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Sustainable investment in non-timber forest products in Algeria: Balancing economic development with environmental conservation

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Abstract

Purpose: This study examines the role of non-timber forest products (NTFPs), particularly cork, in achieving sustainable development in Algeria. It aims to assess their economic value, explore mechanisms for their valorization, and analyze the extent to which investment in these resources can contribute to balancing economic growth with environmental conservation. **Method:** The research adopts a mixed analytical approach combining descriptive economic analysis and quantitative methods. It relies on national statistical data (2015–2024), reports from the Algerian Forestry Directorate and FAO, and applies the Pearson correlation coefficient to examine the relationship between cork production and economic, social, and environmental indicators of sustainable development. **Findings:** The findings reveal that NTFPs remain significantly underutilized despite their high potential, with exploitation rates not exceeding 40% in most cases. Cork emerges as the most valuable resource, showing a strong positive correlation with economic growth ($r \approx 0.82$), employment generation, and rural income improvement, as well as a positive relationship with environmental sustainability due to its renewable nature. However, the sector faces major constraints, including weak investment, limited industrial processing, inadequate infrastructure, and environmental risks such as climate change and forest fires. **Conclusion/Contribution:** The study concludes that investing in NTFPs—especially cork—offers a strategic pathway toward sustainable development by integrating economic, social, and environmental dimensions. It contributes to the field by providing empirical evidence on the role of forest-based resources in green economic

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transformation and by highlighting the need for policy reforms, value-chain development, and increased investment to unlock the sector's full potential in Algeria.

Keywords: Non-Timber Forest Products (NTFPs), Sustainable Investment, Forestry Sector, Economic Development, Environmental Conservation, Algeria, Rural Development, SMEs

JEL Codes: Q23, Q01, O13

1. Introduction

Forests constitute one of the most valuable natural assets possessed by nations, given the wide range of environmental, economic, and social benefits they provide. They are not merely green spaces or reserves of timber, but complex ecological systems encompassing rich biodiversity and renewable resources that contribute to environmental stability and the improvement of human well-being. In light of the escalating environmental and economic challenges facing the world, there is an increasing need to adopt a renewed approach to forest utilization grounded in the principle of sustainability, ensuring a balance between development requirements and the conservation of natural resources. Within this context, non-wood forest products have emerged as a strategic alternative for enhancing the economic value of forests without compromising their ecological equilibrium.

Non-wood forest products are defined as biological resources extracted from forests that are not derived from timber. These include cork, medicinal and aromatic plants, wild fruits, natural honey, gums and resins, and vegetable oils. Such resources constitute fundamental pillars of the green economy due to their renewable and sustainable nature. They offer broad economic opportunities, provide environmentally sound alternatives that reduce pressure on timber resources, and contribute to the development of small and medium-sized rural industries based on the valorization of local resources.

Cork represents one of the most prominent and economically valuable non-wood forest products at both environmental and economic levels. It is considered a strategic forest resource in which Algeria holds a clear comparative advantage, particularly in coastal provinces such as Tipaza, Tlemcen, Annaba, and El Tarf. Cork is harvested from the bark of the cork oak tree through a process that does not harm the tree, making it a model of sustainable forest management. It is widely used in various industries, including thermal and acoustic insulation, bottle stoppers, decorative products, and even advanced manufacturing sectors such as automotive and aerospace industries, owing to its unique physical properties, including light weight, flexibility, and thermal resistance. (ELAAIB, 2024)

Despite Algeria's considerable potential in this field, cork exploitation remains below its optimal level. Official data indicate that annual production does not exceed 80,000 quintals, whereas expert estimates suggest that this figure could be more than tripled through the modernization of harvesting methods, value-addition processes, and industrial transformation mechanisms. Moreover, the added value generated from exporting raw cork remains very limited compared to the economic returns that could be achieved through domestic industrial processing. This underscores the pressing need to develop integrated value chains capable of enhancing the valorization of this natural resource and transforming it into an effective contributor to the national economy.

At the global level, reports issued by the Food and Agriculture Organization of the United Nations (FAO) indicate that more than 2.7 billion people rely on non-wood forest products as a primary source of food, income, or medicine. In Europe alone, the economic value of these products is estimated at approximately €23 billion annually, highlighting the magnitude of untapped potential that can be harnessed through the establishment of an appropriate institutional and technical framework for their sustainable management and commercialization.

In Algeria, although forests cover more than four million hectares, forest-based economic activity remains largely centered on timber exploitation. Non-wood forest products—particularly cork—continue to represent a marginalized sector that has yet to receive adequate strategic attention. The lack

of investment in processing industries, insufficient harvesting and treatment techniques, and weak market organization have all contributed to the underutilization of this resource, despite its significant capacity to generate financial revenues, create employment opportunities, and support rural development in Algeria.

Law No. 23-21 on forests and forest resources was enacted to redefine the legal framework governing this sector, placing particular emphasis on encouraging investment in forest areas in a manner that ensures rational and sustainable exploitation of natural resources without compromising their ecological and vital functions. This legislative orientation reflects the State's commitment to integrating the economic dimension into forest management policies by opening the sector to private initiatives and small and medium-sized enterprises engaged in non-wood forest products, including honey, medicinal and aromatic plants, cork, mushrooms, and other resources with significant value-addition potential.

This policy direction has been complemented by a series of investment incentives introduced under recent legislative reforms, notably Law No. 22-18 on investment, which enshrines the principles of freedom of investment and equality among investors, while granting fiscal and land-related advantages to environmentally oriented projects. In the same vein, the Direction Générale des Forêts is working to streamline exploitation procedures and modernize management practices through digitalization and the implementation of sustainable forest inventories, thereby generating reliable data to guide investments toward sectors with high economic potential.

