC from ILCs before interviewing individuals (who also are asked to provide their own PIC) while knowledgeable ILCs have developed terms of engagement with researchers. These are promising developments.
- A system needs to be in place to assist ILCs produce legally binding agreements to prevent lopsided agreements. Such an agreement would include suitable mutually agreed terms (MAT) before access is allowed, and again before utilization takes place. Such a system should be developed by ILCs, ethics bodies, academia, government officials, and the competent authority, within a country and between Caribbean countries. Allowing bioprospecting to occur in a country without these legal documents, hinders sharing of benefits.
- Even with PIC and MAT in place, to ensure ABS, the patent system needs to ensure that a certificate of compliance to the NP is obtained before the patent can be granted. A certificate of compliance needs to be issued by a competent authority. It should record date and place GR was accessed, description of GR utilised, source from which GR was directly obtained, name of any accessed ILC, any associated TK, names of any local informants, names of any local scientists involved in accessing the GR, access permits where applicable, presence or absence of rights and obligations relating to ABS and obligations regarding subsequent application and commercialisation, ethical approval of individuals and any ILCs involved, due diligence declaration to a relevant

authority upon receipt of research funding and at the final stage of development of a product. To be NP compliant means users must do everything within reason to at least identify the country of origin of the GR they intend to use. This will allow tracing back to source when benefits are to be shared.

- During ethnobotanical studies, local informants are usually not included as co-authors, often only the external researcher, who came into the region for only a short period of time, is the only author on the paper, leaving out even local researchers who assisted with of the study. It should be required that local researcher(s) be involved with local bioprospecting projects and that they be listed as co-authors in any derived publications. This is especially so when external researchers are only in the region for a short period of time and depend on local researchers for help getting around, obtaining ethics approval etc.
- Other weaknesses in the system that need to be addressed include but are not limited to the following:
    - Consultants, Academia and Government regulators in the Caribbean often have no access to or membership in existing global natural product databases. This is especially limited in the smaller islands.
    - General and specialist information capacity is limited among regulatory agencies, customs officers, and other relevant bodies.
    - Taxonomy training is insufficient and of limited interest to students, herbariums are under-funded and under-staffed, flora and fauna guides insufficient.
    - Limited local capacity for exploration especially of marine and terrestrial invertebrates. Limited capacity in submersible.
    - How can we arrange the IPR system to include community-TK?
    - Who will foot the bill if litigation is needed between the country of origin and the user?

Opportunities Identified for Realizing Benefits Accruing from Bioprospecting in the Caribbean

Five identified opportunities for gaining equitable benefits from Caribbean biodiversity will be shared in this paper. The first and most important opportunity is to ratify the NP so it can be used for those cases for which it applies. The second is to use ecobioprospecting and ethnobiotechnology to obtain more benefits throughout the value-chain. The third is to turn value chains into value rings.

The fourth is to develop alternative IPR regimes such as copyleft and geographical indicators to gain sustainable benefits from regional biodiversity. The fifth is to develop a regionally accessible and standardized bioprospecting database. To explain these opportunities, it is necessary to introduce a new version of the value-chain. These opportunities forecast a roadmap towards a more equitable, sustainable, economically viable biodiversity-rich future for the Caribbean.

Proposed Value-Web for Biodiversity Hotspots

The typical value-chain for bioprospecting was developed by users and not by the country of origin, where GR is accessed. It pre-supposes that the GR collected at the beginning of the process from the country of origin, will be available when R&D is complete, and material is needed for mass-pr1oduction of drugs. It also assumes that manufacturing will occur in the user country.

Just as food-chains are better viewed within a food web, value-chains are better viewed in a value-web as proposed in Figure 2. This figure models all the

