Revista Cubana de Ciencias Forestales

Volume 13, issue 1; 2025, January-April

liberciencia
EDITORIAL CIENTÍFICA UNIVERSIDAD DE PINAR DEL RÍO

UNIVERSIDAD DE PINAR DEL RÍO
HERMANOS SAÍZ MONTES DE OCA

CFORES
REVISTA CUBANA DE CIENCIAS FORESTALES

ISSN: 2310-3469 RNPS: 2347
Revista CFORES, January-April 2024; 13(1): e859

Original article

Ecological, cultural and economic evaluation of Bixa orellana L. (Bixaceae) as a non-timber forest product

Evaluación ecológica, cultural y económica de Bixa orellana L. (Bixaceae) como producto forestal no maderable

Avaliação do aproveitamento de Bixa orellana L. (Bixaceae) como produto florestal Não madeireiro

Alfredo Jiménez González[1*], *Maverick Magallán*[1], *Yajhaira Romero*[1], *Jesús Pinargote*[1]

[1]State University of Southern Manabí. Ecuador.

*Corresponding author: alfredo.jimenez@unesum.edu.ec

Received: 10/08/2024.

Approved: 12/01/2025

Published: 13/01/2025

ABSTRACT

Bixa orellana species is known in Ecuador and other regions of the world, is valued for its bixin content, a pigment used in the food, cosmetics and medicinal industries. This study was carried out in the communities of San Vicente, Santa Rosa and El Tigre, located in the Campozano parish, Paján Canton, Manabí, Ecuador, with the aim of evaluating its potential as a Non-Timber Forest Product from the social, ecological, cultural and economic perspectives. The results indicate that 53% of the respondents have primary education and that the use of achiote is mainly oriented to food (23.2%), colorants (21.2%) and medicinal uses (18.5%). The analysis also revealed that achiote dye is mostly used in the preparation of dishes such as seco de gallina (37.99%). Regarding the medicinal uses of achiote, 39.65% of respondents use it specifically to treat throat conditions; However, achiote production in these communities is limited and its commercialization is carried out without added value, which diminishes its economic potential. Finally, guidelines are proposed for the sustainable management of the *B. orellana species* as a Non-Timber Forest Product, promoting a more profitable and sustainable use of achiote, including the strengthening of value chains and the conservation of biodiversity.

Keywords: forest, communities, species, markets, uses.

RESUMEN

El achiote, como se le conoce en Ecuador y otras regiones del mundo a la especie *Bixa orellana*, es valorado por su contenido en bixina, un pigmento utilizado en las industrias alimentaria, cosmética y medicinal. Este estudio se llevó a cabo en las comunidades de San Vicente, Santa Rosa y El Tigre, ubicadas en la parroquia Campozano, Cantón Paján, Manabí, Ecuador, con el objetivo de evaluar su potencial como Producto Forestal No Maderable desde las perspectivas social, ecológica, cultural y económica. Los resultados indican que el 53 % de los entrevistados tienen educación primaria y que el uso del achiote está principalmente orientado a la alimentación (23,2 %), colorantes (21,2 %) y usos medicinales (18,5 %). El análisis también reveló que el colorante de achiote es mayormente empleado en la preparación de platos como el seco de gallina (37,99 %). En

relación con los usos medicinales del achiote, el 39,65 % de los encuestados lo utiliza específicamente para tratar afecciones de la garganta; sin embargo, la producción de achiote en estas comunidades es limitada y su comercialización se realiza sin valor agregado, lo que disminuye su potencial económico. Finalmente, se proponen directrices para el manejo sostenible de la especie *B. orellana* como Producto Forestal No Maderable, fomentando un uso más rentable y sostenible del achiote, incluyendo el fortalecimiento de las cadenas de valor y la conservación de la biodiversidad.

Palabras clave: bosque, comunidades, especies, mercados, usos.

RESUMO

O urucum, como é conhecida a espécie *Bixa orellana* no Equador e em outras regiões do mundo, é valorizado por seu conteúdo de bixina, um pigmento utilizado nas indústrias alimentícia, cosmética e farmacêutica. Este estudo foi realizado nas comunidades de San Vicente, Santa Rosa e El Tigre, localizadas na paróquia de Campozano, cantão de Paján, Manabí, Equador, com o objetivo de avaliar seu potencial como Produto Florestal Não Madeireiro sob as perspectivas social, ecológica, cultural e econômica. Os resultados indicam que 53,0 % dos entrevistados possuem educação primária e que o uso do urucum está principalmente orientado à alimentação (23,2 %), corantes (21,2 %) e usos medicinais (18,5 %). A análise também revelou que o corante de urucum é amplamente empregado na preparação de pratos como seco de gallina (37,99 %). Em relação aos usos medicinais do urucum, 39,65 % dos entrevistados o utilizam especificamente para tratar condições da garganta; entretanto, a produção de urucum nessas comunidades é limitada e sua comercialização ocorre sem valor agregado, o que reduz seu potencial econômico. Por fim, são propostas diretrizes para o manejo sustentável da espécie *B. orellana* como Produto Florestal Não Madeireiro, promovendo um uso mais rentável e sustentável do urucum, incluindo o fortalecimento das cadeias de valor e a conservação da biodiversidade.

Palavras chave: floresta, comunidades, espécies, mercados, usos.

INTRODUCTION

In the series edited by the Food and Agriculture Organization of the United Nations on The State of the World (FAO, 2024), it is stated that almost 6 billion people use non-timber forest products. Around 50% of the the world's population relies on wild-collected species (the total number of species used is estimated at 50,000 species). 70% of the world's poor people use wild species to obtain food, medicine, energy and income, and for other purposes.