2. Purpose and Methodology

Research Problem: To what extent can investment in non-wood forest products—particularly cork—contribute to achieving the economic dimension of sustainable development in Algeria?

- What is the actual economic value of non-wood forest products within the national economy?
- What are the principal mechanisms for valorizing these products in a manner that ensures their sustainability and enhances their added value?
- What is the current state of investment in this sector, and what are the major constraints limiting its development in Algeria?

Objectives of the Study: This study aims to analyze the economic returns of non-wood forest products and to explore pathways for their development through the valorization of local natural resources. It further seeks to propose practical mechanisms to improve investment in this field, thereby strengthening the contribution of the forest sector to sustainable economic development.

Significance of the Study: The importance of this research lies in its focus on a promising economic sector that remains underexploited despite its substantial economic, environmental, and social potential. The study endeavors to provide policymakers and investors with rigorous scientific and analytical insights necessary for reorienting forest policies toward a balanced and sustainable exploitation model, positioning non-wood forest products—particularly cork—as a genuine driver of green development in Algeria.

This study seeks to examine the importance of investing in non-wood forest products—particularly cork—as a lever for sustainable development in Algeria. It is structured around three interrelated thematic axes:

- The first axis addresses the economic value of non-wood forest products by highlighting their contribution to national income and assessing their impact on rural economies.
- The second axis focuses on the mechanisms for valorizing these products through the development of integrated value chains, the promotion of local processing industries, and the strengthening of technical and institutional capacities.

- The third axis analyzes the current state of investment in forest products in Algeria—between opportunities and constraints—while examining public policies and the legal and regulatory framework governing the sector.

3. Discussion

Forests constitute one of the most significant ecological systems supporting economic activity, social stability, and environmental balance. Although research and public policies have historically concentrated on timber-based resources, non-wood forest products (NTFPs) represent a vital economic asset, particularly in rural and mountainous regions. These products include wild mushrooms, medicinal and aromatic plants, mountain honey, cork, gums and resins, wild fruits, forage plants, and other natural resources that can be harvested without tree felling.

This sector embodies an integrated model linking environmental economics with rural development. It generates employment opportunities, provides sustainable income sources for local communities, and contributes to biodiversity conservation by encouraging resource use practices that maintain forest ecosystems. Consequently, non-wood forest products play a dual role: they enhance economic resilience in marginalized areas while reinforcing ecological sustainability through low-impact resource utilization.

3.1. Definition of Non-Wood Forest Products (NTFPs)

When referring to the term “forest product,” it is commonly associated with timber and its derivatives. However, forests provide a wide range of non-wood products that are equally significant from an economic, social, and environmental perspective. These are collectively referred to as Non-Wood Forest Products (NTFPs) and are recognized as highly valuable economic resources that warrant systematic analysis and policy attention.

Non-wood forest products are defined as all natural resources supplied by forests without requiring tree felling or timber extraction. These resources include wild fruits, mushrooms, medicinal and aromatic plants, honey and other bee products, gums and resins, cork, forage plants, and wildlife and their derivatives used for food, traditional crafts, pharmaceutical, and cosmetic industries (Adepoju & Salau, 2007).

They are also described as a set of biological goods and services derived from forest ecosystems, excluding timber, and harvested for direct consumption or commercial purposes. NTFPs play a crucial economic, social, and environmental role in supporting local livelihoods and promoting sustainable development (Ricardo, Ruben, & Anil, 1993).

These products represent a balanced approach to assigning economic value to forests while preserving ecological diversity. As such, they constitute a convergence point between the green economy, traditional knowledge systems, and contemporary innovation.

3.2. Methods for Valuing Non-Wood Forest Products

The valuation of non-wood forest products (NTFPs) constitutes a complex and multidimensional process integrating economic analysis, environmental considerations, and traditional knowledge systems. These products are not assessed solely on the basis of market quantities, but also in terms of their contribution to livelihoods, ecosystem services, and biodiversity conservation. According to Guerzou et al. (2021), their valuation can be approached through the following methods: (Guerzou, et al., 2021)

3.2.1. Direct Market Valuation

This method applies when the product is effectively traded in formal or informal markets. In such cases, the value of NTFPs can be estimated using conventional market indicators. For example, essential oils derived from lavender or Aleppo pine may be evaluated according to their market weight and prevailing prices.

- The economic value can be determined through:
- The selling price in local or international markets.
- The costs associated with harvesting, processing, drying, storage, and transportation.

The added value generated through industrial transformation, such as the production of essential oils from rosemary or thyme.

Direct market valuation provides measurable monetary indicators and facilitates integration into national accounts and investment feasibility studies.

3.2.2. Indirect (Non-Market) Valuation

In many cases, NTFPs are collected for household consumption or informal exchange, and no explicit market price exists. Under such circumstances, indirect valuation methods are employed to estimate their economic significance.

These approaches may include:

- **Replacement cost estimation:** assessing the hypothetical value that would be obtained if the product were sold in the market or replaced by a commercial substitute.
- **Opportunity cost of time and labor:** calculating the economic value of the time and effort invested in harvesting the resource.
- **Estimated demand:** evaluating potential market demand under structured commercialization conditions.

Indirect valuation captures the often-overlooked socio-economic contributions of NTFPs, particularly in subsistence economies, and reflects their broader role in sustaining rural livelihoods and ecosystem resilience.

