Prioritization of useful plant species to boost conservation and bioeconomy in Colombia: a case study in three biodiverse areas

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Abstract

A new big challenge for megadiverse countries is to develop in a sustainable way, while leveraging their economies and the conservation of ecosystems. Colombia is in search of nature-based solutions that help to improve local livelihoods and strengthen conservation projects, especially in biodiverse regions with historically complex socio-economic contexts. Creating Value Chain Networks (VCN) from sustainably harvested Non Timber Forest Products (NTFP), transformed into Natural Ingredients (NI) and final products, might contribute to buffer the transformation pressure of ecosystems in hotspots of deforestation. A community-based prioritization process was conducted in three biodiverse areas of Colombia to understand the NTFP and NI obtained from native useful plant species potential to boost Colombia's bioeconomy. Through interdisciplinary methodologies that involved both social and natural sciences, 30 species with corresponding NTFP and NI were prioritized (10 for each pilot area). An extensive taxonomic and use diversity was found, from which the most representative families were Arecaceae, Fabaceae, Malvaceae, and Marantaceae, and the most important plant use category reported was food. When data was complemented with local surveys and literature review, a final matrix of prioritized species emerged and a 20-year agenda of implementation is proposed. This might be the first time in Colombia where suitable species and products that accomplish sustainability criteria are prioritized based on the community's traditional knowledge and the scientific evidence. Based on this new evidence, decision-makers and environmental government institutions are encouraged to use this information to focus their development agendas and research projects.

Keywords: Colombia, Conservation, Bioeconomy, Non Timber Forest Products (NTFP), Natural Ingredients (NI), Value Chain Network (VCN), Sustainability.

I. Introduction

Halting deforestation in the major “hotspots” of biodiversity is a global priority, especially in the Neotropics where Colombia occupies a privileged position (Hansen *et al.,* 2013; Negret *et al.,* 2019). Hosting 5 different biogeographic regions and at least 140 different ecosystems, Colombia holds over 10% of the world’s biodiversity, (Rincón Bermúdez *et al.,* 2009). The country has around 26,134 vascular plant species of which ca. 6,253 are endemic species (Diazgranados *et al.,* 2020), and almost 7,480 have a documented use (Diazgranados *et al. in prep*). Around 79 % of the useful plant species documented for Colombia have medicinal uses, 32% are harvested as raw materials (including personal care products and textiles), 28% provide environmental services and 26% are sources for human food (Diazgranados *et al.,* 2021).

Harvesting Non-Timber Forest Products (NTFP) is an ancient practice that has boosted the development of many communities, preserving natural heritages, while protecting cultures and native ecosystems (Iqbal, 1993; Ticktin, 2004; Walter, 2001). Around 80% of the population in developing countries use NTFP for health and nutritional needs (FAO, 2014). The incomes obtained from the commercialization of NTFP (*e.g.,* fruits, seeds, fibers, dyes, medicines, waxes, oils, etc.) usually contribute to the rural livelihoods, reducing the degradation rate of tropical ecosystems and contributing to their long-term conservation (Evans, 1993; Ruiz Pérez *et al*,. 2004; Shackleton *et al*., 2015; Wahlén, 2017; de Beer and McDermott, 1989; Myers, 1988; Nepstad and Schwartzman 1992; Neumann and Hirsch, 2000; Marshall *et al.,* 2006; López, 2008). Sustainable use of NTFP should prioritize native species, preserving their population structure, phenology and life cycles (Ticktin, 2004). As a consequence, in-depth knowledge of the species, their NTFP, the ecosystems and the communities that inhabit them is mandatory to achieve successful conservation models.

Some of the NTFP that can be obtained from Colombia’s biodiversity could improve the livelihoods of many vulnerable communities and be the cornerstone for green development and conservation in Colombia. Recently, some research projects such as P4F “Unleashing non-timber forest products in Colombia”, have been promoting a sustainable use of NTFP, contributing to the decree 690 of 2021 (Minambiente, 2021) which for the first time defines the sustainable harvesting of NTFP in the country. Some of the principal plant species that are examples of current conservation processes through the harvest of NTFP in Colombia are: *Iraca* (*C. palmata*), *caña flecha* (*G. sagittatum*), *jagua* (*G. americana*), *naidí* (*E. oleracea*), *asaí* (*E. precatoria*), *agraz* (*V. meridionale*), Vainilla (*V. planifolia*) and *flor de Inírida* (*G. superba* and *S. teretifolium*) (Portilla *et al.,* 2004, Díaz-López, 2003; Caleño, 2020; Copete, 2020a; Copete, 2020b; Asoprocegua, 2017; Fernández *et al.,* 2016; Torres *et al.,* 2016; Álvarez, 2019). These case studies are some of the very few examples where NTFPs obtained from native plant species are being commercialized through value chain networks (VCN), improving the livelihoods of Colombia’s rural communities.

Value chain analysis has emerged on the new research agenda for NTFP (Jensen, 2009), as it comprises the factors influencing actors to transform these resources to market products

(Matias *et al.,* 2018). Therefore, boosting sustainable NTFP value chains fosters the conservation-through-utilization strategy, leading to the reconciliation of seemingly conflicting interests (Kusters *et al.*, 2004; Sunderlin *et al.,* 2005; Arnold and Ruiz-Perez, 2001). Following the definition of Fondo Biocomercio (2009, p. 14), Natural Ingredients (from now on NI) are: *'The solid or liquid raw material extracted from simple physical and chemical processing of plants and other living, native organisms, used in the development of biodiversity-based products'*. Certain NTFP such as dyes, waxes, oils, gums, resins, latex and varnishes can be considered as NI (Rojas *et. al,* 2021b). In 2019 Colombia had a negative trade balance on the international commercialization of NI of $57,1 million dollars, which is significantly higher than expected when considering the country's biodiversity. Furthermore, compared to Latin America, Colombia accounts for only 0.27% of the region's exports of NI (Rojas *et al.,* 2021a). Hence, its potential remains unmet towards meeting the Colombian government's commitment to bioeconomy.

Growing a bioeconomy in Colombia involves identifying and producing NI from NTFPs via biotech and non-biotech pathways, as part of a process of value-creation and innovation that encourages the replacement of synthetic compounds with those of natural origin (Biointropic, 2018). Thus, supplying NI is essential in differentiating Colombian products in global value chains (ONUDI, 2015). Currently, the national government is implementing the development of a national bioeconomy through a Green Growth strategy (DNP, 2018), taking advantage of the nation's large natural capital (Canales & Gómez*,* 2020). After developing the Green Business Strategy, the concept of bioeconomy has been promoted by the Green Growth Mission defining it as *"a model that efficiently and sustainably manages biodiversity and biomass to generate new value-added products, processes and services, based on knowledge and innovation"* (DNP, 2018, p. 28).

Some studies suggest an absence of institutional leadership, the inefficient use of natural capital, low investment in research and development, and regulatory barriers as the main causes hindering development of bioeconomic initiatives in the country (DNP, 2018; Moñux *et al.,* 2018). For instance, administrative inefficiencies in obtaining sustainable harvest permits for NTFP products and contracts to access genetic resources for commercial purposes may have played a particularly important role (Biointropic, 2019; Papell *et al.,* 2020). Furthermore, the local transformation of these harvested NTFPs products into NI is still very scarce, so it is necessary to deepen the knowledge about native Colombian plant species and the NTFPs of the country. In this context, it is essential that biodiversity becomes a differentiating factor in the bioeconomy in order to overcome challenges at the national level.

In addition, conservation-through-utilization strategies require consideration of social aspects so that NTFP value chains can strengthen local livelihoods. It has been documented that value chain governance, social heterogeneity, species processing knowledge, sustainable practices, inclusiveness and fair distribution of benefits, participation in NTFP markets, working conditions and complementary income affects NTFP value chain development (Wiersum, Ingram, & Ros-Tonen, 2014; Virapongse, Schmink & Larkin, 2014; Shanley et al., 2016; Ingram, 2017; Auch & Pretzsch, 2020; Lan et al., 2021). Therefore, research methodologies that explore local communities' interests and perceptions around the NTFP species are key to understanding the role that NTFP value chains play in promoting a sustainable development and enhancing local livelihoods (Adonteng Kissi & Adonteng Kissi, 2018; Grima et al., 2017; Garret et al., 2017).

This research aims to determine the criteria under which NTFP and derived NI commercialization might contribute to improve the livelihoods, governance systems and conservation strategies of three study areas in Colombia (*i.e.,* Becerril, Otanche and Bahía Solano). The objectives of the study were to 1) identify with primary and secondary data priority native plant species based on a multi-criteria assessment, and 2) establish a framework for evaluating the relative potential of the top-10 identified priority species and their NI. The manuscript is divided into four parts. The first part describes the methods for collecting and analyzing primary and secondary data to identify, rank and assess the relative potential of priority species. The second part focuses on the results from the literature and the study cases to define from a multi-criteria assessment which NI value chains have the highest potential for the Colombian bioeconomy, and thus, are most beneficial to the Colombian society. Finally, we examine limitations, opportunities, and success factors weighing on the potential value chains, and the perspectives on boosting an inclusive bioeconomy that highlights NI from wild harvest in Colombia. These context-dependent inputs will assist in decision-making regarding the costs and feasibility of working towards sustainable management of ecosystems through NTFPs and NI in Colombia.

II. Materials and Methods

1. Study Area

In this study, three municipalities were prioritized as pilot areas suitable for the assessment of the Value Chain Networks (VCN). During 2021, fieldwork trips were conducted in each one of these municipalities: Becerril (Cesar), Otanche (Boyacá) and Bahía Solano (Chocó).

a. Municipality of Becerril (Cesar)

Becerril is a municipality located in the middle-east of the department of Cesar 80 km south of its capital city, Valledupar (Figure 1). The borders of the municipality are: East (*Serranía del Perijá* - Venezuela), North (*Agustín Codazzi* municipality), South (*La Jagua de Ibirico* municipality) and West (*El Paso* municipality). The *Serranía del Perijá* spans through an area of 16,500 km^2 and is the northernmost point of the eastern *Cordillera* of Colombia (Forero, 1970)., with altitudes that range from 100 to 3600 m.a.s.l. The *Serranía del Perijá* has a western slope (*i.e.,* Colombia) with a prevalence of Tropical Dry Forest (from now on TDF), and an eastern slope (*i.e.,* Venezuela) with a prevalence of Tropical Rainforest (from now on TRF). The biodiversity of *Serranía del Perijá* in Becerril, is influenced by the Caribbean, Medium Magdalena valley and Andean floras, with the presence of TDF, xerophytic/sub xerophytic shrubs, cloud andean-forests and, together with the *Sierra Nevada de Santa Marta*, some of the most septentrional *Páramos* in the planet (Rivera-Díaz. & Fernández-Alonso, 2003). In addition, some pristine riparian TDF can still be found locally in small valleys of streams such as the *Canyon of the Socomba river*, which was one of the most collected localities in Becerril (Pers. Observation, 2021).

The municipality of Becerril has a population of 21,611 inhabitants, distributed in two mayoral districts (*Estados Unidos* and *La Guajirita*) and 57 "*veredas"*. The municipality also comprises 74.61% of the urban population and 25.39% of the rural population (DANE, 2018a). In turn, inhabitants of the Yukpa Ethnic Group predominate in rural areas, representing 12.4% of the population of the municipality. Regarding social challenges, poverty is a relevant factor of vulnerability where 35.48% of the population has unmet basic needs (NBI), and 48.6% of the municipality's population is under multidimensional poverty conditions (DANE, 2018b).