B. orellana (Bixaceae) is an arborescent plant from the intertropical regions of America native to Brazil, but it grows in other regions of South and Central America. It is cultivated in countries such as Peru, Mexico, Ecuador, Indonesia, India, Kenya and East Africa. It is known as achiote de la montaña (annatto of the mountain), achioti, bixa, bija, bijol. Achiote is a plant that has been used as a food supplement and for the alternative treatment of some diseases. It has been used in many parts of the world for the prevention and treatment of health disorders such as constipation, fever, heartburn, asthma, scabies, ulcers, among others (Ríos *et al*., 2022).

This research aimed to evaluate its potential as a Non-Timber Forest Product from ecological, cultural and economic perspectives. It also presents the properties and uses of this species, as well as guidelines for its sustainable use. In addition, the value chains and markets for its commercialization are analyzed, with a view to improving the quality of life of the communities involved and recovering the ancestral practices of extraction and use of achiote as a NTFP.

This work is the result of a graduation project for the Master's Degree in Sustainable Forest Management, from the Graduate Institute of the State University of Southern Manabí and the R&D&I project " *Inventory of biological resources of interest for local development in the parish of El Anegado, Manabí, Ecuador* ", financed by said university.

MATERIALS AND METHODS

Location of the study area

The communities of San Vicente, Santa Rosa and El Tigre are located in the Campozano parish, belonging to the Paján canton, located in the southern part of the Manabí province, Ecuador. The climate data of the study areas reflect temperatures of 25 °C to 29 °C and rainfall concentrated between January and March, with 200 mm in February. From April to November, drought predominates, with a warm climate and seasonal rains.

Methodology

Tours in the field were performed, as well as conversatories with the leaders of the areas of study and with the president of the parish council of Campoz, to determine the amount of people who inhabit the enclosures St. Vincent, Santa Rosa and El Tigre.

Characterization of the properties and traditional uses of the specie B. Orellana (achiote) in different contexts (food, medical, and cultural)

In the character of the traditional properties and uses of the *Bixa orellana* as NTFP in the areas of study, the empirical method of semistructured interviews was used, based on the reports of Jiménez *et al.* (2019) and Jimenez *et al*. (2018), as it is detailed below:

The semistructured interview's name is "form for obtaining information on the main property and traditional uses of the species *Bixa orellana* (a c hio t) in diverse contexts (food, medicine and culture)". The interviews, 100 in total, were conducted to inhabitants of the areas of study. It had 12 questions and served for investigating about sociocultural, age, gender and level of schooling aspects of the sample. Also, it was possible to research on other uses of the species object of study, to know:

Could you explain how you use achiote and how long you have known about it in your community or family? How do you use it in cooking or for food, and do you know of any medicinal uses? Also, does it have any cultural significance in your community? How did you learn about these uses, are they passed on from generation to generation? Have you noticed changes in its use over time? ¿Are there special practices or rituals

associated with it? What is your perception of the use of achiote and its future, especially in relation to the interest of young people? Finally, is there anything else you would like to share about achiote or do you know other people who could provide information?

Population and show

A simple random analytical sample was applied and the sample was calculated according to the criteria of Torres *et al*. (2018) how is it present in the Equation 1.

$$n = \frac{N*Z^2*p*q}{d^2\,(N-1)+ Z_a^2*p*q} \quad (1)$$

Where:

N = size of the population

Z = level of confidence of 95 %

p = probability of success, expected opportunity q = probability of failure

d = precision (maximum allowable error in terms of proportion).

Based on the data previously described, the sample size corresponding to the communities under study was calculated.

San Vicente Community

Security = 0.5%

Accuracy = 0.5%

N = 85

Expected proportion = it is assumed that it may be close to 18%; if there is no idea of this proportion, the value that maximizes the sample size would $p = 0{,}5$ (50 %)be used (Equation 2)

$$n = \frac{85*(1{,}96)^2*0{,}5*0{,}5}{(0{,}18)^2\,(85-1)+ (1{,}96)^2*0{,}5*0{,}5} = 34 \quad (2)$$

$$n = 34$$

Santa Rosa Community

Security = 0.5%

Accuracy = 0.5%

N = 75

Expected proportion = it is assumed that it may be close to 18%; if there is no idea of this proportion, the value that maximizes the sample size would be used (Equation 3)

$$n = \frac{75*(1,96)^2*0,5*0,5}{(0,18)^2\ (75-1)+\ (1,96)^2*0,5*0,5} = 32\ (3)$$

$$n = 32$$

The Tiger Community

Security = 0.5%

Accuracy = 0.5%

N = 87

Expected proportion = it is assumed that it may be close to 18%; if there is no idea of this proportion, the value that maximizes the sample size would $p = 0,5$ (50 %)be used (Equation 4)

$$n = \frac{87*(1,96)^2*0,5*0,5}{(0,18)^2\ (87-1)+\ (1,96)^2*0,5*0,5} = 34\ (4)$$

Analysis of worth chains and the markets existing for the achiote, identifying opportunities for your development and sustainable marketing

For getting a market study, some inquiring on the demand, supply, prices and market trends of the achiote (annatto) was done. A map of the chain of value of the achiote from the collection / cultivation until the final consumer was performed. Furthermore, farmers, merchants and consumers were interviewed to understand the dynamics of the market using the method proposed by (Torres, 2018)

Proposal for guidelines to promote the sustainable use of achiote as a NTFP and its contribution to sustainable forest management in the communities of San Vicente, Santa Rosa and El Tigre, Campozano parish, Paján canton, Manabí province, Ecuador

For and the analysis of policies, a study of existing ones related to NTFP was carried out. For consulting with stakeholders, meetings with key actors (government, local community, NGOs) were done in order to gather opinions and needs.