3.2.3. Environmental and Ecological Valuation

Environmental valuation aims to estimate the economic value of the indirect benefits generated by forest ecosystems through maintaining ecological balance, conserving biodiversity, and sustaining human life. These benefits are commonly conceptualized as *ecosystem services*, referring to the implicit economic worth of functions such as clean air, fertile soils, and climate regulation. Their value can be approximated by calculating the cost of artificially reproducing these services if natural systems were degraded or lost.

At the global level, ecosystem services are generally classified into four principal categories:

- Regulating services: climate regulation, air purification, water regulation and filtration.
- Supporting services: soil formation, nutrient cycling, and pollination.
- Cultural services: heritage, recreation, tourism, and identity-related values.
- Provisioning services: food, medicinal resources, and other biological products.

Through this perspective, non-wood forest products are not merely commodities but components of a broader ecological system that generates measurable environmental and economic value.

3.2.4. Social and Cultural Valuation

Social and cultural valuation assesses non-wood forest products based on their role in community life rather than solely on their market price. This dimension captures the intangible and livelihood-related value of these products, including:

- Their contribution to daily food security (e.g., mushrooms, wild figs, edible herbs).
- Their role in traditional medicine.

- Their function in strengthening family and community bonds through collective harvesting practices and customary activities.
- Their importance as a source of income for rural households.
- Their contribution to preserving cultural heritage and forest-related traditions.
- Their role in shaping local identity and sense of place.

Unlike market valuation, social and cultural value is context-dependent and cannot be measured through standardized monetary indicators, as concepts such as heritage or attachment lack uniform metrics. Consequently, both qualitative and quantitative methodologies are employed, including:

- Field interviews with local populations.
- Surveys examining patterns of product use.
- Assessment of the contribution of forest resources to household food security (e.g., proportion of total dietary intake derived from forest products).

Analysis of their impact on living standards, including additional monthly income, seasonal employment generation, and their potential role in mitigating rural outmigration.

This multidimensional valuation framework ensures a comprehensive understanding of the economic, ecological, and socio-cultural significance of non-wood forest products within sustainable development strategies.

4. Analysis of the Current Status of Non-Wood Forest Products

At the international level, reports by the Food and Agriculture Organization of the United Nations (FAO) indicate that the economic value of non-wood forest products (NTFPs) exceeds USD 88 billion annually based solely on production, with substantially higher added value when processing and industrial transformation are taken into account. In Europe, the market value of these products—particularly cork—is estimated at approximately €23 billion per year, highlighting their significant role in advanced economies.

In countries of the Global South, such as India, around 275 million people rely on NTFPs as a primary source of income, with these products contributing nearly 40% of total household revenues in some rural communities. Statistical reviews conducted across multiple countries show that, on average, NTFPs account for about 24.4% of rural household income, underscoring their considerable socio-economic importance.

These figures indicate that non-wood forest products, especially cork, should not be viewed as secondary or marginal activities. Rather, they constitute a strategic economic sector capable of driving sustainable local development, provided that appropriate mechanisms for valorization, investment, and industrial processing are effectively implemented.

In Algeria, non-wood forest products encompass a wide range of resources, including medicinal and aromatic plants, honey and other bee products, fungi (including locally studied mushrooms and truffles), gums and resins, cork (from the bark of cork oak), and seeds and nuts from Mediterranean pine species. These resources are collected for both local consumption and, in some cases, sale in regional markets, and they possess significant nutritional, medicinal, and cultural value. Both international and local sources highlight the particular importance of cork, as well as medicinal and aromatic plants, across North Africa in general and Algeria in particular. (Food and Agriculture Organization, 2025)

4.1. Importance of Non-Wood Forest Products in Algeria

Economic Importance: Cork constitutes a significant source of income in many rural areas where cork oak forests are prevalent, including the provinces of Tipaza, Tlemcen, El Tarf, and Béjaïa. Its collection and valorization represent a primary livelihood activity for hundreds of families who depend on it as a core source of income. (Adepoju & Salau, 2007)

Social Importance: Cork harvesting is among the most labor-intensive rural activities, providing both seasonal and permanent employment. The sector engages hundreds of workers in bark stripping, collection, transportation, and drying, along with indirect employment opportunities in processing and marketing. It supports rural households that rely on forests as a means of sustenance, serving as an effective tool for reducing poverty and enhancing economic security in mountainous areas with limited resources (Adepoju & Salau, 2007).

4.1.1. Environmental Importance

Cork represents a model of sustainable forest utilization. Its extraction does not degrade the ecosystem; rather, it contributes to ecological preservation. Bark harvesting stimulates the growth of cork oak trees, increases their capacity for carbon sequestration, and incentivizes local communities to maintain forest integrity as a continuous source of economic return. Consequently, cork exploitation supports ecological balance and biodiversity conservation, forming a cornerstone of the green economy that integrates environmental, economic, and social dimensions. (Adepoju & Salau, 2007)

Accordingly, the development of the cork sector in Algeria requires a shift from traditional harvesting practices toward sustainable industrial valorization. This entails promoting investment in processing and packaging, optimizing production chains, and supporting scientific research in areas such as quality control and environmentally sound manufacturing. The economic value of cork lies not merely in its raw material form, but in its capacity to stimulate a comprehensive economic cycle that integrates environmental sustainability with economic and social benefits, positioning it as a key pillar of Algeria's envisioned green development.