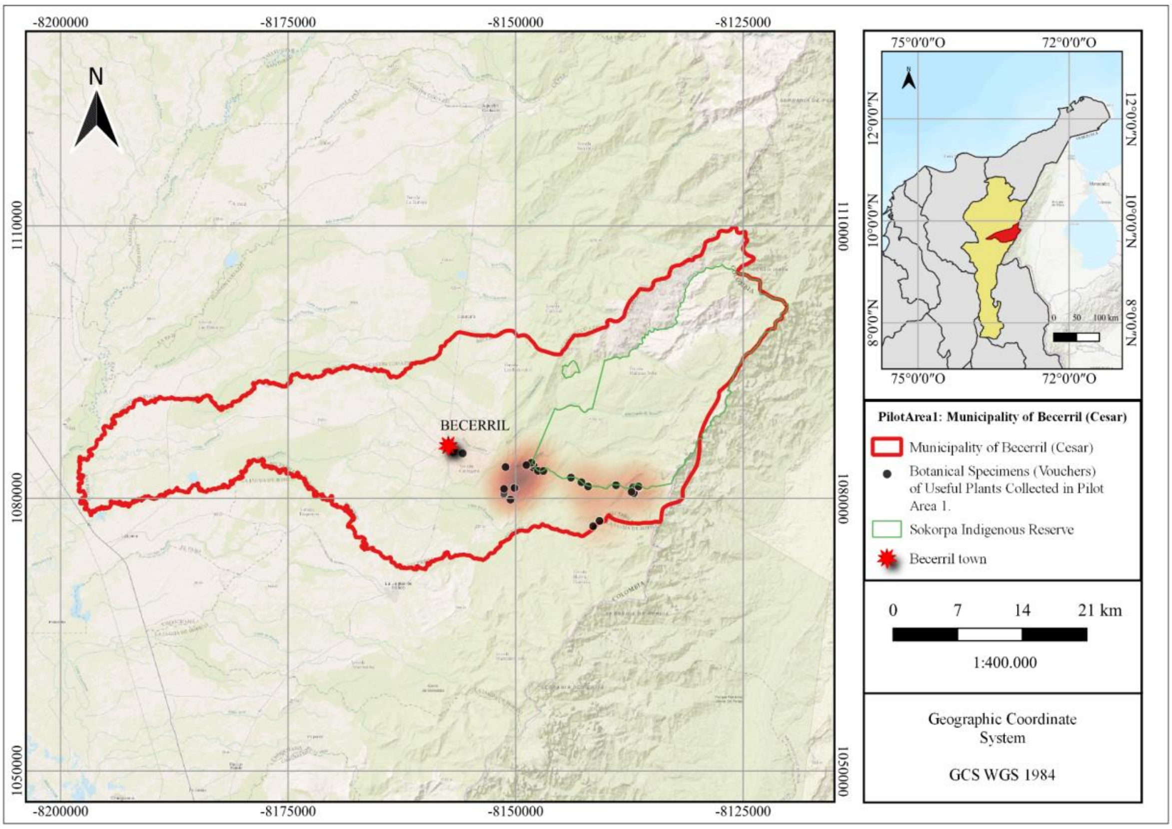

Figure 1. Study area in the Municipality of Becerril, showing the records of the botanical samples collected. The red buffer around the collection records (black dots) highlights the intensity of the sampling per zone.

b. Municipality of Otanche (Boyacá)

The municipality of Otanche is located on the west of the department of Boyacá (Figure 2). The borders of the municipality are: East (*Ricaurte* province), North (*Santander* department), South (*Cundinamarca* department) and West (*Puerto Boyacá* municipality) (EOT Otanche, 2001). Otanche encompasses part of *la Serranía de las Quinchas* located in the western slope of the eastern *cordillera*, reaching the Medium Magdalena Valley which was part of the

"*Refugio Pleistocénico del Carare*", a highly important biogeographic region (CORPOBOYACA, 2008; Hernández y Sánchez en Halffter, 1992). Due to its biogeographical and ecological importance *La Serranía de las Quinchas* was declared as a *Regional Natural Park* (PNR) in 2008, through the agreement 0028 of Corpoboyacá (Corpoboyacá, 2008).

La Serranía de Las Quinchas together with *Serranía de San Lucas* are the two biggest remanent forests of the Medium Magdalena Valley, one of the principal centers of biodiversity and endemisms of Colombia. It presents floristic components of the Tropical Rain-Forest (TRF) and Premontane Andean Rain-Forest (PRF) (EOT Otanche, 2001; PM Serranía de las Quinchas, 2005). This area also has floristic affinity with the *Chocó Biogeográfico*, due to the miocene connection that existed between these two biogeographic regions, bordering the central and western *cordilleras* (through the north) and creating an important area for species exchange (Quiñones *et. al.,* 2021; Hernández y Sánchez en Halffter, 1992). Additionally, there is a high diversity of epiphytes and orchids, and over 30 useful plant species have been reported so far in the region (Ulian & Diazgranados, 2020).

The municipality of Otanche has a population of 10,788 inhabitants, distributed in 43 *veredas*. Likewise, only 0.09% of the population is urban and the vast majority, 99.91%, is rural (Alcaldía de Otanche, 2019). In terms of social challenges, compared to the average of the department of Boyacá, Otanche still presents many challenges to overcome in terms of multidimensional poverty; the department has a multidimensional poverty incidence of 16.6%, while for the municipality of Otanche 44.7% of its population is under conditions of multidimensional poverty (DANE, 2018b).

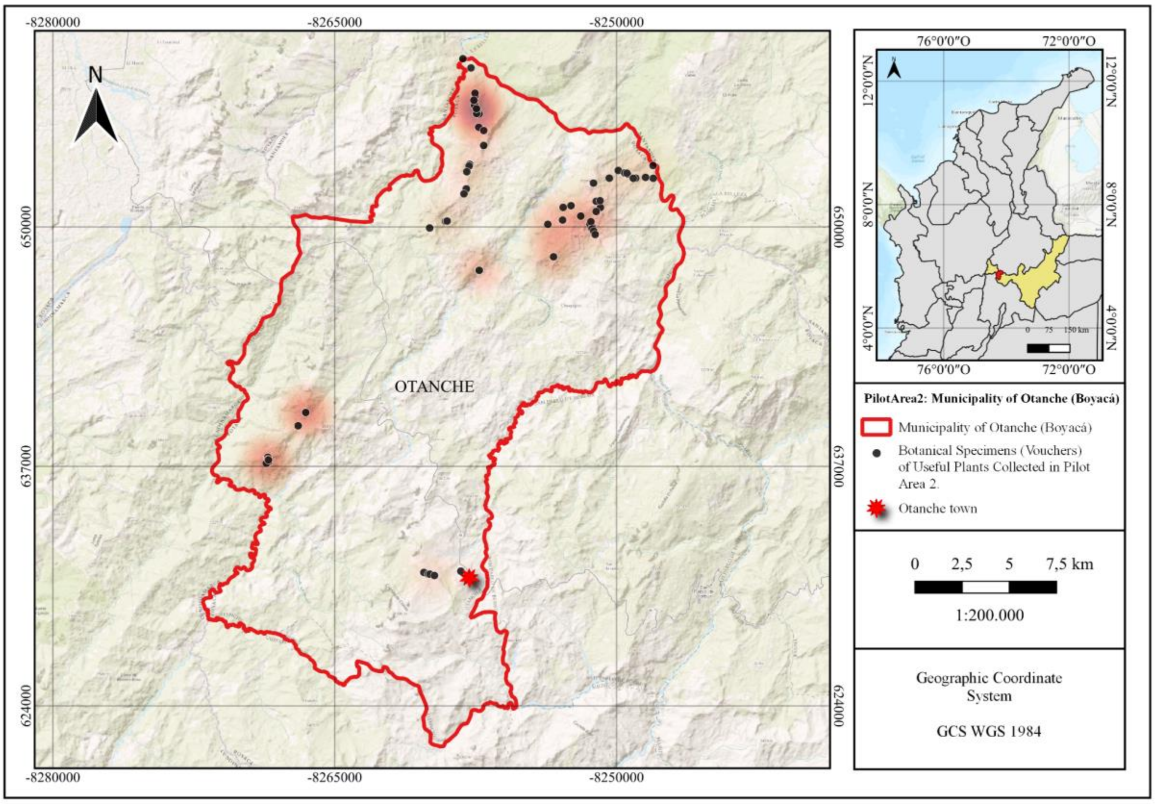

Figure 2. Study area in the Municipality of Otanche, showing the records of the botanical samples collected. The red buffer around the collection records (black dots) highlights the intensity of the sampling per zone.

c. Municipality of Bahía Solano (Chocó)

Bahía Solano has an area of 1,667 Km^2 and borders on the West with the Pacific Ocean, to the North with the municipality of Juradó, to the South with the municipalities of Nuquí and Alto Baudó, to the East with the *Serranía del Baudó* and the municipality of Bojayá (Alcaldía municipal, 2012) (Figure 3). The southern part of the municipality includes a part of the *Parque Nacional Natural Utría*, which has over 54,380 marine and terrestrial hectares (Figure, 4). The Chocó biogeographical region of Colombia ranges from the pacific coast of Panamá to Ecuador is well known for being a global Hotspot of Biodiversity, with one of the highest biodiversity concentrations per area in the world as well as an unusually high number of endemic species (Gentry, 1978; 1982; Myers, 1988). The prevailing ecosystems are lowland TRF and Mangroves, from 0 m.a.s.l., to Sub-Andean cloud forests in the *Serranía del Baudó*, which reaches over 1,500 m.a.s.l. and is located in the eastern part of the municipality.

The municipality of Bahía Solano has a population of 10,123 inhabitants, distributed in two mayoral districts *(Delfines and Bahía Cúpica)* and 16 smaller settlements (Alcaldía Municipal de Bahía Solano, 2005). Along with biological diversity, Bahía Solano hosts a great ethnic diversity, where Afro-Colombian communities represent 84.1% and indigenous communities 13.3% of the population (DANE, 2018a). Likewise, 63.52% of the population's municipality is located in the urban center and 36.48% of the population lives in the dispersed rural area (Alcaldía Municipal de Bahía Solano, 2020). Regarding social challenges, compared with the average of the department of Choco, Bahia Solano does not show many differences in multidimensional poverty issues, where the rate of the department is 45.1%, while for the municipality of Bahia Solano 46.6% of the population is multidimensionally poor (DANE, 2018b).

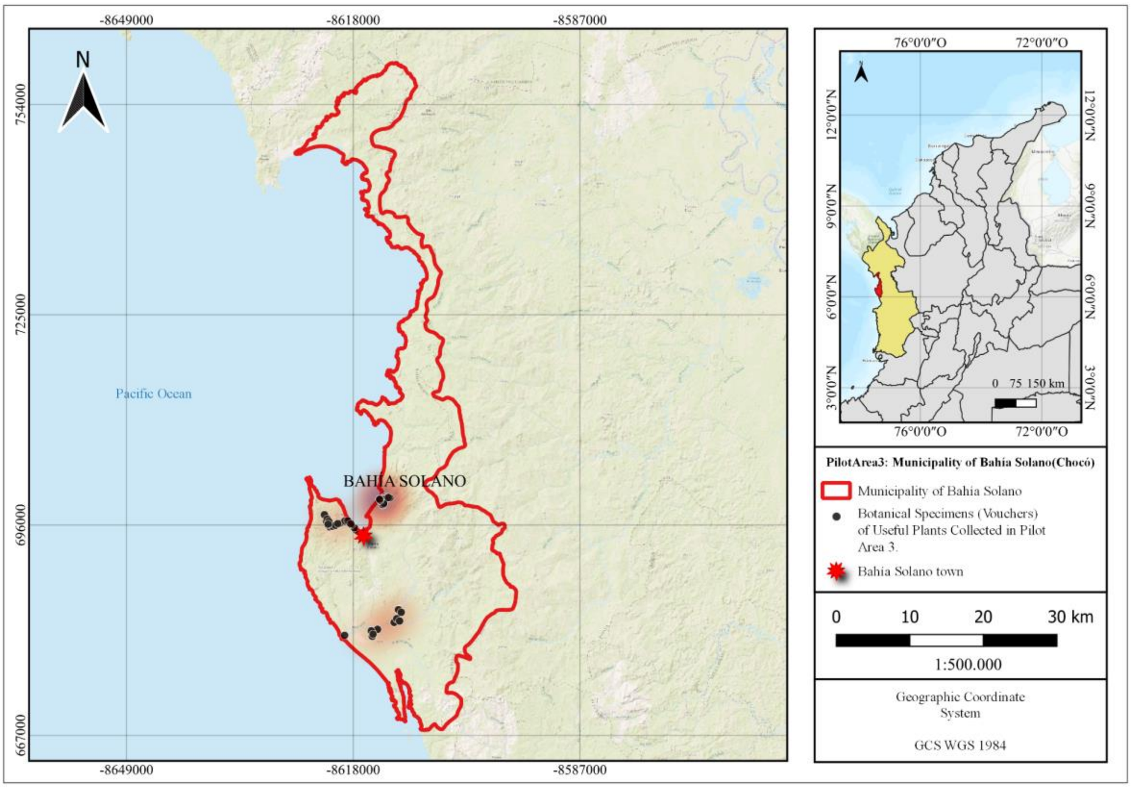

Figure 3. Study area in the Municipality of Bahía Solano, showing the records of the botanical samples collected. The red buffer around the collection records (black dots) highlights the intensity of the sampling per zone.