The starting point was the information generated about the *B. Orellana.* Technical lines were proposed, allowing the appropriate use of the species object of the study as NTFP of vegetable origin in a wide perspective. For example, the use of the species as provision and marketing as mentioned in Pineda *et al.* (2019), also in the guide to study non-timber forest products (Aguirre, 2015) and in the Proposals for actions for the sustainable use of non-timber forest products, described by Segurado -Gil, Rodríguez-Matos and Leyva-Miguel (2020).

RESULTS AND DISCUSSION

Characterization of the properties and traditional uses of the species B. orellana (achiote) in diverse contexts (food, medicinal, and cultural)

The social and cultural aspects of agreement to the distribution of data on schooling, genders and age groups are present the Figure 1 where the antecedents of communities are presented in a study and the proper research of the species *B. orellana* was performed.

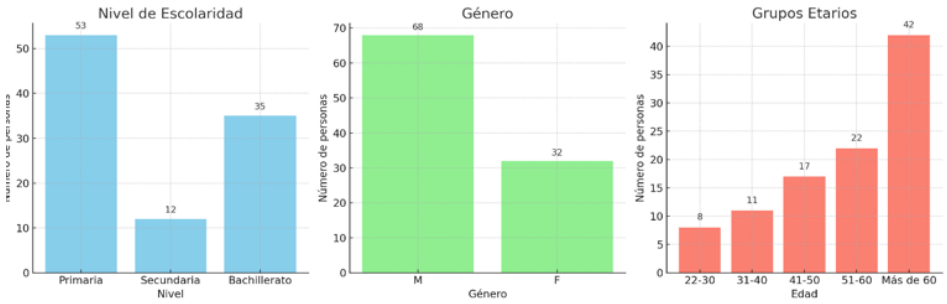

Figure 1. *- Distribution of schooling, gender and age groups in the study areas*

The results shown in Figure 1 indicate that 53% of the respondents have primary education, 35% secondary education, and 12% high school education. Regarding gender distribution, 68% are men and 32% women. In terms of age, 42% of the participants are over 60 years old, being the most represented age group, while only 8% are between 22 and 30 years old, which coincides with the study by Bermúdez *et al.* (2018) , where the age group over 60 years old also predominated.

This educational and age profile contrasts with that observed by Angulo and Rosero (2012), who reported that the majority of respondents had secondary education and a closer relationship with nature. This suggests that, in the communities studied, formal education could be less developed, which could influence the interaction with natural resources. Consequently, these results underline the importance of considering sociodemographic characteristics when analyzing how communities manage and use their natural resources, since factors such as age and educational level are determining factors in the knowledge and use of these resources.

Based on the 100 residents interviewed, the Figure 2, determines that in the area of study, six activities of general uses that the homes develop as part of his consumption were identified. These activities of uses are: food, dye essence, insecticide, sale of the product, medicinal and therapeutical purposes. Annatto gathering for different uses at homes, that have contributed to productive restoration projects, is an activity that can be added to the previous group.

Figure 2. - *General uses of the species B. orellana, in the study areas*

The results presented in Figure 2 show that 23.2% of the respondents use *B. orellana* mainly as food, with 94 citations, followed by its use as a coloring essence, which reaches 21.2% with 86 citations, and finally for medicinal purposes, representing 18.5% (75 citations). Regarding its culinary application in the communities of San Vicente, Santa Rosa and El Tigre, 37.99% of the respondents use the coloring derived from *B. orellana* in the preparation of chicken stew, while 33.62% use it in the preparation of rice with trimmings, and 28.38% use it to season meats.

These results differ from the findings of Aroca *et al.* (2022), who highlighted *B. orellana* as an essential ingredient in Ecuadorian cuisine, used not only to add color but also flavor to emblematic dishes such as fish stew, tamales, soups, empanadas, and marinades for meats. The variability in uses reflected in both investigations could be due to regional or cultural differences in culinary preferences and in the integration of *B. orellana* into traditional food practices. This underscores the importance of considering the local context when studying the use of natural resources in different communities.

Table 1 shows the manner of use in the kitchen or in the feeding of the species object of the study, detailing some recipes or preparation methods.

Table 1. - *Use of the B. orellana species in traditional cuisine*

Enclosures	Methods and use of the species		
	Dry chicken dye	**Trimming rice**	**Seasoning meats**
Saint Vincent	29	31	28
Santa Rosa	27	22	15
The Tiger	31	24	22
Total	**87**	**77**	**65**
Percentage (%)	**37.99**	**33.62**	**28.38**

The results obtained show that the use of *B. orellana* as a colorant in the preparation of chicken stew is predominant, with 37.99% of the citations, followed by its use in the preparation of rice with trimmings (33.62%) and for seasoning meats (28.38%). This pattern of use reflects the culinary importance of *B. orellana* in the communities studied, where it is mainly integrated into traditional dishes.

Additionally, the use of *B. orellana* as food (23.2%) and as a coloring essence (21.2%) coincides with the findings of Ríos *et al.* (2022), who reported that achiote seed is widely used in food, although their study also mentioned a limited medicinal use of the leaves to treat ailments such as stomach pain, dandruff problems, and prostate conditions.

On the other hand, Ayala *et al.,* (2018) highlight the extraction of bixin from *B. orellana* as a key apocarotene in the formulation of pharmaceutical, food and cosmetic products, highlighting a more industrial and specialized approach compared to the traditional use reported in the communities of San Vicente, Santa Rosa and El Tigre. These differences in the use of *B. orellana* between studies reflect the versatility of the species, as well as the influence of the context on its application.

When evaluating the medicinal use of the species B. *orellana*, the areas of study are represented in Figure 3 which details the percentage of the different medicinal uses.