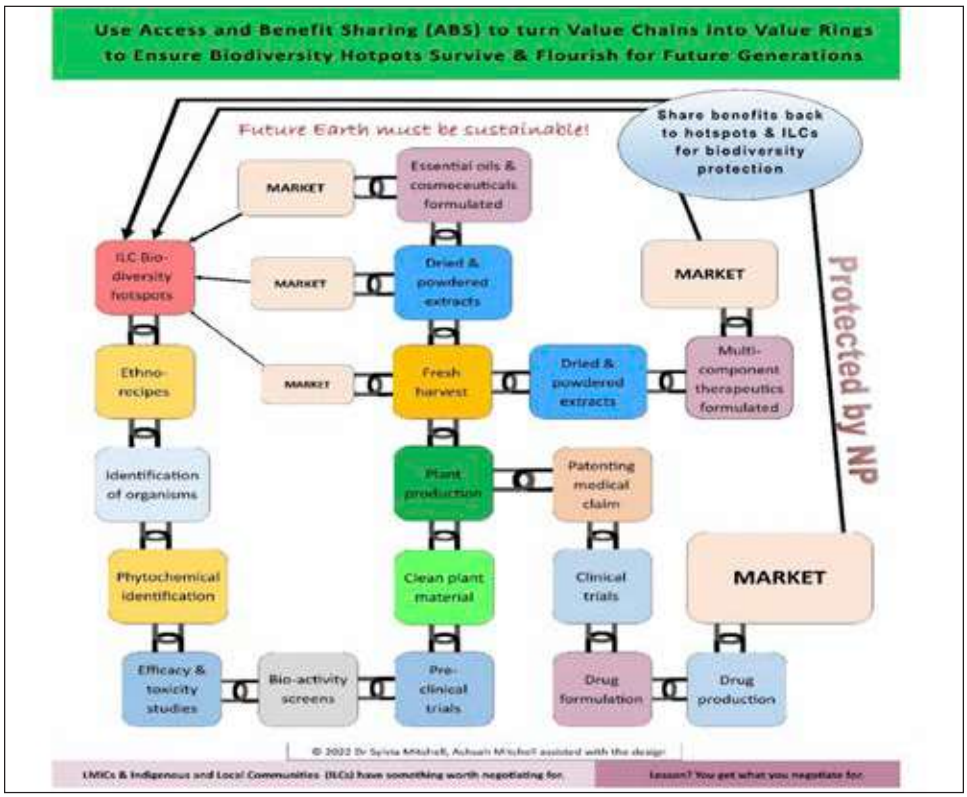

Figure 2: Value-chains turn to Value-rings in a Value-Web to support Sustainability of Genetic Resources and traditional knowledge in biodiversity-rich countries of origin

value-chains from biodiversity, for fresh produce, dried and powdered products (such as turmeric), essential oils and fine chemicals, nutraceuticals, cosmeceuticals (multi-component therapeutics) and pharmaceutical drugs. Modelling the value chains in a value-web, makes it easier to visualize the relationships of the market to the GR, TKs and ILCs, and their relationship to the Access and Benefit Sharing (ABS) envisaged by the Nagoya Protocol.

Opportunity 1: Become NP compliant, Ratify NP, and use the Nagoya Protocol

By overcoming the challenges outlined above and others, the remaining countries of the Caribbean will ratify the Nagoya Protocol and enjoy its benefits. Based on the bioprospecting cases shared in this paper, there is a long way to go to realize this opportunity. The Caribbean countries that have not yet ratified the Nagoya Protocol (Table 1) still require help to do so. This paper is written in support of CARICOM coming together and ratifying the Nagoya Protocol as one avenue towards redress of the historical problem of biopiracy as part of the inequitable, extractive, biased, racist colonial plantationocene. Suggestions of how to turn these challenges into opportunities is given in Table 6.

Table 6: How to turn challenges into opportunities to become NP compliant

Challenges	Opportunities
Too little action, inertia	CARICOM and regional universities should OWN and LEAD the process since most countries still to ratify are in CARICOM
Continuity is lacking, too few meetings, officers keep changing especially due to external factors such as COVID	Develop a CBD-NP-ABS bioprospecting website hosted by CARICOM and accessible to ILCs and regional universities, inviting every country in the Caribbean to take part; Rotate leadership amongst countries
Biopiracy is still happening	Develop a reporting system so what happens in one country can be known by other countries; establish a standardized bioprospecting registry
Information on completed and ongoing relevant projects (GIZ, GEF, UNEP, IUCN and others) not easily available	Establish a database of past regional ABS projects and outputs and make it available to all Caribbean countries via the proposed CBD-NP-ABS website. OWN the process!

Table 6 continues

Table 6: How to turn challenges into opportunities to become NP compliant *(cont'd)*

Challenges	Opportunities
Patents do not include country of origin of GR nor ILCs	Patents should be required to declare the country of origin, any involved ILCs (e.g., where ethnobotany surveys were conducted) and any local participants involved. Where not possible a competent authority be established to issue internationally-recognized certificate of compliance prior to acceptance of a patent request.
Patents do not recognize communal knowledge	Develop better forms of ILC rights recognition that are grounded in indigenous systems of authority and knowledge, reflective of communal and ecological systems of management of biocultural resources.
There are no Caribbean-wide standard MAT and PIC forms	Standardize forms at least for CARICOM and put them on the website in all languages of the Caribbean
As well as benefit sharing, more research is needed for GR & TK	This requires sustained attention to our Flora and Fauna from government, academia, ILCs and private sector.