2. Data collection

2.1. Workshops

In total, seven workshops were conducted: 2 in Becerril, 3 in Otanche, and 2 in Bahía Solano. The aim of these workshops was to prioritize, in a participatory manner, species suitable for the development of NTFP and natural ingredients value chains. This prioritization followed a multi-criteria assessment since it was assumed that the use of these species should promote the conservation of ecosystems as well as the socio-economic development of the territories On average, each workshop involved the participation of 15 people who were divided into 3 roundtables, addressing the following categories of general use of Cook's (1995) economic botany: (1) Food and Social uses; (2): Environmental uses and Materials; and (3): Medicines, Poisons, and Fuels.

Participants mentioned a wide diversity of plant species (common names) with their current and/or traditional uses in the area, classifying them into the use categories of each table (Figure 4a). In this way, information about hundreds of useful plant species was collected during each workshop, according to the general category of use (Figure 4b). Subsequently, introduced and exotic species for Colombia (*e.g.,* Citrus, Plantains-Bananas, Wheat, Sugar

Cane, Coffee, etc.) were excluded from the analysis. Afterward, multi-criteria assessment dimensions (table 1) were explained so that the communities would only select native species that meet two or three dimensions, with the aim of being able to preselect between 10 and 20 species in each workshop.

Table 1. Multi-criteria assessment dimensions

Biological-Ecological	Social and Cultural	Political and Economic
• Native species important for the ecosystem (ecosystem services provider) and for other species (umbrella) • With wide distribution nationwide, but hopefully restricted to Colombia. • The resource, or part of the plant to be harvested, has high growth rates, high resilience, and productivity.	• The species and/or derived natural ingredients have high importance and social use. • They are part of the worldview and are closely linked to the folklore and cultural traditions of the communities of the pilot areas.	• Clear knowledge-legislation of the regional environmental authorities about the species used. • The products derived count with a market and commercialization circuits (*i.e.,* it has a real economic value, local, regional or national). • The product to be marketed is a source of labor (formal and informal).

Species that met the three dimensions would have priority in the pre-selected list of species prioritized by the community (Figure 4c). Finally, a voting process was carried out in each workshop (Figure 4d), where each participant was asked to select three (in Otanche and Bahía Solano) and ten (in Becerril) species out of the preselected list (*i.e.,* those species with intersections in two or more dimensions). For Bahía Solano and Otanche, participants ranked these species from 1 to 3, being the 1st position the most preferred species to be prioritized in the region and the 3rd position the "least" preferred of the selected species. In Becerril, participants ranked the species from 1 to 10, being the 10th position the "least" preferred of the identified species.

(a) 

(b) 

(c) 

(d) 

Photographs taken by: Rocío Peña, Sabina Bernal, Tatiana Rojas and Edgar Padilla.

Figure 4. Description and methodology of the workshops. The workshops began by explaining the different categories of plants uses, in order to form rotating roundtables for naming plants and associated uses (a). The results were shared considering only native species (b) and then proceeded to a prioritization from a multi-criteria framework (c). Finally, a vote process was held to select the species that best met the criteria (d).

2.2) Literature review

Following Stockdale *et al.,* (2019) framework, the current management system of the species prioritized by the local communities was documented for the three study areas. As proposed in the workshops, the existing management system was divided into its biological-ecological, social, and economic dimensions, to proceed with primary and secondary information to evaluate each aspect in terms of its potential for sustainability. Ultimately, this includes the effort that local communities might deliver to achieve sustainable management (Figure 5).

According to the effort required, the following division of the potential can be made: (i) **High potential.** when a minimal effort is required from local communities to harvest a highly renewable NTFP (*e.g.,* leaves, flowers, fruits) of a very productive and fast-growing species; (ii) **Medium potential.** when a medium effort is required to harvest NTFP (*e.g.*, exudates: latex, resins, gums, oils) of a medium productive species with medium growing rates; and (iii) **Low potential.** when a greater effort is required to harvest NTFP (*e.g.,* whole plant, roots, bark, meristems) of a scarce species with low productivity and low growing rates. In this case, communities might choose to channel its efforts into another activity to sustain and earn income.

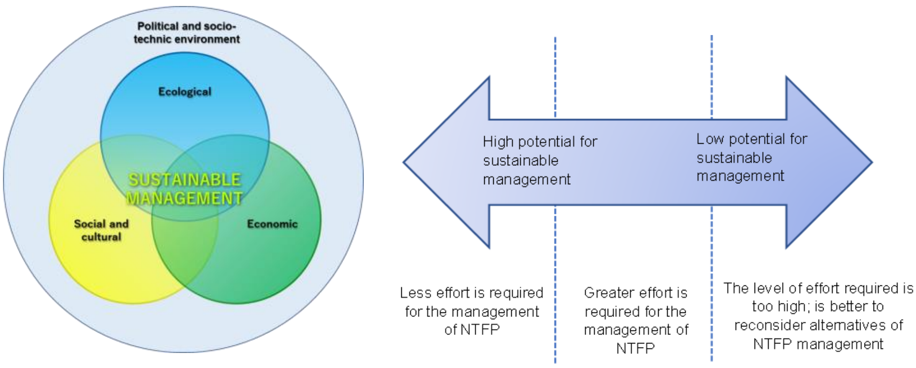

Figure 5. Graphic representation of the potential to achieve sustainable management of NTFP Stockdale *et al.* (2019)

To this end, a series of tables have been generated to examine the literature review on ecological, biological, and economic (markets and demand) potential for sustainable management, for the identified top 10 species with local communities in each study area. In this literature review, no secondary information was collected for local governance processes and livelihoods since this information depends on primary information as it is context-related and there is limited information available. According to the classification of potential per species, the variables were classified into High Potential (HP), Medium Potential (MP), and Low Potential (LW) in the cases that each of the criteria established is accomplished. The different colors and categorical values for the potentials are denoted as follows: HP in light green, with a categorical value of 3; MP in light blue, with a categorical value of 2; and LP in light orange, with a categorical value of 1.

2.2.1. Biological assessment of sustainability

Some NTFP species are inherently better able than others to tolerate the impacts of harvesting. According to Stockdale *et al.* (2019), ecological attributes such as abundance, distribution, growth, reproduction of the resource, and management-related aspects, such as the part of the plant used for natural ingredients (non-timber uses), have a great influence on the potential for sustainable management. Therefore, the Origin, Threat Category, Distribution, Abundance, Part of the plant used, Phenology/Productivity, Growing rate and Ecological Importance were the main variables analyzed for each species. These variables list the most important ecological-biological characteristics that define the potential for sustainable management regarding non-timber uses. Detailed criteria for each variable in this dimension and respective potential assessment can be seen in Appendix 1 (Table 1).

2.2.2. Economic (markets and demand) assessment for sustainability

Some studies have found that communities are more likely to organize to protect and manage forests if they themselves attribute a convenient economic value to the resource (Hobley y Shah, 1996). In this context, we consider variables such as the number of commercialized end products in the national market, including the different categories of natural ingredients established by *Fondo Biocomercio* (2009) as well as NTFPs defined by Torres and Casas (2014). Conversely, end products might refer to both primary and secondary transformations or as inputs in the manufacturing process. By primary transformation, we consider products obtained directly from raw materials without any kind of value-added. Conversely, we refer to secondary transformation to those products that have had different processes and degrees of elaboration and industrial finishing with greater added value.

In addition, we appraise organizations from Small & Medium Enterprises (SME's) that include Community-based companies to independent suppliers and Multinational Corporations (MNC's) along with the historical production of the species (at the municipality, department, and national level) in Agronet's database from the Ministry of Agriculture. Finally, support actors include government agencies, community-based associations, private and public institutions, universities, research institutes, financial institutions, and NGOs. Detailed criteria for each variable in this dimension and respective potential assessment can be seen in Appendix 1 (Table 2).

2.3) Surveys

Eighty (80) focal surveys were conducted in the three study areas from July to November 2021 as a primary source of information to address multi-criteria dimensions of sustainable management. For Becerril and Otanche, APSACESAR and *Corporación Boyapaz* helped us conduct 30 surveys, per area, while for Bahía Solano the Pacific Botanical Garden helped us gather data from 20 people due to logistic limitations. In Becerril 63,3% of the people surveyed were males (26 to 70 years old); in contrast, 36,7% were females (30 to 68 years old). In Bahía Solano, 60% of the sample were females (27 to 70 years old), whereas 40% were males (35 to 70 years old). Finally, in Otanche, 50% of the sample were women (26 to 76 years old) and 50% were men (21 to 60 years old).

The survey was divided into three dimensions: Biological-Ecological (Appendix 1, Table 3), Livelihoods and Cultural Appropriation (Appendix 1, Table 4), and Governance and Value chains (Appendix 1, Table 5). The first dimension explores the perceptions of abundance, distribution, parts of the plant used, productivity, environmental importance, and harvest locations of the prioritized species. The second dimension investigates the perception of uses, knowledge, popularity, and benefits for each species. Finally, the third dimension brought together local knowledge about the historical production, circuits of commercialization, organizational processes, and natural ingredients. Data analysis for each species was made by considering the number of answers from the sample.

3. Data analysis

3.1) Workshops

a. Prioritization process with the community

Once individual votes were obtained in each area, the information was organized counting the number of times each named species remained from the 1st position to the 10th (in Becerril), and from the 1st position to the 3rd (in Otanche and Bahia Solano). According to Montaño et al. (2006), a technique for weighting the parameters is the multi-criteria analysis (MCA), which allows the analysis of different expert views regarding the quantitative importance of each parameter in the standard (Mendoza et al. 1999). MCA's two simplest methodologies for the analysis of principles, criteria, and indicators are ranking and rating. In this study, only the ordinal ranking was considered. This consists of sorting all items in a list in order of importance, where the most important has the highest ranking (n=number of indicators), the next has a value of n-1, and so on.

Following Montaño *et al.* (2006) framework, it was assigned and multiplied by a score of n=10 (in Becerril) and another score of n=3 (in Otanche and Bahia Solano) to the highest position; that is, position number 1 concerning the preferred species to be prioritized. The same was done with the second position (assigning a score of n-1=9 in Becerril and n-1=2 in Otanche and Bahia Solano), and so on until reaching the lowest position; that is, position 10 in Becerril and 3 in Otanche and Bahia Solano, referring to the least preferred species to be prioritized. Consecutively, for each workshop, the sum of the scores was made in which species *i* had remained from the 1st to the 10th position (in Becerril) and from the 1st to the 3rd position (Bahia Solano and Otanche). This allowed the classification (rank) of the species position; that is, the higher the sum of the scores, the species *i* would be classified within the first positions since species with higher classifications were "rewarded". Then, the information for each municipality was grouped, considering that in each municipality more than one workshop was held.

To achieve this, species that had been named in two or more workshops were placed at the top of the municipality ranking. Therefore, the position of the classification of species at each municipality was determined by: (i) the species was named in the higher number of workshops held in the municipality; (ii) if several species were named in different workshops, the tiebreaker was defined by the lower value of the sum of the classification (ranking) in the workshops in which the species had been prioritized. This reflects that the species occupies the first position (*e.g.,* lower values) and is, therefore, more preferred than other species to be prioritized.

3.2) Literature review

Subsequently, different weights were assigned for each variable under two sustainability dimensions in the literature review. The weights assigned to the different biological variables follow the recommendations of Stockdale *et al.,* (2019) and local experts, agreeing that the variables of abundance, part of the plant (structure) harvested and productivity are the most important variables when prioritizing species for sustainable use (harvest) models. These set of variables, were given a weight of 30%, each in the sample. In parallel, variables such as growing rate (15%) and ecological importance (10%), although very important for sustainable harvest models, were given lesser weights. Finally, origin, threat category and distribution were given weights of 5%, since they have a lower contribution to the sustainability assessment of a species.

In parallel, regarding the economy (markets and demand) it is worth mentioning that Global value chains (GVCs) represent a major source of upgrading social opportunities and a new path for development. GVCs can create new opportunities on the labor demand side, but supply and demand cannot meet if national supply is missing (Taglioni and Winker, 2016). This potential gap illustrates the importance of embedding national policies into a broader portfolio of policies aimed at upgrading skills, physical and regulatory infrastructure, and enhancing social cohesion. Therefore, national market variables such as 'Number of commercialized end products', 'Number of enterprises', and 'Number of support actors' have greater weight (25% of the dimension) in comparison to the same variables at the international level (10%), as a proxy for national market size as stated by Asplund and Sandin (2003). Finally, the only variable that had a lower weight (5%) was 'Production in the last reported year', since Agronet only considers cultivated production (mainly monocultures) and not wild harvest of NTFPs.