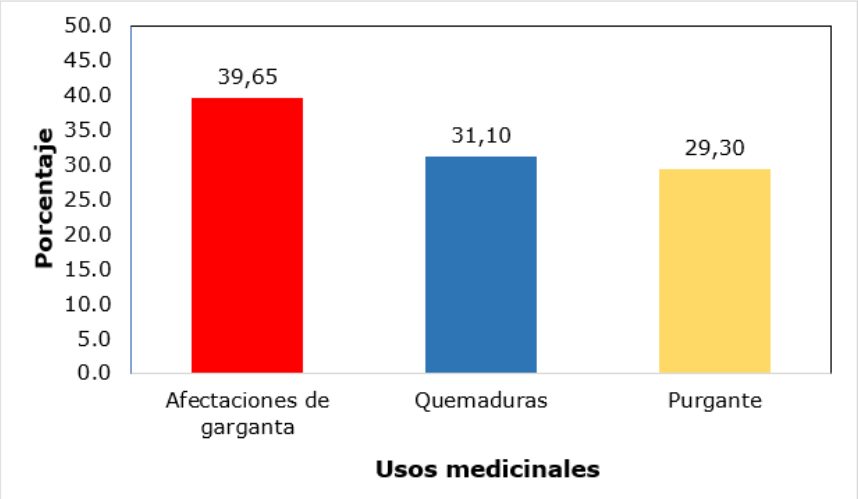

Figure 3. - *Uses of the B. orellana species in natural and traditional medicine*

Figure 3 shows that the species *B. orellana* is mainly used in natural and traditional medicine to treat throat conditions, representing 39.65% of the citations in the communities of San Vicente, Santa Rosa and El Tigre. This predominant use is followed by its application in the treatment of burns (31.10%) and as a purgative (29.30%).

The use of *B. orellana* in the treatment of throat conditions is well documented in traditional Andean medicine. Paniagua-Zambrana, Bussmann, and Romero (2020) point out that the leaves and seeds of this plant are prepared in the form of decoctions or infusions to treat throat irritations and infections, which could be related to its anti-inflammatory and antimicrobial properties. Similarly, Oliveira *et al.* (2021) report its use in Brazilian folk medicine to treat respiratory disorders, suggesting its usefulness in managing conditions related to upper respiratory tract infections.

The use of *B. orellana* in the treatment of burns is associated with its healing and anti-inflammatory properties. Vilar *et al.* (2014) review its traditional use, where seed paste or extracts are applied topically to burns. The carotenoids and flavonoids present in the plant seem to play an important role in tissue repair and the reduction of oxidative stress, accelerating the healing process. These findings highlight the potential of *B. orellana* to be studied as a natural remedy for skin lesions.

As a purgative, *B. orellana* has been traditionally used to promote intestinal cleansing, often in detoxification rituals in various cultures. Vilar *et al.* (2014) identify the plant's seeds and bark as common components in formulations designed to stimulate digestive processes. This activity could be linked to secondary metabolites such as tannins and alkaloids, which exhibit effects on gastrointestinal motility. However, controlled studies on its efficacy as a purgative are limited, suggesting the need for further pharmacological investigations.

The medicinal uses of *Bixa orellana* reflect its versatile pharmacological profile, supported by bioactive compounds such as carotenoids, flavonoids and alkaloids. Despite its widespread use in traditional medicine, rigorous clinical studies are essential to validate these effects and establish safety profiles. Furthermore, the development of standardized extracts could facilitate its integration into modern therapeutic practices.

In addition to the uses already mentioned, *B. orellana* has shown potential in other medicinal applications, as evidenced by recent studies. Rivera *et al.* (2024) evaluated the antifungal activity of an ointment developed from B. orellana leaves. This study revealed that the aqueous and ethanolic extracts of the leaves contained high concentrations of bioactive compounds, such as flavonoids, phenols, and tannins. The optimal ointment

formulation, consisting of 25% annatto extract, achieved a significant inhibition zone against dermatological fungi, suggesting that *B. orellana* has great potential in the prevention and complementary treatment of dermatological diseases. These results broaden the spectrum of medicinal uses of *B. orellana* , highlighting its relevance both in traditional medicine and in the development of modern pharmaceutical products.

Table 2 details the previous information and shows the transmission of the knowledge about annatto and the changes in use of it.

Table 2. - *Changes in use and knowledge of the species object of study*

Enclosures	Change in species uses and knowledge		
	Yeah	**No**	**Knowledge from generation to generation**
Saint Vincent	0	34	34
Santa Rosa	0	32	32
The Tiger	0	34	34
Total	**0**	**100**	**100**
Percentage (%)	**0**	**100**	**100**

The results obtained in this study reveal that, in the communities of San Vicente, Santa Rosa and El Tigre, no significant changes have been observed in the way *B. orellana is used*, and that the knowledge associated with this species is passed on consistently from generation to generation. This finding suggests a stability in the traditional practices related to the use of *B. orellana* within these communities. However, another important aspect revealed by the interviews is that *B. orellana* does not have a significant cultural use in these areas, since 100% of the interviewees indicated not using the species for cultural purposes.

This result contrasts with the findings of Lozano *et al.* (2021), who in their study pointed out that the origin and use of natural dyes and colorants, such as those derived from *B. orellana*, have a magical connotation in other cultures. These researchers highlighted that, in some communities, achiote is considered a gift from the divinities and is attributed with supernatural powers, used to ensure success in war, hunting, in curing diseases, and even to guarantee a peaceful afterlife.

