The Contribution of Non-Wood Forest Products to Rural Livelihoods in Tunisia: The Case of Aleppo Pine

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Abstract: Research Highlights: Recently, there has been a growing interest in the contribution of Non-Wood Forest Products (NWFPs) to livelihoods and food security among local populations in Tunisia. NWFPs have gained special attention given the relevance of this forest heritage to alleviate poverty and improve household economies. Background and Objectives: This study focuses on determining the contribution of Aleppo pine production to local household livelihood and food security in Tunisia (Siliana province). The relevance of this region as a leading Tunisian Aleppo pine producer makes the analysis especially interesting. Materials and Methods: Data were obtained using structured surveys distributed among rural household heads during the collection season. A logistic regression as well as food security indicators were calculated to evaluate the contribution of NWFPs to household livelihood. Results: Empirical findings support evidence that there is a significant difference between the alternative sources of revenues. The collection of Aleppo pine was significantly affected by gender, attending extension days and agricultural training program, distance to market, household size and livestock activity. Conclusions: Aleppo pine plays an important role in supporting rural livelihoods and provides an important safety net for the local population throughout the year.

Keywords: forest income; food security; Aleppo pine; NWFPs; Tunisia

1. Introduction

Tunisian forests provide a wide range of products and services of which the most important are Non-Wood Forest Products (NWFPs). Recently, there has been a growing social and political interest in worldwide NWFPs production [1]. Weiss et al. (2020) advocated that NWFPs may contribute to human nutrition, renewable materials, and cultural and experiential services, as well as to create income opportunities and to provide jobs for men and women in rural areas [2]. NWFPs are characterized by their significant market value and contribution to local livelihoods. They provide a wide range of benefits upon which rural populations supplement their income and meet a large number of their basic needs of subsistence and trade [3]. Moreover, the author advocated that households are involved in the management of forest areas in order to obtain products that ensure their survival. The collection of NWFPs offers an important subsistence support to local populations living within forest areas through representing the lion’s share of their household income and food security, as well as providing multiple social and cultural values [4]. Indeed, the commercialization of NWFPs could ensure a direct access to the cash economy for local populations [5]. While the contribution of environmental products and services to rural livelihoods is widely recognized, their economic significance within forest communities...
remains insufficiently explored [6]. Despite the relevance of the NWFPs sector, there are very few empirical applications that analyze the contribution of NWFPs to household income, mainly due to the data scarcity in developing countries.

Commercial extraction of NWFPs alleviates poverty in forest areas and could contribute to biodiversity conservation [7,8]. Rural populations worldwide have traditionally collected various NWFPs to fulfill their livelihood needs, such as direct provisioning to cash income and household requirements at critical time of the year [1]. Nevertheless, Ojea et al. (2016) reported that NWFPs could not be the most important source of income for local people living within forest areas.

In developing countries, NWFPs play an important role in the household economy of rural populations. These products include all extracted goods from forests and woodlands other than timber, such as aromatic and medicinal plants, grazing, fruits, nuts, vegetables, fibers and resins [9]. NWFPs contribute to a household’s income by providing subsistence and consumption needs (e.g., energy and nutrition) and ensuring regular cash income [10,11]. Harvesting NWFPs is a challenging task and requires intensive work. However, yields are considered low in comparison with employed labor and efforts in extraction and harvesting activities.

The forest area and woodlands in Tunisia cover more than one million hectares, of which 52% are pure forest and located in the north of Tunisia [12]. Scrublands cover 34% of the total forest area. All forests are mainly located in humid zones in the north of the country. NWFPs contribute 0.33% to the agricultural gross domestic product and 32.30% to the local forest populations’ income as well as to the preservation of the environment through reducing sedimentation and carbon sequestration [13].

Aleppo pine (*Pinus halepensis* Mill.) is considered as the most abundant pine species in the Mediterranean region and North Africa, particularly in eastern Spain, northern Algeria and Tunisia [14]. The Aleppo pine is the most common species in Tunisian forests with 361,221 hectares representing 53.2% of Tunisian woodlands [15]. Natural stands of Aleppo pine are mainly located in the semiarid areas of northern and central Tunisia [16]. During the last few decades, important efforts were employed in Tunisia to promote and initiate restoration of *P. halepensis* forests. This national strategy was employed to avoid wildfires, to reestablish stands and conserving biodiversity [17,18].