Afterward, the sum of the weighted averages was performed by multiplying the weights of each variable in every dimension by the value of the categorical variables representing the potentials (HP:3; MP: 2; LP: 1). In this study, a measure was needed to distribute data in three assessment potentials. In this regard, the sum of the weighted averages was distributed by percentiles: an approach that indicates what percent of a given data scored at or below a measure. Therefore, we chose this statistical method as according to Devore (2012) is a measure of position that allows categorizing qualitative and categorical data. In this regard, percentile distribution was used to divide data into three groups with the following criteria: (i) LP: data distributed below the 33th percentile; (ii) MP: data distributed between the 33th and 66th percentile; (ii) and HP: data distributed from 66th percentile onwards. By using this statistical approach, not only could it be possible to classify the potential for each species, but also determine how high, medium, or low potential species are located relative to their counterparts.

Subsequently, grouped results are shown for the biological-ecological and economic (markets and demand) dimensions, and the potential is defined with an average of both dimensions, distributing the sample in percentiles to identify the overall sustainable NTFP management. Each dimension had the same weigh (50%), since the marketing of NTFPs can be seen as a middle ground that fosters the "conservation by commercialization" strategy, demonstrated to address ecological, social, and economic concerns (Arnold and Pérez, 2001).

3.3) Surveys

The surveys from the three study areas were divided by municipality and dimension. For each dimension of the municipality, individual surveys were arranged in separate sheets where in another blank spreadsheet the answers of all the surveys were grouped in one average value that ranged from -1 to 1. As in the literature review data analysis, species were ranked into the three potentials: (i) if an answer matched with the HP convention, it was assigned a categorical value of 1; (ii) if it corresponded to the MP criteria, a value of 0 was assigned; (iii) and lastly, if the answers matched with the LP criteria, it was assigned a value of -1. By adding the overall responses of each survey respondent per question and species, a simple average for the species per dimension was found.

Subsequently, different weights were assigned for each variable in the three sustainability dimensions. Therefore, weights for the biological-ecological variables were defined under the same parameters of the literature review: 'Abundance', 'Part-structure of the plant used' and 'Productivity' had the highest weights (20% of the dimension), followed by 'Environmental importance' and 'Harvest systems' (15% each) and finally, perception of 'Distribution' had the lower weight (10%).

Regarding livelihoods criteria, communities that widely use a species are more likely to continue with its use, potentialize and diversify it as part of their livelihoods (Barnes *et al.,* 2017). Therefore, 'Uses of the species' explored the purposes of use and was assigned with a higher weight (35% of the dimension). Secondly, due to the violence-related displacement of rural areas in Colombia, it is likely intergenerational transmission of plant use knowledge is affected, making NTFP appropriation in value chains difficult. Thus, we assess if currently traditional preparations, remedies, or stories associated with the species are known as these factors may facilitate developing value chains (Eyssartier, C., Ladio, A.H. & Lozada, M., 2009; Lundy et al., 2007). Consequently, we assigned a higher weight (35%) to the variable 'Knowledge of species'. Thirdly, perceived 'Benefits related to the use' (20%) measured how plant uses would improve aspects of communities' wellbeing (Medley et al., 2020), as more perceived benefits, are likely to positively affect individuals' expectations to participate and stay in a related value chain (Garrett et al., 2017; Medley et al., 2020). Finally, the item related to popular uses in the community emphasized wide or sporadic use in special or local events. However, this item limited the assessment of other uses such as environmental or material uses, so it was assigned with less weight (10%).

For governance and value chain criteria, as in the analysis of the literature review, the only variable that had a lower weight (10%) was 'Production in the last reported year (tons)'. Conversely, the variable 'Existence of organizational processes' reveals some governance arrangements in the value chain, as stated by Kaplinski (2000) and Gereffi *et al.* (2005). This variable has a significant weight of 30% of the dimension, as the lack of organizational processes reveals higher efforts to successfully develop value chains. In parallel, 'Trade and consumption circuits' have the same relevance, since short commercialization circuits are a way of supplying local chains by improving the quality of life of farmers in their territory (Rodríguez et al., 2021). Furthermore, if local supply chains have a history of local consumption, these are better prepared for national and international commercialization circuits (Ruiz-Pérez et al., 2004). Finally, the focus of this study is to identify the most beneficial natural ingredients from a sustainability assessment. Therefore, the variable 'Natural ingredients production' preserves a high weight of 30% of the dimension favoring species that have local production of more than one natural ingredient. This is relevant since recent studies have revealed that when primary transformation occurs in biodiverse territories, profit margins for local communities might increase (Hernández-Barrios *et al*., 2014; Ariyo *et al.*, 2018; Folayimi *et al.*, 2019).

Afterward, the averages of the surveys in each study area were multiplied by the weights of each variable in every dimension. As in the literature review, the sum of the weighted averages was distributed by percentiles. Subsequently, grouped results are shown for the three sustainability dimensions, and the potential will be defined with an average, distributing the sample in percentiles to identify the overall sustainable NTFP management.

III. Results

1) Workshops

A cleaned database was obtained with all the species mentioned in the workshops, as described previously with over 665 different useful plant species and morphospecies (see Appendix 2). Of those 72,5 % represented native plants. Otanche is the locality with the highest values of records of useful plants (258) followed by Bahía Solano (212) and Becerril (195) (Table 2). Overall, 429 morphospecies were identified to species, 114 to genus, 59 to family, and 63 remain undetermined (*e.g.,* no voucher, the name does not match any databases or none of the consulted experts knows them, etc.).

Table 2. Summary of the number of useful species mentioned and identified from the workshops in the three study areas.

ID Status	Becerril			Otanche			Bahía Solano			Total
Mophospecies	47			106			83			236
Species	148	Native	93	152	Native	112	129	Native	100	429
		Endemic	2		Endemic	2		Endemic	3	
		Non native	47		Non native	34		Non native	23	
		Naturalized	6		Naturalized	6		Naturalized	2	
Indet.	6			24			33			63
Total	**195**			**258**			**212**			**665**

a. Top 10 prioritized species in each study area

The top 10 prioritized species by the local communities in the three selected study areas were obtained following the methodology previously described (table 3). The taxonomic identification was carried out and the prioritized species are distributed in 27 genera of 17 Families. The most representative families were Arecaceae (5 sp.), Fabaceae (3 sp.), Malvaceae (3 sp.), and Marantaceae (3 sp.). All the supporting information gathered in the workshops with local communities, along with the data analysis to identify the top 30 priority species can be seen in Appendix 3. *C. lutea* was the only species that was independently prioritized in the three pilot areas by the community, whereas in Bahía Solano the community prioritized four palm species out of ten (almost 50% of the top-10).

Table 3. Ranking with the scientific and common names of the top 10 useful plant species in the study areas. Note that some species might have additional common names

	Becerril			Otanche			Bahía Solano		
Rank.	**“Common name”-Scientific name**	**No. of work. Priorit.**	**Sum. of rankings**	**“Common name”- Scientific name**	**No. of work. Priorit.**	**Sum. of rankings**	**"Common name"-Scientific name**	**No. of work. Priorit.**	**Sum. of rankings**

1	“Guáimaro”- *Brosimum alicastrum Sw.*	2	3	“Nacumas”- *Carludovica palmata Ruiz & Pav.*	3	10	"Borojó"- *Alibertia patinoi (Cuatrec.) Delprete & C.H.Press.*	2	2
2	“Corozo”- *Bactris guineensis (L.) H.E.Moore*	2	8	“Bore”- *Xanthosoma sagittifolium (L.) Schott*	3	13	"Vainilla"- *Vanilla cf. planifolia Andrews*	2	5
3	“Guásimo”- *Guazuma ulmifolia Lam.*	2	8	“Cacao”- *Theobroma cacao L.*	2	3	"Milpesos"- *Oenocarpus bataua Mart.*	2	7
4	“Bijao”- *Calathea lutea (Aubl.) E.Mey. ex Schult.*	2	16	“Guatila”- *Sicyos edulis Jacq.*	2	9	"Coco"- *Cocos nucifera L.*	2	11
5	“Mamón”)- *Melicoccus bijugatus Jacq.*	2	18	“Sápiras”- *Vasconcellea cauliflora (Jacq.) A.DC. - V. sphaerocarpa* (García-Barr. & Hern.Cam.) V.M.Badillo	2	10	"Achiote"- *Bixa orellana L.*	2	18
6	“Campano”- *Samanea saman (Jacq.) Merr.*	2	19	“Mámeras”- *Cyclanthus bipartitus Poit. ex A.Rich.*	2	16	"Jagua"- *Genipa americana L*	2	18
7	“Orejero”- *Enterolobium cyclocarpum (Jacq.) Griseb.*	2	25	“Bijao”- *Calathea lutea (Aubl.) E.Mey. ex Schult.*	1	2	"Choibá"- Dipteryx cf. oleifera Benth.	1	2
8	“Camajón / Piñón”- *Sterculia apetala (Jacq.) H.Karst.*	2	27	“Guadua”- *Guadua angustifolia Kunth*	1	2	"Tagua"- *Phytelephas cf. macrocarpa Ruiz & Pav.*	1	3
9	“Jobo”- *Spondias mombin L.*	2	31	“Cilantro sapo”- *Eryngium foetidum L.*	1	2	"Chontaduro"- *Bactris gasipaes Kunth*	1	4
10	“Caracolí”- *Anacardium excelsum (Bertero & Balb. ex Kunth) Skeels*	2	33	“Sacha Inchi”- *Plukenetia volubilis L.*	1	3	"Bijao"- *Calathea lutea (Aubl.) E.Mey. ex Schult.*	1	6

Considering the 30 prioritized species, overall “Food” was the most representative use category with 24 identified species, followed by 20 species used as “materials” and 15 species with “environmental” use (Figure 6). In Becerril, “Food” category was followed by “Materials” and “Environmental” use. In Otanche, “Food” was also the most mentioned use category, followed by “Materials”. Lastly, “Medicines” and “Environmental use” were in third place. In contrast, in Bahía Solano, “Materials” was the most important use category, followed in the same number of responses by “Medicines” and “Food”. Finally, “Environmental uses” was the third most important use category in this pilot area. The species with the highest record of uses were *Guazuma ulmifolia* Lam., *Cocos nucifera* L., *Oenocarpus bataua* Mart. and *Theobroma cacao* L. with 5 general use categories each one.

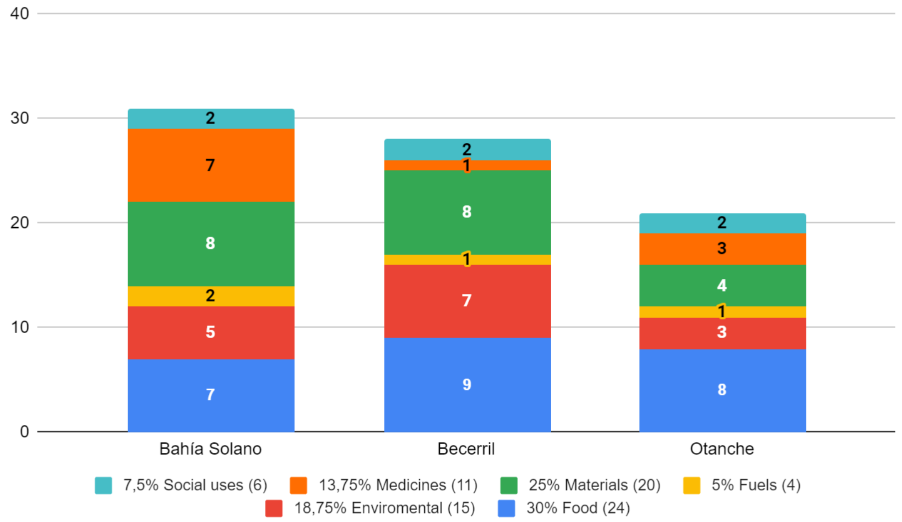

Figure 6. Frequency of use reported for the prioritized top 30 species in the workshops of the three study areas.

2) Literature review

The results of the assessments of sustainability potential for the top 10 priority species per area are presented below. These data are based on the literature review for both biological-ecological and economical (markets and demand) dimensions.