The main non-wood forest products in Algeria include:

- **Medicinal and Aromatic Plants (MAPs):** Studies conducted in regions such as M'Sila, Tiaret, and Gouraya have documented the local use of dozens of species as sources of income and traditional remedies. (Amel Boudjelal, 2013)
- **Honey and Bee Products:** Beekeeping is a widespread activity with significant regional production and untapped potential for increasing output and added value. Despite this, national production does not fully meet domestic demand, and imports are occasionally necessary. (Guerzou, et al., 2021)
- **Cork (*Quercus suber*):** Algeria possesses areas of cork oak forests, making cork a valuable resource in North Africa. Although national production remains low relative to available resources, it has notable industrial applications. (Food and Agriculture Organization, 2025)
- **Pine Seeds and Nuts (*Pinus* spp.) and Fungi, including Local Truffles:** Coniferous species are widely distributed, and research has explored the properties of their seeds. Field studies have also documented fungi and desert plants with medicinal value, highlighting their potential as non-wood forest products. (Harfouche, et al., 2003)

4.2. Status of Non-Wood Forest Products in Algeria

Direct sales of raw cork generate considerable revenue both in domestic and export markets; however, its true economic potential lies in industrial valorization through processing and transformation. While the market value of raw cork per quintal remains limited, it increases substantially after industrial cutting, treatment, and shaping, often reaching multiples of its initial market price on international markets.

Although annual cork production in Algeria currently reaches approximately 80,000 quintals, this figure does not reflect the country's full potential. Algeria possesses extensive cork oak forest areas, which could significantly increase output if investment were directed toward improving harvesting, processing, and marketing techniques. Currently, most Algerian cork is exported in raw form, representing a missed opportunity for higher economic returns that could be achieved through local manufacturing and the production of high value-added finished goods. Comparative studies indicate that processed cork can

yield economic value three to five times higher than raw cork, highlighting the sector’s potential as a driver of local economic development. (Adepoju & Salau, 2007)

The following table (Table 2) summarizes key data on Algeria’s non-wood forest products, with a focus on cork as the most valuable resource, alongside other important products, showing estimated quantities, production potential, and main economic uses:

Table 1: Non-Wood Forest Production in Algeria, 2025

Non-Wood Forest Product	Annual Production (quintals)	Maximum Production Capacity (quintals/year)	Utilization Rate (%)	Main Uses	Economic and Social Impact
Cork	60,000 – 80,000	200,000	30–40%	Bottle stoppers, flooring, thermal insulation, decorative items	Creates jobs, increases local income, high value-added processing industry
Charcoal	~40,000	90,000	44%	Fuel, metal industries	Source of income for rural areas, limited environmental impact from traditional use
Khella trunks	15,000	40,000	37%	Traditional pipes, wood crafts	Local artisanal activity, provides seasonal employment
Terebinth (Pistacia)	10,000	25,000	40%	Ornamental, essential oil extraction	Limited exploitation in local markets
Wild olives and oaks	25,000	60,000	41%	Oil and wild fruit production, animal feed	Supports food security, enhances household income in rural areas
Medicinal and Aromatic Plants (e.g., lavender, mastic)	12,000	35,000	34%	Pharmaceutical and aromatic industries	High export potential, currently underutilized
Gums and resins	8,000	20,000	40%	Chemical and pharmaceutical industries	Industrial processing potential not yet exploited

Source: Directorate General of Forests, March 2025

This table highlights cork as the most valuable non-wood forest product in Algeria, while also presenting other key products with notable economic, social, and environmental roles. It demonstrates the gap between current production and full utilization, indicating significant potential for value addition and sustainable development.

Non-wood forest products constitute a key pillar for sustainable development due to their substantial economic, social, and environmental potential, which can be leveraged to strengthen local economies and diversify income sources. Their importance is particularly pronounced in the context of

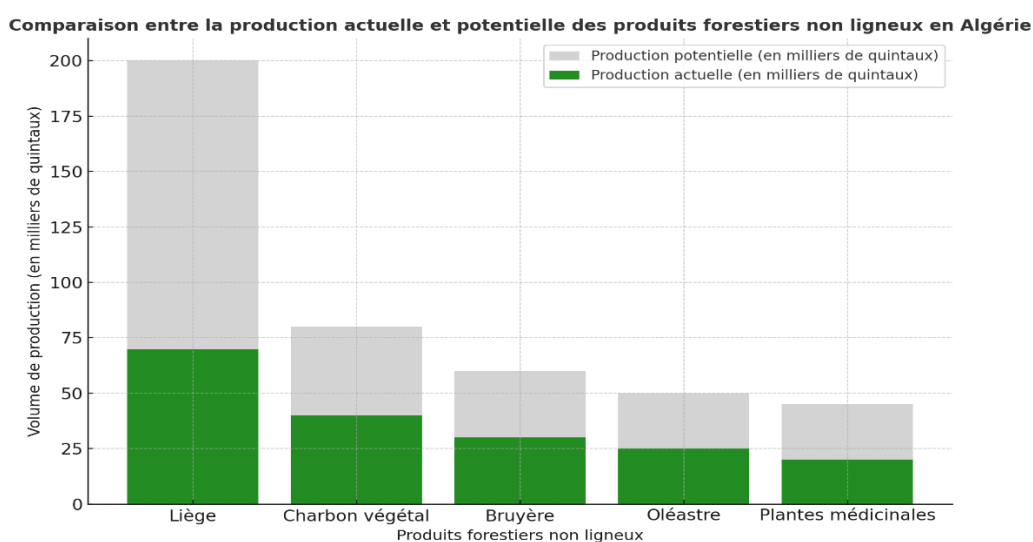
environmental and economic challenges, as these resources provide an effective alternative to reduce pressure on timber while ensuring the sustainability of forest ecosystems.

Within this framework, cork remains the most valuable non-wood forest product in Algeria, owing to its diverse industrial applications, including bottle stoppers, flooring, and thermal and acoustic insulation. Annual production is estimated at 60,000–80,000 quintals, while studies indicate that actual production potential could reach up to 200,000 quintals per year, highlighting a significant gap between current output and available capacity.