Aleppo pine provides various products and services to local populations, such as Aleppo pine seeds (APS) (called “zgougou” in Tunisia), fuelwood products, corns as well as forest employment. Actually, the average consumption of APS is about 1.5 kg per family per year. Meanwhile, the national consumption of milled APS is estimated at 0.5 kg/family/year. Tunisian consumption of APS is expected to increase to reach 2 kg/family/year over the next couple of years [11]. This product has a particular cultural importance. APS are sold throughout the country on the occasion of the religious feast of Mouled to prepare a sweet pudding called “Assida-Zgougou”. Recently, APS have gained multiple usage, being a key ingredient in various agro-food industries such as ice-creams, candies and pastries. Cheikh-Rouhou et al. (2006) highlighted the nutritional benefits from consuming APS given the high content of protein (22.7%), oil (43.3%) and various mineral elements (potassium, magnesium and calcium) [19].

All forests are state-owned, and all usage rights are obtained from the General Directorate of Forest. There is an increasing demand for APS in this country. This grey-black seed has a particular importance in Tunisia since it is the most widely used seed source for many human consumption and forestry purposes [20,21]. Moreover, NWFPs provide livestock fodder and energy for processing inedible food, which indirectly affect food security. The general contribution of NWFPs to rural households in Tunisia, and in Siliana in particular, is still overlooked. Food insecurity is the major problem that rural households living around forests are facing, which could leave rural development at stake. Indeed, it is of great importance to evaluate the current situation and expectations on the future development of the Aleppo pine sector in Tunisia. The relevance of this sector in the Tunisian agricultural economy makes this analysis interesting.
Despite the relevant role of Aleppo pine in Tunisian rural development, the literature on this sector is very sparse in this country. To our knowledge, no previous published study has focused on the socio-economic role of Aleppo pine in rural communities in Tunisia. The present research study contributes to fill this gap. This analysis would allow assessing the economic relevance of NWFPs in livelihood strategies of Tunisian rural communities and their contribution to household income and food security, to provide useful information for policy makers with respect to the link between rural development and food security.

The paper is organized as follows. The next section describes the methodology used in the empirical application. Then the discussion of the main results from the empirical implementation is presented. The paper will finish with concluding remarks.

2. Materials and Methods

The most relevant decision to be taken by economic agents that live in forest regions is whether to collect APS or to look for another economic activity. Such behavior could be analyzed as a discrete decision by making use of the logit model, where the dependent variable \( Y_i \) is a binary variable representing two possible outcomes \([22]\), the decision of the \( i \)-th household to collect APS \((Y_i = 1)\) or not \((Y_i = 0)\). \( X_i = (X_{1i}, \ldots, X_{ki}) \) is a vector representing the potential variables that could influence the outcome \( Y_i \). In order to identify factors that influence the collection of NWFPs by households, this relationship can be expressed as follows:

\[
Y_i = f(X_{i}, \varepsilon_i) \tag{1}
\]

The logit specification then provides a model of observing the probability of collecting NWFPs \( \pi_i \). The logistic function is specified as follows:

\[
\pi_i = \frac{\exp(X_i'\beta)}{1 + \exp(X_i'\beta)} \tag{2}
\]

where \( \beta \) is a vector of parameters to be estimated and \( \varepsilon_i \) is the error term, assumed to follow a logistic distribution. The regression coefficients are estimated using the maximum likelihood estimation technique and the log-likelihood function is specified as follows:

\[
\log L(\beta) = \sum \{ y_i \log(\pi_i) + (1 - y_i) \log(1 - \pi_i) \} \tag{3}
\]

Marginal effects at the sample mean have been computed to determine the effect on the probability of increasing a predictor by one unit while holding the other variables constant. Marginal effects for continuous variables measure can be approximated by the following expression:

\[
\frac{d\pi_i}{dx_{ij}} = \beta_j \pi_i (1 - \pi_i) \tag{4}
\]

While for categorical variable the \( dY/dX \) formula is used indicating the discrete change from the base level zero to one. That is, the marginal effect \( X_i = \pi \ (Y = 1 | X, X_i = 1) - \pi \ (Y = 1 | X, X_i = 0) \).