With respect to the above, the absence of a cultural meaning in the communities studied could be influenced by factors such as cultural differences or the loss of traditions over time. However, this relationship has not been demonstrated in the present study, which highlights the need to investigate this aspect as a complement. This contrast highlights the importance of considering cultural diversity and variability in traditional practices when studying the applications of *B. orellana* in different social and geographical contexts.

The way in which *B. orellana is used* sustainably, the interviewees detail how they consider this aspect in Figure 4.

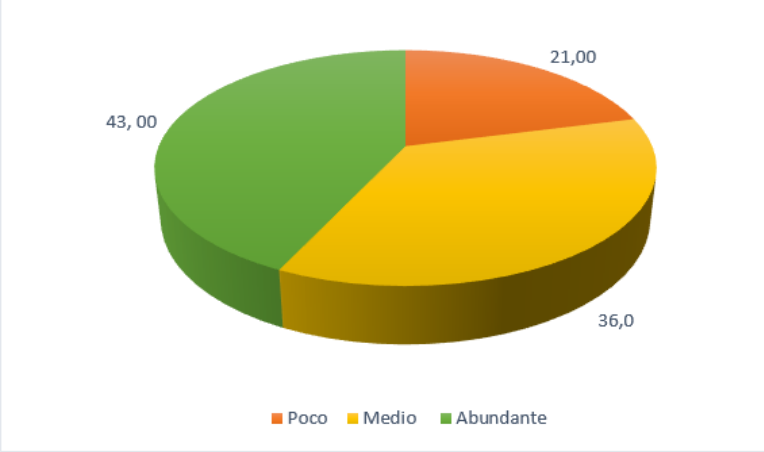

Figure 4. *- Perception of those interviewed in the San Vicente, Santa Rosa and El Tigre areas regarding the use of the B. orellana species*

The perception of those interviewed in the communities of San Vicente, Santa Rosa and El Tigre on the sustainability of the use of *B. orellana* (Figure 4) reveals that 43% consider it sustainable, while 36% perceive it as of medium sustainability, and 21% consider it as unsustainable. These results reflect a divided opinion on the sustainability of the use of achiote in the areas studied.

Cultivation and harvesting of *B. orellana* must balance increasing global demand with ecological conservation. Hirko and Getu (2022) highlight that while the plant is resilient and adaptable to diverse climates, unsustainable practices such as overexploitation and lack of crop rotation can deplete soil fertility and reduce biodiversity. They propose that

integrating agroforestry systems and sustainable agricultural techniques can increase productivity while protecting the ecosystem.

The commercial value of *B. orellana* lies mainly in its seeds, which contain bixin, a natural carotenoid used in the food, cosmetics, and pharmaceutical industries. Husa, Hamzah, and Said (2018) highlight the efficiency of organic solvent extraction methods in obtaining high-quality bixin, although they raise concerns about the environmental impact of using and disposing of these solvents. Advances in green chemistry and eco-friendly extraction methods, such as supercritical fluid extraction, offer avenues to mitigate these impacts and align with sustainability goals.

One of the critical challenges in the sustainable use of *B. orellana* is the storage stability of bixin. Husa *et al.* (2018) demonstrate that inadequate storage conditions, such as exposure to light and heat, can degrade bixin, reducing its economic and industrial value. Implementing good practices in storage and processing, including controlled environments and stabilizing agents, is essential to maximize plant value and minimize waste.

Hirko and Getu (2022) also highlight the importance of involving local communities in the sustainable management of *B. orellana*. Promoting fair trade practices and offering training in sustainable cultivation can economically empower communities while ensuring the long-term availability of this resource.

Analysis of existing value chains and markets for achiote, identifying opportunities for its development and sustainable marketing

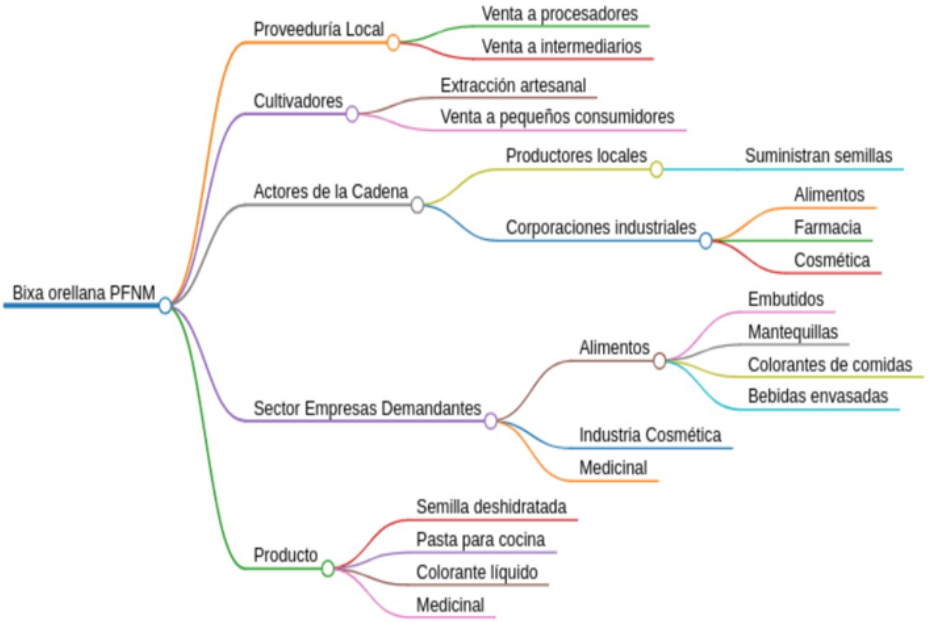

Figure 5. *- Productive chains of the species B. ore lana as NTFPs*

Regarding value chains, the results indicate that the 300 ha of achiote cultivated are marketed autonomously, without associated organizations, limiting their reach at the provincial and national level. Figure 5 shows a diagram of the production chain of *B. orellana*.