2.1. Biological assessment of sustainability

All the information collected in this dimension was detailed in Appendix 4 (Table 1 - 3), in which reference is made to the bibliographic references of the biological-ecological literature review matrix. The corresponding data analysis and the potential assessment in this dimension is detailed in Appendix 4 (see table 4 - 6). In this dimension, 11 species were classified with a high potential for sustainable NTFP management; 3 in Becerril, 4 in Otanche and 4 in Bahía Solano. The species with the highest position in this potential were: *B. guineensis* (Becerril), *C. palmata* (Otanche) and *O. bataua* (Bahía Solano). Regarding medium potential for sustainable NTFP management, 12 species were identified (4 in Becerril, 3 in Otanche and 3 in Bahía Solano). Within this potential, the following species occupied the highest positions in percentile 66: *G. ulmifolia* (Becerril), *X. sagittifolium (Otanche) and C. nucifera (Bahía Solano).* Finally, the remaining 9 identified priority species had a low potential for sustainable NTFP management: 3 in Becerril, 3 in Otanche and 3 in Bahía Solano. Of these species stand out *S. apetala* (Becerril), *P. volubilis* (Otanche), and *V. planifolia* (Bahía Solano), with the highest positions of percentile 33. Furthermore, "*Bijao*" (*C, lutea)* was the only plant to be always in the top 3 of species with highest biological potential of sustainability in the three study areas.

2.2. Economic (markets and demand) characteristics for the potential of sustainability

All the information collected in this dimension was registered in detail in Appendix 5 (see Table 1 - 3), in which reference is made to the directory of enterprises, support actors, commercialized end products at the national and international level for the prioritized species per area. Based on the information gathered, the potentials HP, MP, and LP were categorized according to the values of the variable mentioned in the data analysis section.

The results of this process and the potential for the use of the prioritized species in the three selected study areas are detailed in Appendix 5 (see table 4 - 6). In this dimension, 13 species were classified with a high potential for sustainable NTFP management; 4 in Becerril, 4 in Otanche and 5 in Bahía Solano. The species with the highest position in this potential were: *B. guineensis* (Becerril), *T. cacao, V. cauliflora - V. sphaerocarpa, S. edulis* and *P. volubilis* in Otanche and *A. patinoi, V. planifolia, C. nucifera, B. orellana* and *B. gasipaes* in Bahía Solano. Regarding medium potential for sustainable NTFP management, 8 species were identified (3 in Becerril, 3 in Otanche and 2 in Bahía Solano). Within this potential, the following species occupied the highest positions in percentile 66: *E. cyclocarpum* (Becerril), *G. angustifolia (Otanche) and O. bataua (Bahía Solano).* Finally, the remaining 9 identified priority species had a low potential for sustainable NTFP management: 3 in Becerril, 3 in Otanche and 3 in Bahía Solano. Of these species stand out *S. apetala* (Becerril), *C. lutea* (Otanche), and *G. americana* (Bahía Solano), with the highest positions of percentile 33. In contrast to the results of the biological and ecological dimension, *C. lutea* was not ranked as a high potential species in any study area; in fact, in Bahía Solano and Otanche was determined to have a low potential under this dimension.

Considering the two dimensions, the Overall Sustainability Assessment (OSA) gathers the results for the Biological-Ecological and Economic (Markets and demand) criteria for the 30 species of the three study areas into an average for each species (see Table 4). In sum, 11 species were over the percentile 66 and were identified with a high potential for sustainable management (36.67%), these are: *B. guineensis (Uva de lata), M. bijugatus (Mamón), G. ulmifolia* (Guácimo) *and B. alicastrum* (Guáimaro) in Becerril; *T.cacao (Cacao)*, *C.palmata (Nacumas)*, *G.angustifolia (Guadua)* and *P.volubilis (Sacha Inchi)* in Otanche; and *A.patinoi (Borojó)*, *B.orellana (Bija)* and *C.nucifera (Coco)* in Bahía Solano. Furthermore, 10 species were classified in medium potential (3 in Becerril, 3 in Otanche, and 4 in Bahía Solano) and 9 in low potential (3 for each study area).

2.3. Overall sustainability potential of NTFPs species management

Table 4. Potential assessment of sustainable management of NTFPs under literature review biological-ecological and economic (markets and demand) dimensions.

Becerril (B)				Otanche (O)				Bahia Solano (BS)			
Species	**SWA (Biological)**	**SWA (Economic)**	**Simple average**	**Species**	**SWA (Biological)**	**SWA (Economic)**	**Simple average**	**Species**	**SWA (Biological)**	**SWA (Economic)**	**Simple average**
B. guineensis	2,85	2,85	2,85	*T. cacao*	2,8	3	2,9	*A. patinoi*	2,9	3	2,95
M. bijugatus	2,8	2,75	2,775	*C. palmata*	3	2,65	2,825	*B. orellana*	2,9	3	2,95
G. ulmifolia	2,8	2,7	2,75	*G. angustifolia*	2,8	2,7	2,75	*C. nucifera*	2,6	3	2,8
B. alicastrum	2,4	2,65	2,525	*P. volubilis*	2,4	3	2,7	*O. bataua*	2,8	2,4	2,60
C. lutea	2,9	1,75	2,325	*V. cauliflora - V. sphaerocarpa*	2,35	3	2,675	*V. planifolia*	2,2	3	2,6
S. apetala	2,8	1,85	2,325	*S. edulis*	2,2	3	2,6	*B. gasipaes*	2,1	3	2,55
S. mombin	2,85	1,35	2,1	*X. sagittifolium*	2,7	2,15	2,425	*C. lutea*	2,9	1,75	2,33
E. cyclocarpum	2,65	1,5	2,075	*C. lutea*	2,9	1,75	2,325	*G. americana*	2,6	1,95	2,28
A. excelsum	2,4	1,75	2,075	*E. foetidum*	2,8	1,5	2,15	*D. oleifera*	2,15	2,25	2,2
S. saman	2,65	1	1,825	*C. bipartitus*	2,6	1,35	1,975	*P. macrocarpa*	2,7	1,05	1,88
OSA	**Percentile**	**Cut-off point**	**Ranks**	**Percentile**	**Cut-off point**	**Ranks**		**Percentile**	**Cut-off point**	**Ranks**	
HP	**66**	2,513	>=2,514	**66**	2,699	>=2,7		**66**	2,6	>=2,61	
MP			2,10 to 2,513			2,423 to 2,699				2,329 to 2,60	
LP	**33**	2,099	<=2,099	**33**	2,422	<=2,422		**33**	2,328	<=2,328	

On the other hand, as the aim of the study is to identify the most useful plant species for natural ingredients, from the 11 high potential species the following natural ingredients were described in the market research shown in Figure 7.

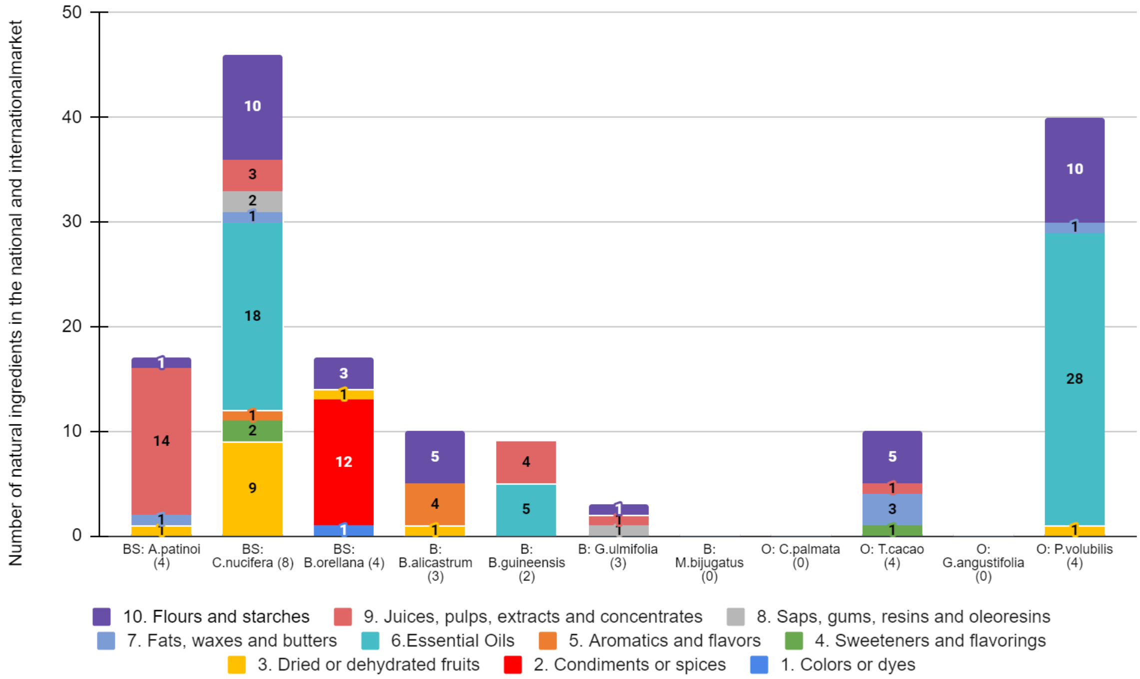

Figure 7. Most beneficial natural ingredients under sustainability assessment in the three study areas.

Even though this list of species has a high potential for sustainability management, not all of them are commercialized as natural ingredients in the national or international market. This is the case of *M. bijugatus (Mamón)*, *C. palmata (Nacumas)* and *G. angustifolia (Guadua)*. However, most of them have at least one NI and the species with the highest amount of natural ingredients (28) on the market is *P. volubilis* (Sacha Inchi) as it is widely used in national and foreign markets, especially in Peru, for its oils and seed powders (10). Similarly, *C. nucifera (Coco)* proved to have the most diverse portfolio of natural ingredients as it is known for the coconut oil and essential oil (18) as well as for the flour (10), dried shredded fruit (9), juice (3), sweetener (2) and butter (1). In parallel, *A. patinoi (Borojó)* is mainly offered as a juice and frozen pulp (14) whereas *B. orellana (Achiote)* is commonly used as a condiment (12) for traditional Spanish and Latin American preparations. On the other hand, the *B. guineensis (Uva de lata)* is also commercialized as an essential oil (5) and a juice or a pulp (4). Even more, for *G. ulmifolia (Guásimo)* the flower and leaf extract are used as a natural ingredient for hair treatments but there is little consumption of the natural ingredients alone. Finally, as expected, the market for *T. cacao* (Cacao) inside and outside the country is the most developed compared to the other prioritized species in terms of a wide range of product portfolios from natural ingredients to value-added products. Nevertheless, the natural ingredient that stands out is cocoa powder (5) followed by butter (3) which is also used as raw material for other chocolate products.

3) Surveys

The results of the assessments of sustainability potential for the top 10 prioritized species per study area are presented below. These results are based on the primary information gathered from the surveys (perception) of the inhabitants of the three study areas (see Appendix 6).

3.1. Results of sustainability per dimension

For the biological and ecological dimension, 11 species were classified with a high potential for sustainable NTFP management; 4 in Otanche, 4 in Becerril, and 3 in Bahía Solano. The species with the highest position in this potential were *T. cacao* (Otanche), *B. guineensis* (Becerril) and *C.nucifera* (Bahía Solano). Regarding the medium potential, 8 species were identified (2 in Otanche, 2 in Becerril, and 4 in Bahía Solano). Within this potential, the following species occupied the highest positions within percentile 66: *C. bipartitus* and *G. angustifolia* (Otanche), *A. saman* and *G. ulmifolia* (Becerril); *C. lutea*, *B. orellana, G. americana* and *P. macrocarpa* (Bahía Solano). Finally, the remaining 11 identified priority species were allocated on the low potential: 4 in Otanche, 4 in Becerril and 3 in Bahía Solano. Of these species stand out *X.sagittifolium* (Otanche), *B. guineensis* (Becerril), and *V. planifolia* (Bahía Solano), with the lowest positions of percentile 33. Furthermore, *C. lutea* is the only species present in the three study areas but identified with a high potential in Otanche, a medium potential in Bahía Solano and a low potential in Becerril. All the data analysis for the 3 dimensions can be seen in Appendix 7, Table 1.