The selection of explanatory variables relies upon the previous literature, data availability and knowledge of the sector. A dummy variable that indicates the respondent’s gender \((X1)\) is used \([23,24]\); it takes a value of one for men and 0 for women. \((X2)\) is a dummy variable that equals one if respondents attend extension days and zero otherwise. \((X3)\) is a dummy variable that equals one if the respondent participates in agricultural training program and zero otherwise. \((X4)\) is defined as the number of people in the agricultural household \([25]\). Farm size \((X5)\) is defined as the total area of farmland owned by the household and is expressed in hectares \([26]\). The degree of specialization measured as the proportion of agricultural revenue to total household revenue is reflected in \((X6)\) \([27,28]\). Distance to market is also considered through \((X7)\), reflecting the distance covered in kilometers from the respondents’ home to the nearest market \([26,29,30]\). Finally, livestock
activity is reflected in dummy variable (X8), indicating the presence of animal husbandry or not.

Furthermore, to determine the extent to which NWFPs collection contributes to household food security, food security indicators were calculated for the sample households. The following lines describe the main indicators used for this analysis based on a well-built concept of food security measures proposed by the Food and Agriculture Organization (FAO) and previous research studies.

Food security is a complex concept and could be defined as a state in which all people have sustainable physical, social and economic access to sufficient and safe food that meets their dietary needs and preferences to ensure productive and healthy lives [31]. The concept of food security relies on four fundamental pillars, namely, availability, accessibility, food utilization and stability. Previous studies focused on both food availability and access measured at the household level using indicators of calorie intake or dietary diversity [32–34]. The first component, availability, includes all domestic quantities of food produced during the year, the amount of food stocks available at the beginning of the year and the quantities of food that can be acquired with available or imported incomes [35]. The second pillar, household’s food access, determines the ability of a household in terms of both physical access to food and adequate purchasing power [36]. In addition, the food utilization reflects to which extent households meet their energy needs and nutritional requirements. The use of food takes into account the preparation of food and its distribution among family members, health and diet variety. The last food security dimension refers to food stability. The latter represents the ability of households to obtain food over time without serious shocks and vulnerability. This fourth pillar incorporates the food price and income stability of vulnerable populations. There are two main indicators widely used in the literature as measures for food security at the household level: frequency and dietary diversity and food behavior. Each indicator can be defined through different sub-indicators. The former indicator could include the food consumption score, household food diversity score and undernutrition [37–39].

The Food Consumption Score (FCS) is a weighted diet diversity index developed by the World Food Program and used as a proxy for food consumption and access to food. It is the most used among the food security indicators. The FCS looks at the food consumption frequency of households from various food groups over a seven-day period [40,41]. FCS is calculated using the following formula:

\[ FCS = \sum_{i} \mu_i \times x_i \]  

(5)

where \( i \) represents food group (e.g., cereal, legume, vegetable, fruit, meat, sugar, dairy products, oil and fat) and \( \mu_i \) is a weight assigned to food group \( i \). Following [42], the weights used in the analysis were cereal = 2, legume = 3, vegetable = 1, fruit = 1, meat = 4, sugar = 4, dairy products = 0.5 and oil fat = 0.5). \( x_i \) indicates the number of days of consuming each food group \( i \) (\( \leq 7 \) days). FCS varies between 0 and 112. Standard thresholds 28 and 42 are used to determine the three categories of household food consumption: acceptable food security, >42; between 28.5 and 42, medium food security; and low food security, <28.