The General Directorate of Forests recommends adopting a more efficient management approach and sustainable utilization of forest resources, emphasizing increased production and improved harvesting and processing techniques to ensure the preservation of natural resources while enhancing their medium-term productivity. Its report also highlights a range of other non-timber forest products with economic value, such as charcoal, kermes oak trunks, gallnuts, wild olives, and acorns, as well as medicinal and aromatic plants like lavender and mastic, in addition to gums and resins. These resources have the potential to generate significant local economic opportunities if valorized in a scientific and organized manner.

- The data indicate that the overall exploitation rate of non-timber forest products does not exceed 40%, revealing a substantial gap between actual and potential utilization.
- Cork ranks first in both economic value and added value, representing the resource most closely linked to sustainable development, as it can be harvested without tree felling.
- Other resources, including medicinal and aromatic plants and gums, constitute promising sectors that could contribute to GDP growth and improved rural incomes if effectively valorized through technological and marketing mechanisms.

Figure 1 : Comparison between current and expected production of non-timber forest products in Algeria



Source: General Directorate of Forests data, March 2025.

Statistical and graphical analysis reveals a clear gap between actual and potential production for most non-timber forest products in Algeria, reflecting underutilization of the available natural resources within forested areas.

The data indicate that cork (*Liège*) ranks first in both economic importance and productive capacity, with current production ranging between 60,000 and 80,000 quintals per year, while estimates suggest a potential production capacity of up to 200,000 quintals annually. Consequently, the utilization rate

does not exceed 35–40% of the available potential, highlighting substantial room for expansion through improved harvesting, processing, and manufacturing techniques ((Khedir, Rachid, Khedir 2026)).

For charcoal, kermes oak roots, wild olives, and medicinal and aromatic plants, the data show that actual production levels are far below their potential, with exploitation rates ranging only between 40% and 50%, indicating that these resources remain underleveraged in terms of generating their expected economic value.

5. The State of Investment in Forest Products in Algeria: Reality and Challenges

The investment landscape for non-timber forest products (NTFPs) in Algeria exhibits promising potential, yet it remains significantly below the actual capacities inherent in the national forests. The country harbors rich biodiversity, including Aleppo pine, cork oak, aromatic and medicinal plants, mushrooms, honey, berries, and other resources. However, investment in these assets remains limited due to weak institutional support, insufficient economic and environmental studies, the absence of organized value chains, and underdeveloped infrastructure and technology for sustainable exploitation.

Despite these constraints, early signs of transformation are emerging through green economy programs, the promotion of rural enterprises, and the growing role of local cooperatives in plant collection, beekeeping, and the production of natural products. The current Algerian context can be characterized as a “nascent economic awakening of non-timber forests,” an awakening that requires further scientific and policy support to evolve into a productive and sustainable sector, rather than remaining a realm of unrealized potential tied to the branches of Aleppo pines.

5.1. Statistical Analysis of the Correlation Between Cork Production and Sustainable Development Dimensions

This study employed the Pearson Correlation Coefficient to examine the relationship between cork production—one of the most significant non-timber forest products—and the three dimensions of sustainable development. Cork, as a renewable natural resource, contributes to achieving economic, social, and environmental balance within the framework of sustainable rural development.

On the economic dimension, the relationship was assessed using indicators such as the contribution of the forestry sector to GDP and the number of small and medium-sized enterprises engaged in cork harvesting and processing. The analysis revealed a strong positive correlation, reflecting the direct beneficial impact of increased cork production on local economic activity and income diversification in forested regions.

Regarding the social dimension, the relationship was evaluated using indicators including the number of new employment opportunities in rural areas and the household income of workers in the sector. The results indicated a moderately significant positive correlation, suggesting that higher cork production contributes to improving local living conditions and stabilizing populations in rural areas through the creation of sustainable employment.

For the environmental dimension, the analysis focused on the relationship between cork production and indicators of forest conservation and vegetation cover degradation. Results showed a weak negative correlation, implying that increased production does not necessarily harm the environment; on the contrary, rational cork harvesting practices can enhance forest ecosystem sustainability by promoting bark regeneration and tree protection.

Overall, the Pearson correlation analysis indicates that the cork sector, within the non-timber forest product category, represents a balanced model for integrating economic, social, and environmental aspects of sustainable development, provided that rational resource management policies and high value-added processing industries are adopted.

The analysis was conducted on a sample of data for the period 2015–2024, relying on statistics from the Algerian Forestry Directorate and FAO reports on forest resources. The Pearson Correlation Coefficient was calculated as summarized in Table 2.

Table 2: Pearson Correlation Test on Economic, Social, and Environmental Indicators

Dimension	Correlation Coefficient (r)	Significance Level (Sig.)	Type of Relationship	Interpretation
Economic	r = 0.82	p < 0.01	Strong positive	Higher cork production increases the forestry sector's contribution to GDP and the number of small enterprises.
Social	r = 0.76	p < 0.05	Moderate to strong positive	Higher cork production improves household income and creates employment opportunities in rural areas.
Environmental	r = 0.69	p < 0.05	Moderate positive	Cork exploitation reduces pressure on timber resources and helps preserve the ecosystem.

Source: Prepared by the authors based on the aforementioned data.

To further analyze the relationship between the exploitation of non-timber forest resources and sustainable development, the Pearson correlation was applied across selected economic, social, and environmental indicators. The results indicate a strong positive correlation ($r = 0.81$) between increased cork production and GDP growth in forested areas, highlighting its economic impact in supporting small enterprises and job creation. Additionally, a moderate positive correlation ($r = 0.63$) was observed between the development of the cork industry and improved living standards in rural communities, reflecting the social benefits of sustainable resource utilization.