Opportunity 2: Stabilise the bioprospecting value-chain by using the principles of Ecobioprospecting and Ethnobiotechnology

Countries of origin are biodiversity-rich tropical countries and unlike User countries, need to put more attention on the earlier links in the value-chains (Figure 2) The NP aims to return benefits many years after the original biodiversity was accessed. The ABS system in countries accessing external GR does not need to include procedures to ensure sustainability of the GR accessed. However, those countries from which GRs are being accessed (usually Biodiversity Hotspots) need to ensure their GRs are sustainably maintained. Ecopharmacognosy was coined by Cordell (2013) to describe the "study of sustainable, biologically active natural resources" to ensure that 'selected, valuable traditional medicines are not depleted in their natural environment, but instead alternative resourcing is developed'. This paper recommends applying the principles of Ecopharmacognosy.

Due to the historically extractive plantationocene period, with ongoing neglect of the country of origin (due to non-sharing of benefits), in this case the Caribbean Island Biodiversity Hotspot, and notwithstanding the efforts of international organizations such as UNEP, CEPF and IUCN, sustainability of the bioresource is still threatened (Mitchell et al., 2018a, 2019). There remains a need for plant

pictures in regional floras, morphological and ecological studies, and support for regional herbariums including putting them online. There remains need for basic botanical research to identify medicinal plants and their bioactive phytochemicals that are known only by ILCs for example, the endemic root tonic plants in Jamaica (Mitchell, 2011). This is where ethnobiotechnology can help.

Ethnobiotechnology is concerned with developing biotools and biotechniques that are tailored to and appropriate for indigenous people and their communal knowledge systems, and local communities of the small, developing, tropical states of the Caribbean (SIDS) (Mitchell, 2014). Ethnobiotechnology is the means whereby we can achieve ecopharmacognosy. Studying plants, or any natural organism, for their use as global medicine, must take into account proper identification and long-term sourcing. Support is needed to: identify organisms (morphology, genetic fingerprint, common names, scientific names, pictures of their life cycle stages, chemical fingerprint, etc.), monograph development, adequate and accessible regional flora and fauna guides, online access to regional herbariums, propagation and conservation protocols, and ethno-appropriate school gardens and curriculum. Any associated folk knowledge of how biodiversity can be used, whether for health, to weave baskets, feed animals and so on, should be recognized as intellectual property of the ILC and a method devised to recognize this Intellectual Property Right (IPR). This paper recommends developing ethnobiotechnology solutions.

Ethnobiotechnology can help to support this process by

- Ethnobotanical studies
- Development of local community in vivo, ex vivo and in vitro germplasm gene banks (for conservation)
- Development monographs of folk plants including production of genetic fingerprint, chemical fingerprinting, bioactivity screens and morphological studies.
- Efficacy and toxicity studies of ethnorecipes (Ethnopharmacology)
- Clonal multiplication of chosen folk plant germplasm via tissue culture
- Screening of phytochemicals via tissue culture
- Production of high-value ethnobiopharmaceuticals via tissue culture
- Product development of essential oils and fine chemicals linked to on-farm testing of quantity and quality of yields supporting local industries, including ILCs.
- Using biotechnology to put life back into our soils (biosoils) by using micro-

bial inoculants, biochar etc linked to certified disease-free micropropagated plants, field trials and post-harvest studies.
- Producing ethno-compliant bio-active drugs, nutraceuticals, cosmeceuticals, and multi-component therapeutics.

Opportunity 3: Turning Value-chains into Value-rings for bioresource survival

Not all the links in the value-chains depicted in Figure 2 are usually recognized in the typical bioprospecting value-chain that only considers four phases: collection, identification, screening and commercialization (Melgarejo and Química, 2013; Aquaculture, 2022). A value-chain, which shows how each stage fits into the other, all the way from the bio-resource to various markets is more appropriate to visualize how benefits should be shared (Figure 2). Benefit sharing mechanisms that result in fair and equitable distribution among all parties concerned, including local communities, indigenous groups, universities, companies, countries should be the goal.