Moreover, the Household Dietary Diversity Score (HDDS) is an important indicator of food security that could be used as a proxy measure of household food access based on the previous 24 h [43]. It allows assessing the household’s economic access to food, regardless of its origin, how it is produced, or where it is purchased. Nevertheless, it does not provide information on the diet’s nutritional quality [44]. Swindale and Bilinsky (2006) defined HDDS as the average number of food groups consumed by a household over a given period indicating that a more diversified household diet could be associated with caloric and protein adequacy, percentage of protein from animal sources, and household income. The indicator brings together 12 food groups (cereals, roots and tubers, vegetables, fruits, meat and poultry, eggs, fish and seafood, legumes/nuts, milk and dairy products, oil/fat products, sugar/honey, miscellaneous: condiments, coffee or tea). For each food group,
a dummy variable is created and takes a value of one if the household consumed this specific food group and zero otherwise. The total score for each household is reported on a scale ranging from 0 to 12. Three categories of household dietary diversity based on the following thresholds were identified [44]: low food diversification, HDDS ≤ 4; moderate food diversification, 4 < HDDS ≤ 8; and high food diversification HDDS > 8.

The food behavior of households could be identified through the Coping Strategy Index (CSI). The latter is an indicator of access to food, revealing the severity of strategies that households use to deal with food deficits. Fifteen relevant coping strategies are identified, including NWFPs harvesting (Table 1). This index is well adapted to this problem since it focuses on vulnerable households and assesses the evolution of their food situation and their surviving strategy [41,45].

Table 1. Different types of adaptation strategies.

| Severity Category | Adaptive Coping Behavior                                      | Severity Scale |
|-------------------|---------------------------------------------------------------|----------------|
| Mild              | To reduce the overall amount of food in each meal              | 1              |
|                   | To reduce the number of meals                                 | 1              |
|                   | To rely on less preferred and cheaper foods                   | 1              |
|                   | To be restricted to non-preferential foods                     | 1              |
| Moderate          | To borrow food                                                | 2              |
|                   | To buy food on credit                                         | 2              |
|                   | To Harvest Forest products (APS)                              | 2              |
|                   | To practice early harvest                                     | 2              |
| Severe            | To send household members to eat elsewhere                    | 3              |
|                   | To send household members begging                             | 3              |
|                   | To reduce meals for adults                                    | 3              |
|                   | To have illegal activities                                    | 3              |
| Very severe       | To sell the house or plot or breeding animals                 | 4              |
|                   | To remove children from school                                | 4              |
|                   | To send one of the family members looking for work elsewhere  | 4              |

Source: Adapted from [44].

This indicator may provide information about the contribution of Aleppo pine collection to household purchasing power and food security. The CSI is derived using the following formula:

\[ CSI = \text{Frequency} \times \text{Severity Scale} \quad (6) \]

where frequency is defined as follows: a strategy used every day has a frequency of 7 points; often: 4.5 points; rarely: 1.5 points; and never: 0 points. The index score varies from zero to 252, combining the frequency and severity of the coping strategies. The higher the index score, the more food insecure the household is. This indicator measures what people do when they cannot access enough food. It indicates the adjustments of households with respect to consumption and livelihoods. Three classes of household coping strategies [44] are distinguished using the following thresholds: low level of adaptation, CSI ≤ 3; medium level of adaptation, 3 < CSI ≤ 9; and high level of adaptation, CSI > 9.

Furthermore, the severity of the household food insecurity is determined using the Household Food Insecurity Access Scale (HFIAS) indicator, which focuses on the “access” feature of food insecurity and not on food utilization. It is built upon opinions regarding food vulnerability and behavioral reactions to food insecurity in the household during the past four weeks (30 days). Following [46], households were asked nine “occurrence” questions that represent an increasing level of severity of food insecurity and how many
times the condition happened, namely, rarely (once or twice), sometimes (three to ten times) or often (more than ten times) in the past four weeks (Table 2). A lower score (0–27) indicates a household experienced lower food insecurity (access). Four classes of household food insecurity were determined, based on the following thresholds: $0 \leq \text{HFIAS} \leq 6$, food security; $7 \leq \text{HFIAS} \leq 13$, mild food insecurity; $14 \leq \text{HFIAS} \leq 20$, moderate food insecurity; and $21 \leq \text{HFIAS} \leq 27$, severe food insecurity.