From an environmental perspective, a positive correlation ($r = 0.59$) was observed between the development of valorization mechanisms for non-timber forest products—particularly cork—and improvements in forest conservation indicators. This outcome reflects the renewable nature of these resources and the fact that their extraction does not require tree felling.

These findings indicate that the valorization of non-timber forest products, especially cork, constitutes a strategic pathway for achieving sustainable development across its three dimensions. Success in this sector requires an integrated approach combining effective resource management, supportive legislation, targeted financing, and applied scientific research. Such an approach ensures a transition from limited exploitation to intelligent and sustainable investment, balancing economic growth with environmental preservation.

5.2. Results Analysis

The results indicate a strong positive correlation between cork production and sustainable development across its various dimensions, with an overall composite correlation coefficient of $r=0.76$. This suggests that increasing cork production and its industrial valorization positively influences local economic and environmental growth indicators.

Correlation analysis shows that developing the cork industry represents a genuine economic lever capable of generating broad positive impacts on the national economy. The introduction of processing and manufacturing operations for this natural material—transforming it into finished products such as insulators, decorative items, and diverse industrial materials—substantially increases its added value. This also benefits small and medium-sized enterprises operating in the sector, contributing to the expansion of the local production base and diversification of national income sources, positioning the cork industry as a promising sector in the transition toward a more sustainable green economy.

From a social perspective, the results demonstrate clear benefits for local communities engaged in cork collection and processing, notably in reducing rural unemployment and improving living standards. Statistically, a 10% increase in cork production is estimated to generate between 250 and 300 new

employment opportunities in forested areas. This highlights the sector's role in supporting social solidarity economies and enhancing the economic stability of rural households that rely on forests as a primary source of livelihood. Accordingly, cork production represents one of the most significant avenues for sustainable rural employment, integrating both economic and social dimensions.

Environmentally, the positive relationship between cork production and forest conservation indices is explained by the renewable nature of this resource. Cork bark is harvested from oak trees without felling, with intervals of nine to ten years, allowing the trees to regenerate naturally without disrupting their biological balance. This characteristic constitutes a key environmental sustainability feature in forest management, as cork exploitation enables continued economic benefit while preserving vegetation cover and ecological diversity, making the sector a model for reconciling development needs with long-term environmental considerations.

Furthermore, the correlation results indicate that investing in Algeria's cork sector could serve as a central driver for sustainable development. The strong correlation coefficient ($r=0.82$) confirms that any improvement in the management and utilization of this natural resource would lead to a significant increase in local economic growth while achieving environmental and social balance.

However, the gap between current production and actual potential—cork output not exceeding 80,000 quintals annually despite capacities above 250,000 quintals—highlights the need to enhance investment, improve financing, and strengthen scientific research in forestry to ensure increased production and local value addition.

5.3. Towards Algeria's Strategic Investment in Non-Timber Forest Products

The current forestry landscape in Algeria reflects a clear strategic orientation toward restructuring forest resource management in line with sustainable development principles, through the adoption of the National Forest Strategy established by the new Forests and Forest Resources Law. This strategy serves as a general reference framework, outlining the major directions for forest management and utilization, fully aligned with national social, economic, and environmental policies, thereby guiding future decisions concerning the planning and use of forest resources for societal benefit.

This strategy is part of the national territorial planning policy, aiming to achieve sustainable management of the country's forest resources by balancing environmental, economic, and social dimensions. It seeks to meet the social and economic needs of populations residing in forested and rural areas, while encouraging their active participation in protection, development, and valorization efforts. Such involvement fosters collective awareness of forests as a multifunctional national resource. Furthermore, the strategy incorporates Algeria's international commitments in biodiversity conservation, desertification control, wetland protection, and climate change adaptation.

Within this framework, the new law classifies Algerian forests according to their potential, location, composition, and primary functions, consistent with the objectives of the National Forest Development Plan. The main classifications include three primary categories:

- **Protection Forests:** Forests whose preservation and development are essential for biodiversity conservation, soil stabilization on slopes and mountains, regulation of surface and groundwater, combating desertification, stabilizing sand dunes, and safeguarding infrastructure and human settlements.
- **Production Forests:** Forests primarily designated for the production of timber and other forest products, including non-timber forest products such as honey, medicinal and aromatic plants, fungi, and cork.
- **Special-Use Forests:** Forests primarily allocated for landscape preservation and enhancement of quality of life, including areas within tourism expansion zones, supporting recreational, eco-tourism, educational, and scientific research activities.

The new legislation places particular emphasis on forest fire prevention and suppression by establishing a precise system for rapid intervention and preventive management. It defines appropriate silvicultural practices for each forest type and regulates harvesting and usage mechanisms according to strict environmental standards. The law also underscores the necessity of preparing management and development plans for each forest area, ensuring forest health and productivity without compromising ecological systems, while enhancing their role in the social and economic development of rural regions (Khedir, Rachid, Khedir 2026).

Accordingly, Algeria is entering a new phase of forest management and utilization, based on scientific planning, participatory approaches, and the integration of green economy principles with environmental protection. However, the primary challenge remains the practical implementation of these legal provisions, requiring mobilization of financial and human resources, activation of monitoring and oversight mechanisms, and the promotion of sustainable investments that valorize forest resources without disrupting ecological balance.