For livelihoods, 11 species were classified with high potential; 4 in Otanche, 4 in Becerril, and 3 in Bahía Solano. The species with the highest position were *T. cacao* (Otanche), *B. alicastrum* (Becerril) and *C. nucifera* (Bahía Solano). Regarding the medium potential, only 6 species were identified (3 in Becerril and 3 in Bahía Solano), while in Otanche there were no records of any species in medium potential. Within this potential, the following species occupied the highest positions in percentile 66: *E. cyclocarpum* (Becerril) and *B. orellana* (Bahía Solano). Finally, the largest bulk of the species was allocated on a low potential for NTFP sustainable management (13 species); 6 in Otanche, 3 in Becerril, and 4 in Bahía Solano. Of these species stand out *C. lutea* (Otanche), *A.excelsum* (Becerril), and *P.macrocarpa* (Bahía Solano), with the lowest positions of percentile 33. All the data analysis for the 3 dimensions can be seen in Appendix 7, Table 2.

For the value chain and governance, 11 species were identified with a high potential for sustainable management (3 in Otanche, 4 in Becerril and 4 in Bahía Solano). The species with the highest position in this potential were *T. cacao* (Otanche), *B. alicastrum* (Becerril) and *V. planifolia (*Bahía Solano). Regarding medium potential for sustainable management, 7 species were assessed: 3 in Otanche, 2 in Becerril and 2 in Bahía Solano. Within this potential, the following species occupied the highest positions between the 34th-66th percentile: *B. orellana* (Bahía Solano)*, E. cyclocarpum* (Becerril)*, and S. edulis* (Otanche). Finally, 12 species were characterized with a low potential for sustainable management (4 in each municipality). Of these species stand out *G. americana* (Bahía Solano), *C. bipartitus (*Otanche), and *S. apetala* (Becerril) with the lowest positions in the percentile 33. All of the data analysis for the 3 dimensions can be seen in Appendix 7, Table 3.

The web diagrams of Figure 8 represent the influence of the variables for each dimension (biological, livelihoods and value chain) regarding top-3 high potential species per study area. Across the three dimensions, *B. alicastrum* and *M. bijugatus* (Becerril) and *T. cacao* (Otanche) as well as *A. patinoi* and *C. nucifera* (Bahía Solano) were highlighted to be species with the highest position in percentile 66 for the 14 variables. Regarding the biological criteria, the 'part of the plant used' contributes substantially and consistently to the 9 species, while other variables such as productivity, abundance, and environmental importance present greater variation. In parallel, *C. nucifera* and *T. cacao* were identified as the most abundant species and *V. cauliflora - V. sphaerocarpa* the least. Conversely, *C. nucifera*, *B. alicastrum* and *S. mombin* were the species with the highest productivity rates. Regarding the 'environmental importance', *B. alicastrum* as well as *S. mombin*, *C. nucifera* and *M. bijugatus* were highlighted. Furthermore, the species with the highest regional distribution were *S. mombin* and *M. bijugatus* (Becerril), *T. cacao* (Otanche) and *C. nucifera* (Bahía Solano). Finally, concerning 'harvest locations', the three species of Becerril were identified with several locations as well as *O. bataua* in Bahía Solano.

For livelihoods, the 'species knowledge' has a high influence on Becerril, followed by a lower degree on Bahía Solano's species, while in Otanche this variable has no significant value. As for the 'use of species' variable, there is a high influence on the species of Otanche, but very little or no influence on the species of Bahía Solano. The species that stand out in this variable were mainly in Otanche with the *T. cacao* (Cacao) and *E. foetidum* (Cilantro Sapo) and *B. alicastrum* (Guáimaro) in Becerril. However, there were no uses linked to *A. patinoi* (Borojó) in Bahía Solano. On the other hand, in Becerril and Otanche the 'benefits of the species' have a greater influence than in the species of Bahía Solano. Finally, the popularity of species within the communities varies in a considerable way among all species. The species with greater popularity within the community were *B. guineensis (Corozo)* in Becerril, *T. cacao (Cacao)* in Otanche and *C. nucifera (Coco)* in Bahía Solano.

Conversely, the community identified in value chains that there has been a historical production for *C. nucifera (Coco)* and *A. patinoi (Borojó)* in Bahía Solano, of *B. guineensis (Corozo)* and *M. bijugatus* in Becerril *(Mamón)* but not in Otanche. On the contrary, for trade circuits, the species of Otanche, *T. cacao (Cacao)*, *C. palmata (Nacuma)*, and *P. volubilis (Sacha Inchi)* are also consumed outside the municipality. Conversely, the other 6 species also had commercialization in other departments and cities which makes this variable the one that sets apart the high potential species from the others. For organizational processes, only 44,4% of the species had established organizational processes; the species *B. alicastrum* (*Guáimaro*) in Becerril, *T. cacao* (*Cacao*) and *C. palmata* (*Nacumas*) in Otanche, and *V. planifolia* (*Vainilla*) in Bahía Solano were the ones that stand out. Finally, for natural ingredients, all high potential species had at least 2, except for *C. palmata* (*Nacuma*).

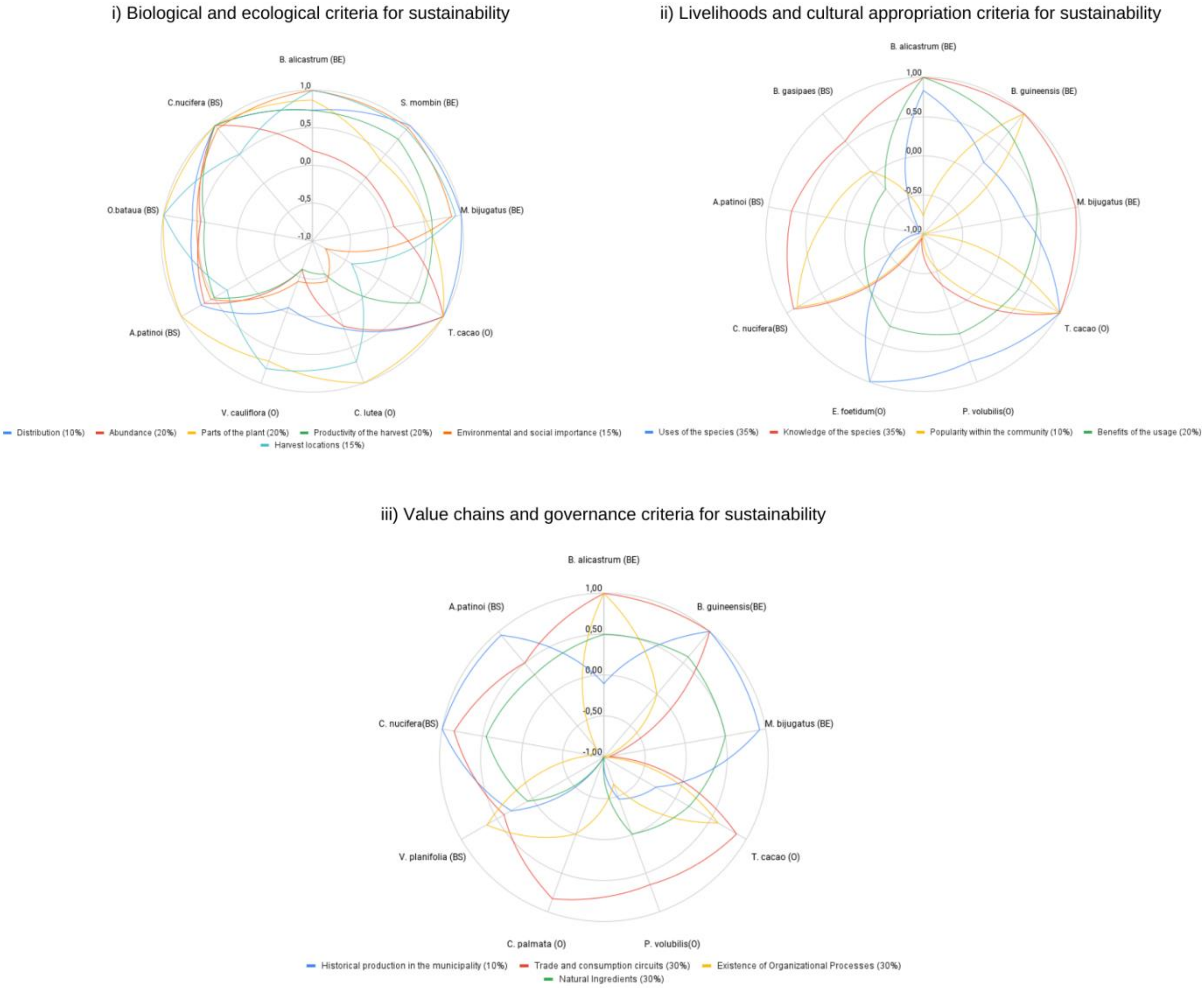

Figure 8. Web diagram of the behavior of the variables for the top 9 high potential species, for the three study areas for: i) Biological and ecological criteria for sustainability, ii) Livelihoods and cultural appropriation criteria for sustainability and iii) Value chains and governance criteria for sustainability**.**

3.2. Overall sustainability potential of NTFPs species management (Surveys)

As for the sustainability assessment for the prioritized NTFP species (Table 5), we can highlight that for the three dimensions, the species whose Overall Simple Average (OSA) is over the percentile 66 are: *B. alicastrum (Guáimaro)*, *B. guineensis* (Corozo), *M. bijugatus* (Mamón) and *E. cyclocarpum* (Orejero) in Becerril; *T. cacao (Cacao)*, *P. volubilis (Sacha Inchi)*, *C, lutea (Bijao)* and *V. cauliflora - V. sphaerocarpa (Sápiras)* in Otanche; and *C. nucifera (Coco)*, *A. pattinoi (Borojó)*, *B.orellana (Bija)* and *B.gasipaes (Chontaduro)* in Bahía Solano. This means that for the final classification, 40% of the total species have a high potential for sustainable management considering the three criteria. Even though *C.lutea (Bijao)* was prioritized in the three study areas, after the sustainability assessment the species was determined to have a high potential for sustainability management only in Otanche. Furthermore, 23.3% of the species were classified with a medium potential for sustainable management whereas 36.67% of the species have a low potential for sustainable management.

Table 5. Potential assessment of sustainable management of NTFP based on the surveys from three sustainability dimensions.

Becerril					Otanche					Bahía Solano				
Species	**SWA (B&EI)**	**SWA (L&CA)**	**SWA (GVCs)**	**SA**	**Species**	**SWA (B&EI)**	**SWA (L&CA)**	**SWA (GVCs)**	**SA**	**Species**	**SWA (B&EI)**	**SWA (L&CA)**	**SWA (GVCs)**	**SA**
B. alicastrum	0,73	0,765	0,74	0,75	*T. cacao*	0,45	0,88	0,47	0,60	*C. nucifera*	0,92	0,18	0,33	0,47
B. guineensis	0,11	0,660	0,580	0,45	*P. volubilis*	-0,05	0,16	-0,05	0,02	*A. pattinoi*	0,63	-0,12	0,16	0,22
M. bijugatus	0,62	0,437	0,290	0,45	*C. lutea*	0,2	-0,1	-0,23	-0,04	*B. orellana*	0,58	-0,23	0,02	0,12
E. cyclocarpum	0,50	0,210	-0,271	0,15	*V. cauliflora - V. sphaerocarpa*	-0,05	-0,1	-0,23	-0,13	*B. gasipaes*	0,68	-0,50	-0,19	0,0003
S. mombin	0,64	0,125	-0,433	0,11	*G. angustifolia*	-0,17	-0,05	-0,2	-0,14	*V. planifolia*	0,28	-0,60	0,07	-0,08
G. ulmifolia	0,42	0,240	-0,336	0,11	*C. bipartitus*	-0,09	-0,1	-0,29	-0,16	*C. lutea*	0,62	-0,44	-0,49	-0,10
A. saman	0,44	0,100	-0,349	0,06	*S. edulis*	-0,24	-0,1	-0,16	-0,17	*G. americana*	0,03	-0,64	0,29	-0,107
C. lutea	0,18	0,167	-0,239	0,04	*C. palmata*	-0,25	-0,1	-0,15	-0,17	*O. bataua*	0,57	-0,60	-0,39	-0,14
A. excelsum	0,38	-0,197	-0,457	-0,09	*E. foetidum*	-0,32	-0,03	-0,23	-0,19	*P. macrocarpa*	0,56	-0,65	-0,45	-0,18
S. apetala	0,35	-0,108	-0,520	-0,09	*X. sagittifolium*	-0,37	-0,1	-0,17	-0,21	*D. oleifera*	0,27	-0,61	-0,44	-0,26

SA	**Percentile**	**Cut-off point**	**Ranks**	**Percentile**	**Cut-off point**	**Ranks**	**Percentile**	**Cut-off point**	**Ranks**
HP	**66**	0,1435	0,1435	**66**	-0,1550	>=-0,1275	**66**	0,096	0,096
MP			0,0637 to 0,1434			-0,1666 to -0,1276			-0,1084 to -0,006
LP	**33**	0,0636	0,0636	**33**	-0,2300	<=-0,1667	**33**	-0,0518	-0,0518

Bearing in mind that the aim of this research is to assess the potential of sustainable management of NTFP and derived natural ingredients, we focused on analyzing the number of times each interviewee identified a natural ingredient for the 10 high potential species in the three study areas (Figure 9).