Although achiote production generates income, it is minimal due to the lack of added value and the waste of byproducts with curative potential, such as leaves and roots. Producers sell the seeds to intermediaries for prices ranging from $2.64 to $2.75 per kg, although they prefer to sell directly to companies such as La Fabril, which offers between $3.52 and $3.96 per kg of pure, quality seed.

These results are consistent with those reported by Torres (2018), who highlighted that key components of the *B. orellana* value chain include growers who artisanally process the dye, selling it to small resellers and local producers who offer dehydrated seeds. In this sense, they agree with what was stated by Clement *et al.* (2024), who claim that, as in other non-timber forest product (NTFP) systems in the Amazon, low added value and marketing limitations result in insufficient income, which inhibits the sustainable and economic development of these communities. This problem is exacerbated by the lack of adequate infrastructure, access to technical and financial services, and insecure land

tenure, which aggravates the ability of these small producers to intensify land use sustainably (Porro *et al*., 2020).

In contrast, initiatives such as those mentioned by Ehrenberg *et al.* (2024) in Yucatán, Mexico, highlight the importance of neglected and underutilized species (NUS) as valuable resources to combat poverty and improve the resilience of agricultural systems. The adaptation of these plants to changing environments makes them resistant to pests and climate change, suggesting an untapped potential in the *B. orellana species* that could be harnessed through the creation of public policies that promote its conservation and sustainable use. The rescue of these species would not only contribute to the preservation of cultural heritage, but could also offer significant opportunities in food and medicine markets, as seen in the case of Mayan fruit trees in Yucatán.

Suggestions of policies and public directions to promote the sustainable use of the achiote as NTFP and its contribution to sustainable forest management

In the current context, characterized by the deterioration of plant resources, it is imperative to adopt an approach sustainable for the provision of the NTFP as is the case of the *achiote* product of the species *B. orellana,* not just to preserve nature, but also to improve the well-being of the local population. The following directions are designed for protect ing and conservating *B. orellana* and encourage its sustainable management in the communities of San Vincent, Saint Pink and The Tiger:

Promotion of Agricultural sustainable practices: stimulate the use of agricultural techniques that improve the productivity and resilience of achiote crops, such as crop rotation and soil conservation practices that prevent erosion and improve soil quality.

Implementation of soil conservation techniques: adopt methods such as direct seeding and mulching, which help maintain soil health and reduce the need for chemical intervention.

Promoting biological control methods: reducing dependence on chemical pesticides by using biological, cultural and physical control to manage pests and diseases, thus promoting a healthier ecosystem.

Biodiversity conservation: integrating strategies that protect natural habitat areas and promote crop genetic diversity, which directly contributes to ecological resilience.

Development of strategic action plans: Establish clear lines of action for the protection, use and conservation of *B. orellana*, thus guiding the investments and efforts of all the actors involved.

Community training: Provide ongoing training to communities on the potential and benefits of *B. orellana*, ensuring that they understand and can apply best practices in the use and management of this resource.

Integrated forest management: implement forest management strategies that balance productivity and conservation, ensuring sustainable use of *B. orellana* and the conservation of associated genetic resources.

Incentive for research and development: support research on good forest management practices and develop harvesting and post-harvest technologies that improve the quality and added value of products derived from annatto.

Bixa orellana products, encouraging the creation of local micro-enterprises that can operate sustainably and with long-term objectives.

Integration of government agencies and organizations (associativity): actively involve entities such as the Decentralized Autonomous Government of the Paján canton and the Ministry of Agriculture and Livestock to provide the technical and financial support necessary for the implementation of these guidelines (Figure 6).

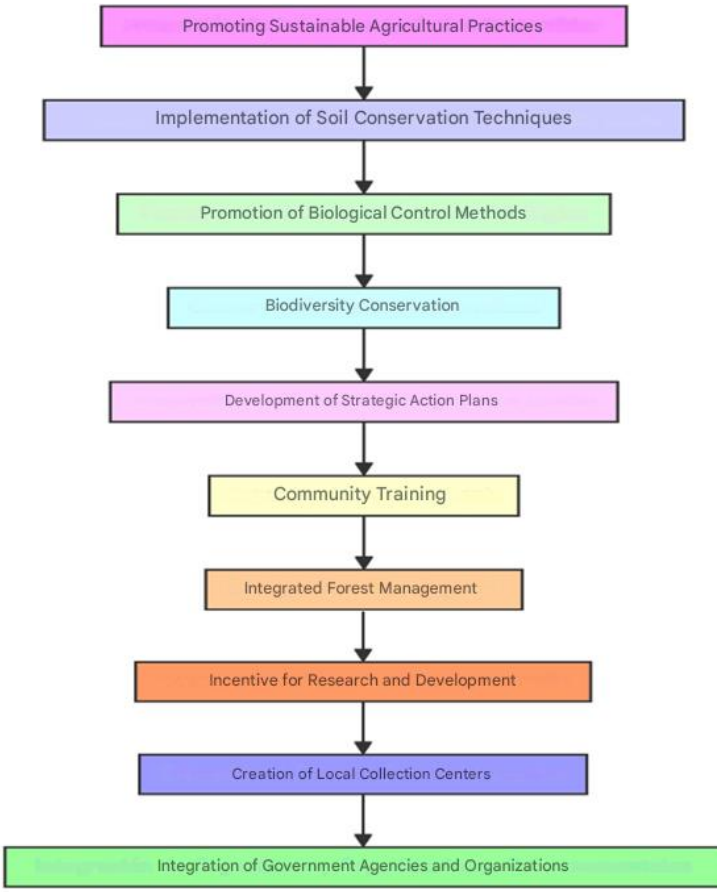

Figure 6. - *Diagram* ***of*** *flow of directions for the Sustainable Management of the species B. ore l l ana as P FNM*

CONCLUSIONS

The predominance of primary education among the interviewees reflects a structural limitation in access to the technical and cultural knowledge necessary to enhance the management of *Bixa orellana* at the local level. In the communities of San Vicente, Santa Rosa and El Tigre, this plant maintains a significant place in traditional cuisine and medicine, although its cultural value seems to be in decline, which shows changes in social and cultural dynamics that affect its perception and use. In addition, the absence of added value and the weak organization in the achiote sector condition its economic potential, restricting the possibilities of generating positive impacts at the socioeconomic and environmental level in the region.