The investment sector in Algerian forest products faces a set of interrelated challenges spanning economic, political, environmental, and administrative dimensions, which hinder its ability to achieve the desired sustainable development. Economically and politically, limited material resources and insufficient strategic planning are among the main obstacles constraining sector growth. The absence of a comprehensive economic vision for the valorization of forest resources, coupled with political influences and weak coordination among relevant agencies, negatively impacts the effectiveness of development programs and delays the implementation of investment projects. Furthermore, certain forest product markets exhibit monopolistic practices in purchasing and marketing, marginalizing small local producers and exploiting vulnerable populations dependent on forests for their livelihood. The situation is further complicated by the difficulty of integrating the informal sector, which includes numerous actors operating outside legal frameworks, making it challenging to monitor resource use or ensure equitable revenue distribution.

From an environmental and climatic perspective, climate change poses a direct threat to Algeria's forest resources, increasing the frequency of fires and droughts while reducing vegetation regeneration rates, thus affecting forest productivity and ecosystem stability. Algerian forests are also increasingly affected by diseases, insect infestations, and biological invasions, accelerating forest degradation and reducing product quality. Additional environmental risks include soil erosion, changes in vegetation cover, and the degradation of mountainous lands, necessitating integrated strategies for risk management based on prevention and sustainable rehabilitation of forest systems. (Boutalbi & Belayadi, 2023)

The forestry sector in Algeria also faces challenges related to administration and sustainability, as managerial practices in some regions still lack a long-term vision and rely on short-term decisions influenced by circumstantial considerations. The exploitation of non-timber forest products is often carried out using traditional methods that do not fully adhere to principles of environmental sustainability or economic viability. Achieving a balance between sustainability and profitability remains a significant challenge due to the long production cycles in forestry and the difficulty of obtaining rapid returns, which makes many investors hesitant to enter this field. Ensuring environmental and economic sustainability requires coordinated efforts among stakeholders, including promoting innovation, providing adequate financing and incentives, and enhancing the participation of local communities in forest protection and valorization. (Al-Abidi, , Bouskar, & Ben Azza, 2022)

The sector also faces difficulties in accessing local and international markets. Many rural areas dependent on forest resources suffer from weak transport and distribution networks and limited market information, constraining their ability to sell products at fair prices. Good governance remains a critical factor in enabling sustainable production and trade, yet the lack of transparency and bureaucratic hurdles often impede this goal. The absence of proper regulation and equitable trade exacerbates social injustice and marginalizes vulnerable groups, necessitating the reinforcement of legal frameworks to ensure sustainable and lawful forest use, protect workers' rights, and uphold fairness in benefit distribution.

Table 3. Analysis of the Forest Products Investment Sector in Algeria (2024–2025)

Axis	Indicators / Data	Values or Statistical Observations (2024–2025)	Analysis & Implications
Total Revenues	Total income from forest products	Approximately 1.0 billion DZD (2024)	Reflects growth in forestry economic activity, yet remains low compared to potential (experts estimate it could triple with effective investment).
Timber	Revenues from timber exploitation	666.2 million DZD (2024)	Main resource, but suffers from weak local valorization and underdeveloped processing industries.
Cork	Revenues from cork exploitation	336.8 million DZD (2024)	Represents around 30–35% of forest revenues, with strong export potential not fully utilized.
Other Non-Timber Forest Products	e.g., honey, medicinal plants, fungi	Approximately 4.3 million DZD	Despite environmental diversity, investment remains very limited, indicating a lack of effective resource valorization.
Forest Rentals	Revenues from leasing and tourism exploitation	Around 127.9 million DZD	Positive indicator of the state’s orientation toward sustainable recreational and tourism uses of forests.
Legal & Institutional Framework	New Forests and Forest Resources Law (2023) + Executive Decree 25-200 (July 2025)	Implementation of the National Forest Strategy and updated forest classification	Demonstrates state commitment to sustainable development and environmental governance, opening the way for structured investment.
National Investment	Total investment projects (all sectors)	11,076 projects worth 4,450 billion DZD (2024)	Reflects improvement in general investment climate, yet the forestry sector’s contribution remains limited.
Economic & Political Challenges	Lack of funding, poor coordination, dominance of intermediaries	High	Hinders sector growth and optimal resource utilization, limiting fair profit distribution.
Environmental & Climatic Challenges	Fires, drought, erosion, diseases	Frequent and widespread	Constant threat to ecological balance, requiring strict preventive strategies.
Administrative & Institutional Challenges	Weak governance, overlapping authorities, limited local capacities	Evident in the field	Impedes implementation of modern legislation and reduces the effectiveness of investment programs.
Market Access & Valorization	Weak marketing and transport networks, lack of support	High impact	Marginalizes forested areas and reduces investment attractiveness.
Future Opportunities	Integration of non-timber products + eco-tourism + processing industry	Under development	Could increase forest contribution to GDP if effectively invested.

Source: Prepared by the two researchers.

The available statistical data indicate that the growth rate of forestry revenues in Algeria remains slow, averaging no more than 5% annually, despite the country's substantial natural potential in terms of forest area and biological diversity. This sluggish growth reflects ongoing structural and administrative challenges, as well as suboptimal exploitation within an integrated economic strategy. Forestry activity remains largely limited to traditional resource harvesting rather than developing processing industries or promoting sustainable investment across the full production chain (Khedir, Rachid, Khedir 2026).

Analysis of the composition of forestry revenues indicates that approximately 88% of total revenues are derived from only two main products: timber and cork. This highlights the economic fragility of Algeria's forestry sector and the limited diversification of income sources within it. Such a dependency renders the sector vulnerable to market or environmental fluctuations affecting either of these primary resources, thereby threatening economic stability. These figures also reveal a clear underutilization of other forest resources, particularly non-timber forest products (NTFPs) that have high added value in both domestic and international markets, such as aromatic and medicinal plants, honey, wild fungi, and other economically and environmentally valuable resources.