Table 2. Household Food Insecurity Access Scale (HFIAS) generic questions.

| No. | Questions |
|-----|-----------|
| 1   | In the past four weeks, did you worry that your household would not have enough food? |
| 2   | In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? |
| 3   | In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? |
| 4   | In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? |
| 5   | In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? |
| 6   | In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food? |
| 7   | In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? |
| 8   | In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? |
| 9   | In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? |

Source: Adapted from [46].

Food insecurity contributes to overweight and obesity, as well as undernutrition, and high rates of these forms of malnutrition arise in many countries [38,47]. The undernutrition indicator intends to measure food deprivation. The Household Hunger Scale (HHS) index was also computed to measure the hunger-specific experience of insecure access to food. The HHS indicator is constructed using a period of 30 days, and consists of three “occurrence” questions (yes or no) and with what frequency (never = 0, rarely and sometimes = 1, or often = 2). Following [48], a household was asked in the past four weeks (30 days): (1) Was there ever no food to eat of any kind in his house because of lack of resources to get food? (2) Did he or any household member go to sleep at night hungry because there was not enough food? (3) Did he or any household member go a whole day and night without eating anything at all because there was not enough food? The HHS score is the sum of all three scores derived from three hunger questions and ranges from 0 to 6, indicating the degree of insecure food access: “little to no hunger in the household” (0–1), “moderate hunger in the household” (2–3), or “severe hunger in the household” (4–6).

The Siliana governorate has very large forests of Aleppo pine covering 80 thousand hectares of which 20 thousand hectares are used for APS production [12]. The study was conducted in the Kesra delegation. It is considered as the highest village in Tunisia and characterized by a semi-arid climate with a mean annual rainfall of 466 mm per year. The Kesra delegation is a gallery forest with a high density of tree species. The vegetation of the study area is dominated by Aleppo pine with the presence of shrubs throughout the year, providing favorable conditions for livestock grazing. Due to forest fires, the density of wild natural resources in the area has progressively declined over time.

Data were collected by face-to-face questionnaires in the main APS-producing areas in Kesra. Five villages were selected, namely, Bou Abdallah, Mansoura, El hammem,
Jabnoun and El Garea, based on field visits, expert consultations and the recommendations in the local official forest document *Organisms in Siliana* (Commissariat Régional au Développement Agricole de Siliana, the Department of Agriculture and Forestry). The selected zones display similar climatic conditions and agro-ecological cropping patterns to obtain relatively homogenous samples of households. An individual questionnaire was employed to collect the socio-economic data from a sample of 250 households located in the study area (Figure 1). The survey was first pre-tested, modified and validated with expert and technicians from the aforementioned forest organisms. Data availability include information on the main actors involved in APS collection, sources of households’ income, contribution of this activity (APS extraction) to interviewed households’ livelihoods, food security, livestock production and management and the socio-economic characteristics of all household members.

![Figure 1. Map of the Siliana governorate, showing the study area and data collection sites.](image)

Collecting APS directly contributes to the livelihoods status of household living in the region of study. Populations living within forest areas collect also fuelwood and medicinal plants. Collecting APS constitutes an important component of the rural households’ economy. Household income is calculated by summing the income of all people in a particular household. It includes three main sources: The first source encompasses all off-farm activities, all self-employment activities (craft activities, own business), permanent job outside the farm (salary), capital gains and transfers. The second one comes from forests and the most important activity in the Kesra delegation was found to be the APS exploitation. The last source is provided by agricultural activities and includes incomes from sales of crops and livestock. The contribution of agricultural, non-agricultural and NWFP income to the total household income is shown in Figure 2. Results show that extra-agricultural activities are the main source, contributing on average 60% to total household income. Forest products are the second source of income (25%) for household members to support their daily lives. These values are relatively close to findings by the authors in [26,49], who found that NWFPs income contributes to 30% and 18–29% of the household income in Nigeria and in Ethiopia–Sudan, respectively. Other studies [50–52] reported much higher contribution of NWFPs to a rural household’s livelihood in Northern Benin (39%), in south-eastern Burkina Faso (45%) and Myanmar (43%), respectively. Results indicate that NWFPs play a very important role in providing food and income for many households, just like in other rural regions [35]. Furthermore, respondents revealed that in the case of crop production shortfall due to bad growing conditions (e.g., dry season), money available for households...
mainly comes from the collection of NWFPs, which are used to ensure their livelihoods during that period. Finally, agriculture constitutes the third source of household income (15%) in the study area. The interviewees depend on livestock as a source of income to buy food and other household needs.