REFERENCES

AGUIRRE MENDOZA, Z., 2015. Guía para estudiar los productos forestales no maderables (PFNM) [en línea]. Ecuador: Universidad Nacional de Loja. Disponible en: https://nikolayaguirre.com/wp-content/uploads/2013/04/aguirre-2015_pfnm.pdf.

ANGULO COLIMBA, A.F., GONZÁLEZ INSUASTI, M.S. y ROSERO GARCES, R.A., 2012. Estudio etnobotanico de las plantas medicinales utilizadas por los habitantes del corregimiento de Genoy Municipio de Pasto Colombia. Universidad y Salud [en línea], vol. 14, no. 2, [consulta: 1 octubre 2024]. Disponible en: https://docs.repositoriobiocultural.org/2021/09/08/estudio-etnobotanico-de-las-plantas-medicinales-utilizadas-por-los-habitantes-del-corregimiento-de-genoy-municipio-de-pasto-colombia/.

AYALA JARA, C., CASTILLO SAAVEDRA, E., ALFARO AVALOS, K., ASPIROS FREYRE, E. y SECLÉN AYALA, L., 2018. Development of a cosmetic dye based on the seed of Bixa orellana L. (Bixaceae) and evaluation of its in vitro effect. Scientia Agropecuaria [en línea], vol. 9, no. 1, DOI 10.17268/sci.agropecu.2018.01.14. Disponible en: https://www.researchgate.net/publication/324071781_Development_of_a_cosmetic_dye_based_on_the_seed_of_Bixa_orellana_L_Bixaceae_and_evaluation_of_its_in_vitro_effect.

BERMÚDEZ DEL SOL, A., SÁNCHEZ, L., ABREU NARANJO, R. y ENGONDO, F., 2018. Traditional use of medicinal plants by the population of the municipality of Santa Clara, Cuba. Journal of Pharmacy and Pharmacognosy Research [en línea], vol. 6, no. 5, Disponible en: https://www.researchgate.net/publication/326991156_Traditional_use_of_medicinal_plants_by_the_population_of_the_municipality_of_Santa_Clara_Cuba.

CLEMENT, C.R., SANTOS PEREIRA, H. dos, GUIMARÃES VIEIRA, I.C. y OYAMA HOMMA, A.K., 2024. Challenges for a Brazilian Amazonian bioeconomy based on forest foods. Trees, Forests and People [en línea], vol. 16, [consulta: 1 octubre 2024].

ISSN 2666-7193. DOI 10.1016/j.tfp.2024.100583. Disponible en: https://www.sciencedirect.com/science/article/pii/S2666719324000906.

EHRENBERG, J.P., CHERNET, A., LUJÁN, M. y UTZINGER, J., 2024. One Health as a potential platform to rescue the neglected fruit trees in Yucatan, Mexico. Science in One Health [en línea], vol. 3, [consulta: 1 octubre 2024]. ISSN 2949-7043. DOI 10.1016/j.soh.2024.100073. Disponible en: https://www.sciencedirect.com/science/article/pii/S294970432400012X.

FAO, 2024. El estado de los bosques del mundo 2024: Innovaciones en el sector forestal para lograr un futuro más sostenible. [en línea]. Roma: FAO. [consulta: 1 octubre 2024]. ISBN 978-92-5-138875-4. Disponible en: https://bibliotecadigital.ciren.cl/handle/20.500.13082/148520.

HIRKO, B., & GETU, A. 2022. Bixa orellana (Annatto Bixa): A review on use, structure, extraction methods and analysis. Journal of Agronomy, Technology and Engineering Management, [en línea] vol. 5 no. 1, 687-696.https://www.fimek.edu.rs/downloads/casopisi/jatem/issue/v5_1/2._Hirko_and_Getu_2022_5%281%29_687-696.pdf

HUSA, N. N., HAMZAH, F., & SAID, H. M. 2018. Characterization and storage stability study of bixin extracted from Bixa orellana using organic solvent. In IOP Conference Series: Materials Science and Engineering [en línea] vol. 358, No. 1, p. 012035). IOP Publishing.https://iopscience.iop.org/article/10.1088/1757-899X/358/1/012035/meta

JIMÉNEZ GONZÁLEZ, A., MACÍAS EGAS, Á.F., RAMOS RODRÍGUEZ, M.P., TAPIA ZÚÑIGA, M.V. y BLANDARIZ, S.R., 2019. Indicadores de sostenibilidad con énfasis en el estado de conservación del bosque seco tropical. Revista Cubana de Ciencias Forestales [en línea], vol. 7, no. 2, [consulta: 1 octubre 2024]. ISSN 2310-3469. Disponible en: https://cfores.upr.edu.cu/index.php/cfores/article/view/412.