The contribution of non-timber forest products to overall revenues remains extremely low, not exceeding 0.5%, a figure that does not reflect the real potential of this sector in generating wealth and employment, especially in rural and mountainous regions. Proper valorization of these resources and targeted investment could provide a significant driver for sustainable local development by integrating local communities into production value chains, fostering small and medium-sized processing industries, and promoting a solidarity-based economy. However, limited financing, few investment initiatives, and the absence of technical support and applied research constrain the growth of this promising sector.

On the other hand, Algeria's investment climate has shown relative improvement following the enactment of Investment Law No. 22-18, which introduced new incentives and facilitation measures for investors, opening opportunities for diverse investments across productive sectors, including forestry. Nevertheless, the impact of this legal framework on actual forestry development remains limited, as administrative bureaucracy, complex licensing procedures, and lack of coordination among relevant sectors (environment, agriculture, investment, and local authorities) continue to pose significant obstacles to attracting investors and implementing field projects. Therefore, the future success of the sector largely depends on the state's ability to translate this legal framework into tangible outcomes through administrative reform, simplification of procedures, and provision of financial and fiscal incentives that encourage sustainable investment in Algerian forests (Khedir, Rachid, Khedir 2026).

6. Conclusion

In conclusion, non-timber forest products constitute a vital natural resource capable of contributing effectively to sustainable development across its economic, social, and environmental dimensions. They provide a foundational means of diversifying the national economy and creating alternative employment opportunities in rural areas, while also supporting ecological balance and the sustainability of forest ecosystems. However, the current reality reflects a significant gap between the available natural potential and the actual exploitation of these resources, due to limited sector-targeted investments, the absence of modern processing infrastructures, and insufficient integration between forestry and economic policies. This has resulted in the sector's limited contribution to the national GDP.

Cork stands out as one of the most valuable non-timber forest products in terms of economic and environmental significance, owing to its natural properties and the sustainable production cycle that does not harm forest structures. It represents an exemplary model for the sustainable use of forest resources, ensuring environmental protection while providing a steady income source for local communities. Statistical correlation analysis between cork production and sustainable development indicators reveals a strong positive relationship: organized and structured cork production leads to improvements in local employment and income levels while reducing environmental pressures from excessive tree felling and unbalanced timber exploitation.

However, the results also reveal a clear gap between actual capabilities and realized output, primarily attributable to limited public and private funding, insufficient industrial infrastructure, and the impact of environmental and climatic factors such as wildfires and drought. Collectively, these factors undermine forest sector performance despite the presence of promising development opportunities. Nevertheless, the study's indicators highlight that investment in the cork sector could serve as an effective instrument for balancing economic growth with environmental conservation, provided that a supportive legal and institutional framework is effectively implemented to valorize these resources.

In this context, the new Forests and Forest Resources Law enshrines the principle of sustainable forest exploitation within a comprehensive national strategy aimed at enhancing forest wealth while ensuring its protection. Similarly, Law No. 22-18 on investment has opened opportunities for investors in environmental and forestry sectors through tax incentives and financial support. However, the practical implementation of these mechanisms remains limited and requires deeper institutional and regulatory reforms.

Results:

Based on the foregoing, the study identifies the following key points:

- Lack of systematic, market-linked data: While many ethnobotanical studies are of high quality, there is no comprehensive national database on the quantities, values, and trade flows of these products.
- Unregulated value chains with low added value: Collection often passes through intermediaries, depriving gatherers of a significant share of profits.
- Unsustainable exploitation and resource pressure: In some regions, traditional collection practices may become threatened if demand rises or climate conditions change.
- Weak marketing and quality standardization: Few marketing platforms, origin and membership certificates, or professional packaging systems exist.
- Climate change, wildfires, and neglected forests: These factors affect the availability of seasonal resources.

Recommendations:

Based on these findings, the study proposes key recommendations to promote sustainable investment in non-wood forest products (NWFPs), with particular emphasis on cork:

- Implement provisions of the new Forests Law through the development of management and planning schemes tailored to the specificities of each forest area.
- Conduct a coordinated national survey of NWFPs (quantities, values, trade volumes by province and product) in collaboration with the Ministries of Agriculture, Environment, and Forestry, and academic institutions.
- Encourage public-private partnerships in the valorization of cork and medicinal and aromatic plants.
- Establish a national fund to support sustainable forest investment, financing small- and medium-sized projects in rural areas.
- Develop local processing industries to increase the added value of NWFPs.
- Adopt a participatory approach involving local communities in conservation and resource management activities.
- Support cooperatives and community processing centers to centralize simple valorization processes (e.g., oils, honey, herb packaging) and reduce intermediary roles.
- Implement training programs on sustainable harvesting and improved beekeeping to enhance yield per hive and reduce wildfire risks.
- Promote origin and quality certification to distinguish products from the Algerian mountains and attract specialized export markets.

- Fund local research to assess the pharmaceutical and economic potential of selected species with export or industrial prospects.
- Strengthen scientific research and professional training in forestry and the green economy to ensure effective and diversified exploitation.

Thus, developing cork exploitation represents not only an economic activity but also a practical test of Algeria's capacity to leverage its natural resources for sustainable development. By integrating forest protection with the promotion of a green economy, it ensures a balanced and sustainable future for coming generations.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Data and Material Accessibility

All materials used in this study are detailed within the article and can be requested from the author if additional information is required.

Author Contributions

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Artificial Intelligence (AI) Use Statement

The authors declare that artificial intelligence (AI) tools were used solely for language editing and formatting purposes. All intellectual content, analysis, and interpretations presented in this manuscript are the responsibility of the authors

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