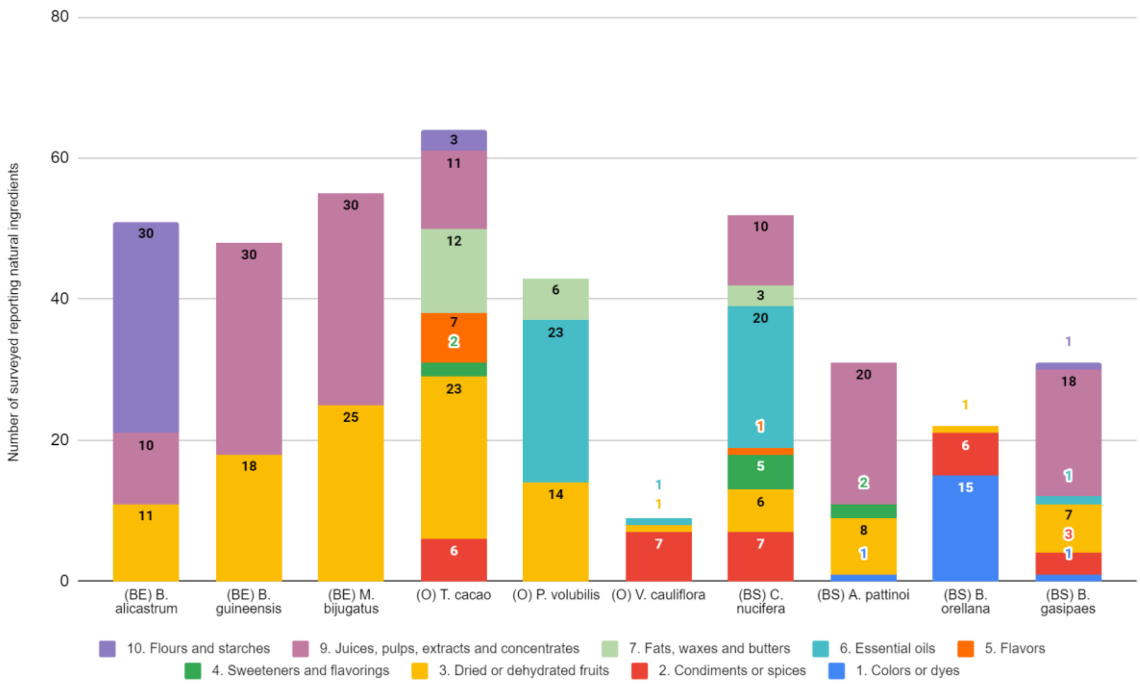

Figure 9. Most beneficial natural ingredients under sustainability assessment in the three study areas

Overall, 9 natural ingredients were identified by interviewees. For instance, in Becerril it was revealed that the species with the most natural ingredients were *B. alicastrum (Guáimaro)*, *B. guineensis (Uva de lata)* and *M. bijugatus (Mamón)*. These ingredients are dried or dehydrated fruits, flours, and starches; fruits, pulps, extracts, and concentrates. For Otanche, it can be highlighted that *T. cacao* (Cacao) is the species with the most natural ingredients followed by *P. volubilis* (Sacha Inchi) and *V. cauliflora - V. sphaerocarpa* (Sápiras) with dried fruits; fats, waxes, and butters; condiments; essential oils; and juices, pulps and extracts. Finally, for Bahía Solano, the species with the highest amount of natural ingredients was *C. nucifera* (Coco), *B. gasipaes* (Chontaduro), *B. orellana* (Bija) and *A. pattinoi* (Borojó). These ingredients are juices and pulps, oils and essential oils, condiments or spices, and dried fruits.

When merging all the sources of information analyzed (*i.e.,* workshops, literature review and surveys), Table 6 reveals that the top identified short-term priority species in the three pilot areas were Corozo (*B. guineensis*) for Becerril, *Cacao (T. cacao)* for Otanche and *Borojó* (*A. patinoi*) for Bahía Solano. Some general remarks about this species include being native to Colombia, with relatively high growing rates, high productivity, wild or semi-wild harvest and important ecological contributions to the conservation of native ecosystems. Furthermore, these species reveal medium to high scores regarding local traditional knowledge of the species and people in study areas identify the benefits derived from them. In addition, in most cases, they are characterized by being species with local, regional, national, and international commercialization circuits.

Bijao was the only species to be prioritized in the three study areas. Some national companies use *Bijao* leaves as bio packaging for traditional guava sweets-snacks called *bocadillos* and as raw materials for biodegradable dishes (Bijopac, 2021). This plant also had an additional NI extracted from its wax, which was used for bitumen, waxes for floors and furniture as well as dentistry patterns; however, these uses have been lost (Corantioquia y Jardín Botánico de Medellín. 2007; González, L & Rojas, G.1980). Currently, people in the study areas usually don't have other perceptions regarding the potential uses of the plant and how they can transform it.

Table 6. Ranking of sustainable management of NTFP of the top 30 prioritized species, considering workshops, literature review and surveys.

Becerril					Otanche					Bahía Solano				
Common name	**Workshops**	**Literature review**	**Surveys**	**Final Ranking**	**Common name**	**Workshops**	**Literature review**	**Surveys**	**Final Ranking**	**Common name**	**Workshops**	**Literature review**	**Surveys**	**Final Ranking**
B. guineensis	2	1	2	**5**	*T.cacao*	3	1	1	**5**	*A.patinoi*	1	1	2	**4**
B. alicastrum	1	4	1	**6**	*C.palmata*	1	2	8	**11**	*C.nucifera*	4	3	1	**8**
M. bijugatus	5	2	3	**10**	*V.cauliflora - V. sphaerocarpa*	5	5	4	**14**	*B.orellana*	5	2	3	**10**
G.ulmifolia	3	3	6	**12**	*G.angustifolia*	8	3	5	**16**	*V.planifolia*	2	5	5	**12**
C.lutea	4	5	8	**17**	*P.volubilis*	10	4	2	**16**	*O.bataua*	3	4	8	**15**
E. cyclocarpum	7	8	4	**19**	*S.edulis*	4	6	7	**17**	*B.gasipaes*	9	6	4	**19**
S. mimbin	9	7	5	**21**	*C.lutea*	7	8	3	**18**	*G.americana*	6	8	7	**21**
S. saman	6	10	7	**23**	*X.sagittifolium*	2	7	10	**19**	*C.lutea*	10	7	6	**23**
S. apelata	8	6	10	**24**	*C.bipartitus*	6	10	6	**22**	*D.oleifera*	7	9	10	**26**
A. excelsum	10	9	9	**28**	*E.foetidum*	9	9	9	**27**	*P.macrocarpa*	8	10	9	**27**

Potential	**Percentile**	**Cut-off point**	**Ranks**	**Percentile**	**Cut-off point**	**Ranks**	**Percentile**	**Cut-off point**	**Ranks**
ST	**33**	11,94	≤11,94	**33**	15,94	≤15.94	**33**	11,94	≤11,94
MT	**66**		11,95 to 20,88	**66**	17,94	15,95 to 17,94	**66**	20,88	11,95 to 20,88
LT			≥20,89			≥17.95			≥20,89

Considering these results, the following 20-year agenda (see figure 10) is proposed to be implemented by decision-makers and environmental authorities, so they can make informed decisions involving the most suitable species regarding high sustainability potential, sustainable management and NI associated to add more value to the current bioproducts in the study areas. In general, 9 species are recommended to be boosted in the short term (0-5 years), 8 species in the medium term (0-10 years) and the largest bulk (10 species) to be implemented in the long-term (0-20 years). Conversely. *C. lutea* is the only special case to be implemented in the three study areas during the whole timeframe due to its wide distribution in Colombia.

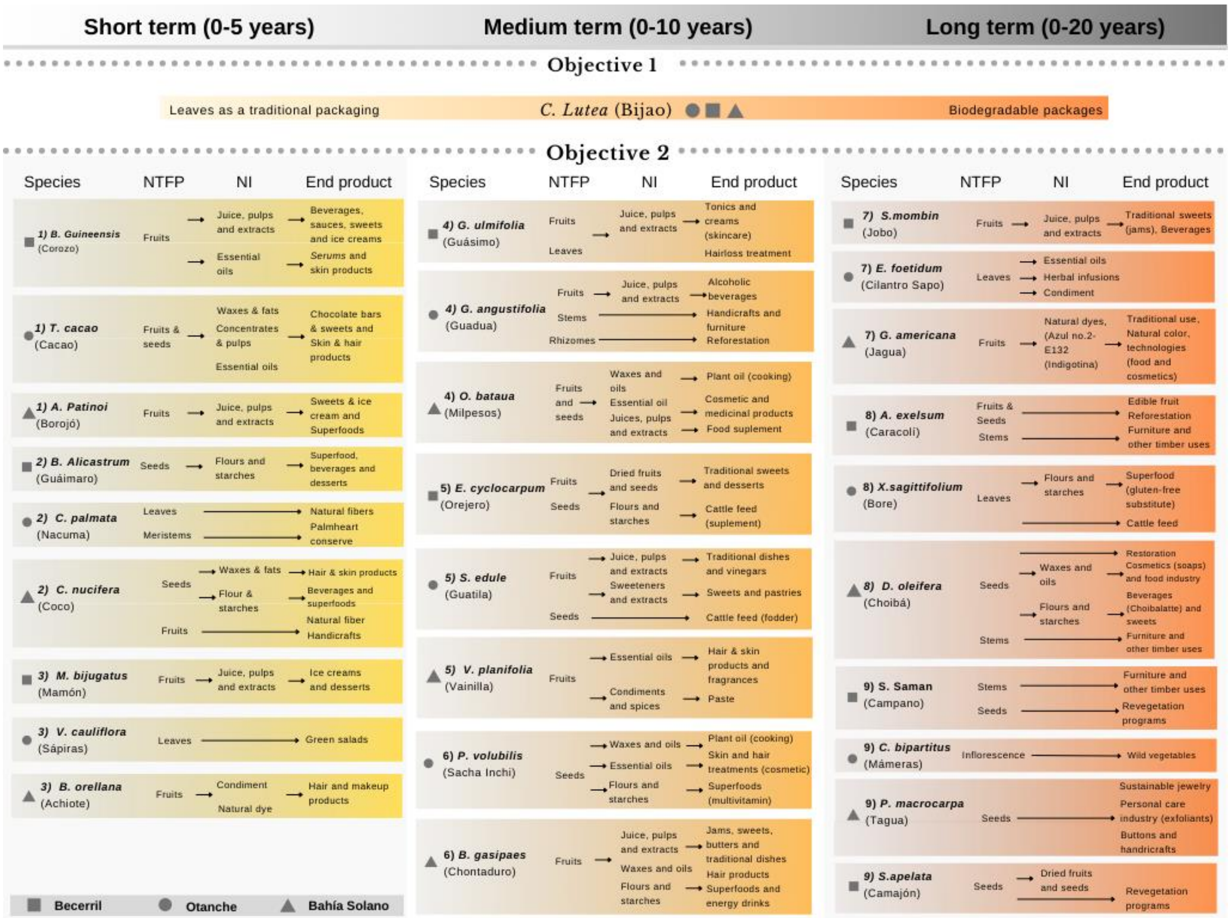

Figure 10. Gantt Diagram for the 20 years agenda for the prioritized species.

Short-term species in Becerril, are found to have great potential for manufacturing NI such as juices, pulps, extracts, and flours for the food industry. For the species of Otanche, the natural ingredients are more diverse due to the multiple uses (*i.e.,* NI) of *Cacao* in the food and cosmetics industry; however, no NI was documented for other short-term species such as Nacumas and Sápiras. Finally, Bahía Solano was identified as the study area with the largest amount of NI; the list goes from natural dyes and condiments (*Jagua and Achiote*) to fats and essential oils (*Coco* and *Milpesos*) as well as sweeteners and extracts (*Vainilla*), pulps and juices (*Borojó and Chontaduro*). It is also relevant to recall, that the largest bulk of long-term species belongs to Otanche, revealing existing local diverse economies that have not been yet embedded into market economies. Therefore, special attention has to be paid to this study area as requires more intensive and sustained intervention in developing and upgrading priority identified value chains.