JIMÉNEZ GONZÁLEZ, A., SALTOS ARTEAGA, E.E., RAMOS RODRÍGUEZ, M.P., CANTOS CEVALLOS, C.G. y TAPIA ZÚÑIGA, M.V., 2018. Aprovechamiento y potencialidades de uso de Phytelephas aequatorialis Spruce como producto forestal no maderable. Revista Cubana de Ciencias Forestales [en línea], vol. 6, no. 3, [consulta: 1 octubre 2024]. ISSN 2310-3469. Disponible en: https://cfores.upr.edu.cu/index.php/cfores/article/view/349.

LOZANO, R.M., ASENCIOS TARAZONA, V. y MENDOZA CARLOS, M.M., 2021. La importancia de los colorantes y tintes naturales para las poblaciones originarias de la amazonia peruana. LLamkasun: Revista de Investigación Científica y Tecnológica [en línea], vol. 2, no. 4, [consulta: 1 octubre 2024]. ISSN 2709-2275. Disponible en: https://dialnet.unirioja.es/servlet/articulo?codigo=8245836.

OLIVEIRA, C. R., CAL, V. D. L. J., VAZ, D. F., FIALHO, P. B., CURIELE, R. S., FIGUEIRA, F. S., ... & DE PAULA VIEIRA, R. 2021. Known and unknown medicinal plants used in respiratory disorders in Brazilian folk medicine: a brief review. Brazilian Journal of Natural Sciences, [en línea] vol. 4 no. 1, 588-605. Disponible en: https://www.bjns.com.br/index.php/BJNS/article/view/130

PANIAGUA-ZAMBRANA, N.Y., BUSSMANN, R.W. y ROMERO, C., 2020. Bixa orellana L. Bixaceae. En: N.Y. PANIAGUA-ZAMBRANA y R.W. BUSSMANN (eds.), Ethnobotany of the Andes [en línea]. Cham: Springer International Publishing, pp. 1-6. [consulta: 14 enero 2025]. ISBN 978-3-319-77093-2. Disponible en: https://doi.org/10.1007/978-3-319-77093-2_39-1.

PINEDA, C., JUMBO BENÍTEZ, N.C., FERNÁNDEZ, P. y JARAMILLO, N., 2019. Productos forestales no maderables en cinco comunidades de la parroquia Manú, Saraguro, provincia de Loja. Bosques Latitud Cero [en línea], vol. 9, no. 1, [consulta: 1 octubre 2024]. ISSN 2528-7818, 1390-3683. Disponible en: https://dialnet.unirioja.es/servlet/articulo?codigo=9349967.

PORRO, R., MILLER, R.P., TITO, M.R., DONOVAN, J.A., VIVAN, J.L., TRANCOSO, R., VAN KANTEN, R.F., GRIJALVA, J.E., RAMIREZ, B.L. y GONÇALVES, A.L., 2012. Agroforestry in the Amazon Region: A Pathway for Balancing Conservation and Development. En: P.K.R. NAIR y D. GARRITY (eds.), Agroforestry - The Future of

Global Land Use [en línea]. Dordrecht: Springer Netherlands, pp. 391-428. [consulta: 1 octubre 2024]. ISBN 978-94-007-4676-3. Disponible en: https://doi.org/10.1007/978-94-007-4676-3_20.

RÍOS RAMÍREZ, S.C., RUIZ POSADAS, L. del M., ASCENCIO VELAZCO, M.S., AGUIRRE DUGUA, X., PINZÓN LÓPEZ, L., SANTIAGO OSORIO, E., AGUÍÑIGA SÁNCHEZ, I. y CADENA ÍÑIGUEZ, J., 2022. Aprovechamientos del achiote (Bixa orellana L.) en una comunidad indígena de Oaxaca, México. Agro divulgación [en línea], vol. 2, no. 6, [consulta: 1 octubre 2024]. ISSN 2954-4483. Disponible en: https://dialnet.unirioja.es/servlet/articulo?codigo=9406562.

RIVERA BARRETO, J.L., RODRÍGUEZ ALMEIDA, N.N., CONFORME GARCÍA, M.M. y DAHUA GUALINGA, R.D., 2024. Actividad antifúngica de un ungüento desarrollado a partir de hojas de Bixa Orellana. Reincisol [en línea], vol. 3, no. 6, [consulta: 1 octubre 2024]. ISSN 2953-6421. DOI 10.59282/reincisol.V3(6)437-460. Disponible en: https://www.reincisol.com/ojs/index.php/reincisol/article/view/210.

SEGURADO GIL, Y., RODRÍGUEZ MATOS, C.Y. y LEYVA MIGUEL, I., 2020. Propuestas de acciones para el uso sostenible de Productos Forestales no maderables. Hombre, Ciencia y Tecnología, [en línea], vol. 24, Disponible en: https://portal.amelica.org/ameli/journal/441/4411976009/4411976009.pdf.

TORRES TORRES, M.G., 2018. Caracterización de las cadenas de valor de los productos forestales no maderables en el Chocó biogeográfico [en línea]. Colombia: WWF-Colombia. Disponible en: https://d2ouvy59p0dg6k.cloudfront.net/downloads/caracterizacion_de_las_cadenas_de_valor_de_los_productos_forestales_no_maderables_en_el_.pdf.

VILAR, D. D. A., VILAR, M. S. D. A., MOURA, T. F. A. D. L. E., RAFFIN, F. N., OLIVEIRA, M. R. D., FRANCO, C. F. D. O., ... & BARBOSA-FILHO, J. M. 2014. Traditional uses, chemical constituents, and biological activities of Bixa orellana L.: a review. The Scientific World Journal, [en línea] no. 1, 857-292. Disponible en: https://onlinelibrary.wiley.com/doi/full/10.1155

Conflicts of interest:

The authors declare not to have any interest conflicts.

***Contribution of the authors*:**

The authors have participated in the writing of the work and analysis of the documents.