Forecasting the future allows one to imagine what a value-web needs to include. When the market is freshly harvested herbs, funds easily reach back to the community that grew them. This then is a value-ring. As the plant material gets dried, powdered, extracted, the value-chain gets longer, and rewards increase while the source is increasingly ignored. Mechanisms such as Fair Trade have been enacted to ensure a value-ring for food crops such as cocoa. However, the longest chain (pharmaceutical) has the most links and the most reward. The Nagoya Protocol attempts to turn this into a value-ring and while it works for drugs in some cases, it is not as easy for other products made from medicinal plants nor for associated traditional knowledge that is held communally in ILCs.

Opportunity 4: Use the principles of the NP where it does not apply

Is the Nagoya Protocol (NP) the only way the Caribbean can obtain benefits from use of its GR and TK, for conservation and developmental purposes? Not at all. The Nagoya Protocol does not apply to multi-component therapeutics, nutraceutical, functional foods or cosmeceuticals made from plants such as pimento to make Jerk Sauce, Khus Khus to make salves, bay leaves to make bay rum. However, the principles of the ABS of the NP with PIC and MATs can still be utilized. Also, other mechanisms and types of IP protection may be applied to

cover these products so that the biodiversity hotspots can be sustainably used and maintained e.g. geographical indicators[7].

Is Access the best criteria on which to base Benefit Sharing? The NP depends on compliance certificates linked to the patent system to link Access to Benefit Sharing, especially between countries. The patent system does not acknowledge communal knowledge. Therefore, the TK of indigenous groups needs a form of rights recognition. Other mechanisms that can be used to protect these inventors include copyright, trade secrets, geographical indicators, copyleft, and restricted databases.

Opportunity 5: Develop a regional and standardized bioprospecting database

While each country ratifies the NP, there is an opportunity, and possibly a necessity to develop a regional ABS database to include: bioprospecting access requests and reports, Caribbean biodiversity-related patents, compliance certificates, ethics proposals from regional and extra-regional scientists, relevant Caribbean literature and reporting of derived products. Together, the Caribbean people must find solutions that will conserve biodiversity while allowing for sustainable use of this shared CIBH bioresource. An output of the UNEP project was the development of standardized methodologies that can be used for developing shared Caribbean national biodiversity registries (Mitchell et al., 2018d). Mechanisms for accessing these registries and the regional ABS database and for sharing benefits amongst the Caribbean nations should be developed. It should be hosted by the Caribbean for use by Caribbean nations.

Bioprospecting from the sea needs special considerations. This is because bioresources more easily move around and can thus be present in the seas of more than one nation. However, the Caribbean Sea has plenty of marine genetic resources to share. The value of products derived from marine genetic resources alone has been valued at $50 billion while a single enzyme isolated from a deep-sea hydrothermal vent used in ethanol production had an annual economic impact of $150 million[8].

7. See https://www.myersfletcher.com/resources/item/you-can-t-call-it-that-it-doesn-t-come-from-here-geographical-indication-protection-in-jamaica.html
8. See (https://dsmobserver.com/2020/07/bioprospecting-in-practice-how-a-drug-goes-from-the-ocean-to-the-clinic/)

Conclusion

We have found no comprehensive review of Caribbean bioprospecting nor corresponding investigations into biopiracy. Together with Mitchell et al (2022), this paper attempts to lay a foundation for continued analysis of Caribbean bioprospecting and its potential to enhance the region's development whilst supporting conservation of its biodiversity. Analysis of historic and more recent bioprospecting cases, and any associated benefit-sharing, produced as many questions as answers. Given that the Caribbean is the seventh largest biodiversity hotspot and has been subjected to a history of extractive bioprospecting (biopiracy), which is unfortunately still occurring, several challenges facing the region as it attempts to right this wrong have been presented along with five opportunities. It is hoped that this paper may nudge the Caribbean, and especially CARICOM, to ratify the Nagoya Protocol and establish a robust system to give access to its resources while using the shared benefits to ensure the CIBH remains vibrant, and the Caribbean countries develop sustainably.

Forecast For the Future

It is hoped that the outputs of the projects from 2012 to 2019 assist the remaining Caribbean countries to ratify the Nagoya Protocol and for all to use it so as to reap benefits for our region, for conservation and for developmental purposes. It is hoped that this paper helps clarify the issues and keeps the conversation going and encourages investments into knowing and valuing Caribbean biodiversity, for all our sakes. It is hoped that the Caribbean will develop value-rings and then use the benefits secured to locally develop more links in these biodiversity-driven innovative value-added-chains. It is also hoped that the processes put in place to activate access and benefit sharing within and between countries, will protect the indigenous peoples and help local communities to prosper. It is also hoped that where the Nagoya Protocol does not apply, that other mechanisms to protect our biodiversity for future generations will be developed.

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