IV. Discussion

When compared to other Latin American countries such as Perú, which have a strong BioTrade sector, the evidence suggests that Colombia still has an incipient bioeconomy development (Álvarez *et al.*, 2015; UNEP, 2015; Papell *et al.*, 2020; Rojas *et al.*, 2021a). Our results support this. The big ecological and taxonomic diversity found among the 30 prioritized species (*e.g.,* Herbs, epiphytes, palms, and trees) together with the community's commitment to new developing models are encouraging facts to continue strengthening research, conservation, and bioeconomy in these isolated localities.

As has been stated by Amusa & Jimoh (2012), Balama *et al.* (2016) Assogbadjo *et al.* (2017), and the Nuppun Institute of Economic Research (2019), it is of great relevance to implement NTFP prioritization agendas. In response to this issue, this study proposes a long-term agenda to develop natural ingredients VCN from native plant species in three study areas of Colombia. This is an applied tool for decision-makers to consider suitable and potential species and N.I. in order to be used through sustainable management. For this agenda to be implemented, there must be better articulation between institutions and stakeholders, as well as financing agendas, and the criteria of the communities should be taken into account as a central axis of main decisions.

According to the data obtained for the prioritized species, the most important use category was “Food”, followed by “Material” and “Environmental” categories. “Food” was also the most registered use type in other Colombian ethnobotanical studies such as the work of Cárdenas *et al.,* (2004). Nevertheless, it is worth considering that the “importance” of each general use category was calculated based on the number of different uses reported for each general use category, thereby this “importance” might be relative in some cases (*e.g.,* religious uses could be very important for some people, however, they are within the category of Social uses, and this category was not as mentioned as Food or Medicine). For example, in other studies such as Diazgranados *et al.,* (2020), the useful plants of Colombia are mainly associated with medical uses.

This agenda consists of the 30 prioritized species with an implementation period of at least 20 years, distributed in 3 phases:

1. Short-term identified priority species (0-5 years)

The top prioritized species in Becerril, Otanche, and Bahía Solano were: *Corozo*, *Cacao,* and *Borojó* respectively. Some general remarks about this species include medium to high growth rates, high productivity, and wild harvest, as well as important ecological contributions to the conservation of forests. Furthermore, these species reveal medium to high scores regarding local traditional knowledge of the species, and people in study areas identify the benefits derived from them. In addition, in most cases, they are characterized by being species with local, regional, national, and international commercialization circuits. In parallel, *T. cacao* is a species that could accomplish the biological criteria for sustainability; however, it is usually planted as a monoculture crop. This species could be an example of sustainable production, only if sustainable value chains are fostered through the implementation of semi-wild harvests and/or agro-bio diverse crops with native varieties. Finally, the restricted distribution of *Borojó*, makes it an appealing species for bioeconomy, with one of the biggest markets in Colombia, and one of the highest diversities of final products, Borojó's value chain should be strengthened in Bahía Solano

The other species with high potential of sustainability for bioeconomic development were: *Guáimaro* and *Mamón*, which are trees with high productivity of fruits, commercialization circuits, and high cultural importance. In parallel, *Nacuma* and *Sápiras* have an important traditional knowledge associated with them; nevertheless, their commercialization circuits should be fostered to reach national and international markets. On the other hand, *Achiote* and *Coco* have international commercialization circuits and there is a constant demand from big markets. For *Guáimaro, Mamón, Nacuma, Sápiras, Achiote* and *Coco*, the local organizational process and the VC need to be improved.

2. Medium-term identified priority species (0-10 years)

The medium-term prioritized species in the three pilot areas have in common that their commercialization circuits are informal (commercial operations not registered), with clear regional traditional uses and with a smaller number of established companies and initiatives at the national level, and a low or no incursion in international markets. It is important to highlight that these informal commercialization circuits might hinder the development of smallholder value chains (Thiele *et al.*, 2011; Midgley *et al.*, 2017). In addition, as these circuits are informal, secondary information is usually scarce and difficult to obtain. This reflects the lack of official statistics of natural ingredients in national accounts, as revealed by Rojas *et al.,* (2021a). This was a limitation of this study, as informal economies could not be counted for and they comprise most of the local and regional commercialization circuits. Even though these species face different threats, the solution might lie in conservation through use strategies as was stated by Barrance et al. (2009) and *Ministerio de Ambiente y Desarrollo Sostenible* (2015), where strategies are defined in order to conserve threatened species through adequate management and sustainable use with the inclusion of local communities.

3. Long-term identified priority species (0-20 years)

Long-term prioritized species included trees, herbs, and palms which usually had low growth rates and/or VC models which require more time and effort to achieve sustainability. However, long-term species usually have high ecological importance and are associated with healthy ecosystems, which contributes to developing complementary economic alternatives of conservation such as ecotourism. This species usually has very little or no finished products on national and international markets, and/or they do not have high cultural importance and/or they have a lack of organizational processes. In general, people perceived this species as if they had fewer benefits (economic, social, and/or biological). Therefore, these are the species that require more investment and strengthening of their value chains for sustainable management in the long run. It does not mean that these species are less important, for the implementation than the others, but that the effort-time needed to achieve sustainability may vary depending on the species used and the specific conditions of each value chain. Consequently, even though some species will take longer to achieve sustainability, all the phases and species are recommended to start being implemented in parallel, starting from year 0, with continuous monitoring in order to assess their long-term sustainability.

Considering the ecological heterogeneity of the three study areas, it is noteworthy that *Bijao (C. lutea)* was prioritized in all of them. This fast-growing native herb fulfills the bioecological conditions to have a sustainable use, and there is a cultural appropriation of this species, derived on high use and demand of its leaves as food wrapping (Torres-Morales *et al.* 2021). Therefore, *Bijao* could be considered as a special NTFP of national importance and deserves a special approximation from the central government to the strengthening of its VC and implementation in the NI agenda.

Finally, all the prioritized species and any harvesting model should be strictly monitored during long periods in order to follow sustainable practices (Stockdale *et al.*, 2019). Additionally, the harvest of NTFPs should always be accompanied by sustainable harvest plans and propagation programs, especially if the species are under any threat category, as *Corozo, Chiobá, Vainilla,* and *Chontaduro* are (Calderón *et al*., 2005).

4. Natural ingredients value-chains agenda

Overall, it is important to highlight that this study identified more priority species and natural ingredients than other similar and recent studies in Colombia, such as the one developed by Papell *et al.* (2020). Contrary to what was established by these authors, we identify only native Colombian species, giving more priority to wild harvest and agro-biodiverse practices.

Firstly, by prioritizing the flour, juices, and pulps as NI for the food industry in Becerril, new regional and national markets can be reached through value-added products that foster short-term species as superfoods and dietary supplements with the introduction of new products in health food stores and specialty supermarkets, accounting for the already existing cultural appropriation of these species in the Colombian Caribbean region. In parallel, the presence of juices and pulps comprises an opportunity for their transformation into end-products like ice creams, desserts, and even alcoholic beverages. For Otanche, there is an opportunity to foster short-term species from traditional recipes and household consumption, to innovative and haute cuisine end-products. Therefore, to strengthen the traditional gastronomic value chains in this study area, intensive work in recovering traditional recipes and making new ones capturing new value proposals must be undertaken. Conversely, Bahía Solano's efforts might be placed into the national food and cosmetics industries where it can be used to manufacture end-products from waxes, oils, pulps, and essential oils into novel foods, skin and hair products. To take advantage of the wide portfolio of NI in this study area and the already developed national and international markets for some of its species, a match between the traditional use of the species and the products found on the market must be made.

Likewise, to make a transition from NI to more value-added end products for the food and cosmetics industry, the harvest and transformation capacity of the territories must be considered. For the medium-term species, there is a need for revegetation programs as most of them are cultivated and require the increase of plant material through agroforestry productive systems to maintain the sustainability of NI value chains in the long run. By making this productive conversion while actively recovering the forest, these species can transition from NFTP to NI desirable for the food industry, especially for haute cuisine and local gastronomic tourism, as well as for the natural products industry with nutraceutical/cosmeceutical, functional foods, and nutritional supplements. On the other hand, long-term species need intensive work as most of them do not have documented NI and are mostly used as an NTFP. Nevertheless, some of them have significant ecological importance as umbrella species and by providing ecosystem services important for local communities' well-being such as water regulation and food safety. In spite of their importance, there is little to no research for these species regarding population studies, as well as their phytochemical and bromatological properties which are key to developing and upgrading their value chains in the long term.

V. Conclusions

The potential uses of Colombia's biodiversity are still far away from being documented, and the country has an incipient development in BioTrade and natural ingredients production. However, this study contributes with an inclusive interdisciplinary framework using both social and biological sciences methodologies to identify priority useful plant species and their natural ingredients in Colombia. For this, the traditional knowledge workshops, complemented by biological data of the species, with local context and the communities as the central focus, have proved to be a worthy methodology to prioritize sustainable useful plant species, NTFPs, and NI. This multidisciplinary approach gives a leading role to the inhabitants of the study areas, contributing to their appropriation of biological knowledge in their territories and helping to preserve Colombia's unique biodiversity.

The most frequent general use category was "Food", and therefore it is important to prioritize future efforts towards the food industry and local gastronomic value chains. Strengthening and improving the existing national initiatives, associations, and companies before developing new initiatives based on poorly known species and with high levels of uncertainty. A transition time frame might be useful for the communities to join in the national interest industries, focusing on recovering their traditional knowledge and formalizing it through existing productive value chains. However, before focusing on the development of the food industry in Colombia, it is of the utmost importance to ensure food sovereignty, safety, and autonomy for the inhabitants of the rural areas.

The presented agenda provides tools that decision-makers and stakeholders may use when developing productive projects (*e.g.,* through national-scale policies by the Ministries of Environment and Agriculture), aligned with the sustainability requirements of people and ecosystems. This is a tool that represents a portfolio of possibilities of investment in NTFP, NI, and end-products at a local scale, creating long-term added value transitions, useful to appeal new projects to these study areas. This could not be possible without strengthening and improving the bonds between political-administrative institutions, research institutions, companies, and local communities. To achieve this, it is needed a strong political and corporate will, to conduct long-term agendas which ensure continuity, based on the local livelihood improvement as well as the conservation of biodiversity.

Major challenges emerge around the proposed agenda because informal economies have a crucial role at local, regional, and national levels in Colombia. Other additional challenges are the many obstacles that SMEs have in order to become formalized. If the aim is to leverage sustainable productive models at a national level, the informal economies must be studied in-depth, since there is a big lack of regional context in the institutions.

Over 70% of the useful plant species found in the workshops are native to Colombia. This shows that the communities are appropriated of their ecosystems, and their traditional knowledge has been, at least partially, transmitted. On the other hand, it can be deduced that the environmental conditions of the study areas still preserve a considerable amount of native flora. However, It is worth knowing that many species require parallel programs to regain the traditional knowledge about them and to strengthen local governance systems, and therefore the sustainable harvesting of NTFP and production of NI. For the species with some threat category, it is proposed to preserve them by building up their sustainable use. There has to be a substantial investment in the management plans, including a rigorous monitoring system, which protects the ecosystems and population of the species, based on community monitoring activities in the long term. In parallel, propagation programs of the harvested species are also a crucial tool to ensure sustainable Value Chain Networks as well as the conservation of ecosystems.

By upgrading NTFPs to NI with simple primary transformations easily carried out in these biodiverse territories, commercialized volumes can be reduced. This becomes relevant as production costs decrease when implementing new cost-effective technologies, as prices tend to be higher due to the increase in value-added processes and less volatility in prices as the products are no longer a commodity. Furthermore, this aggregation of value is labor-intensive and extensive in know-how which will be reflected in a greater employment opportunity for the local communities. Conversely, in this proposed 20-year agenda, natural ingredient gaps towards the finished products can be reduced by making a gradual transition from a commodity, to a diversified portfolio of more value-added products for the top-30 identified priority species. To meet this objective, it is necessary to create demand inside and outside the territories (demand-side measures), a process that requires time and can be fed up from bottom-up strategies by fostering and preserving traditional knowledge and already existing livelihoods around priority identified value chains to guarantee their sustainability over time.

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