In addition, different sources of household income were compared using analysis of variance (ANOVA). The latter statistic was performed, and the means were computed based on the least significant difference procedure test. This analysis relies upon the hypothesis that there is a significant difference between households’ income means from different sources (Table 3).

Table 3. Multiple comparisons of mean household incomes from agriculture, off-farm and forest products.

| Comparison of Household Income Source | Mean Differences | Standard Error |
|--------------------------------------|------------------|----------------|
| **Agricultural income**              |                  |                |
| Off-farm income                      | – 244.386        | 93,652 ***     |
| Forest income                        | 83.536           | 36,047 **      |
| **Off-farm income**                  |                  |                |
| Agricultural income                  | 244.386          | 93,652 ***     |
| Forest income                        | 327.922          | 93,652 ***     |
| **Forest income**                    |                  |                |
| Agricultural income                  | – 83.536         | 36,047 **      |
| Off-farm income                      | – 327.922        | 93,652 ***     |

Source: Own elaboration based on survey data. Note: *** and ** represent statistical significance at the 1% and 5% level, respectively.

3. Results and Discussion

Empirical findings from the ANOVA tests suggest that the average incomes of households obtained from off-farm activities are significantly higher than those generated from agricultural activities and APS exploitation. Results also show that agricultural income is significantly higher than forest income, on average.

Results indicate that 20% of the interviewed households generate between 25% and 50% of their total income from selling NWFPs, whereas 30% declared that NWFPs sales account for 50% and 75% of their income (Figure 3). Meanwhile, only 12% of all household heads interviewed stated that more than 75% of their income comes from NWFPS-based business, implying that NWFPs constitute an important component of the economy of rural
households in the study area. Moreover, NWFPS activities could be an important source of cash income for vulnerable households to help assure a year-round food supply [3]. Such an income contribution may serve as a safety net during times of hardship and other emergencies, especially for those that do not possess farmland.

Figure 3. Contribution of NWFPs to household income. Source: Own elaboration based on survey data.

Table 4 presents the summary statistics of the parameters derived from the logistic regression. Most of the parameter estimates are statistically significant, showing the expected effects. Household participation in alternative generating activities varies according to the socio-economic attributes [53,54].

Table 4. Factors influencing a household’s collection of Aleppo pine products.

| Variable                                | Coefficient | Standard Error | Marginal Effects |
|-----------------------------------------|-------------|----------------|------------------|
| Constant                                | −3.280      | 0.817          |                  |
| Gender                                  | −0.968      | 0.474 **       | −0.230 **        |
| Attending extension days                | 1.732       | 0.849 **       | 0.348 ***        |
| Agricultural training program           | 1.208       | 0.600 **       | −0.273 **        |
| Household size                          | 0.212       | 0.083 ***      | 0.053 ***        |
| Farm size                               | −0.013      | 0.012          | −0.003           |
| Agricultural income share in total income | 1.140     | 0.764          | 0.283            |
| Distance to market                       | 0.288       | 0.053 ***      | 0.072 ***        |
| Livestock activity                      | −1.084      | 0.376 ***      | −0.262 ***       |
| \( \chi^2 \) test                      | 103.54 ***  |                |                  |
| Log-likelihood function                 | −121.511    |                |                  |
| Pseudo-R\(^2\) test                     | 0.299       |                |                  |
| Total observations N                    | 250         |                |                  |

Source: Own elaboration based on the survey data. Note: *** and ** represent statistical significance at the 1% and 5% level, respectively.

Results show that collection of APS by Kesra habitants are influenced by gender, attending extension days and agricultural training programs, distance to market, household size and livestock activity. Gender has a significant effect on the decision to collect APS or not, suggesting that rural women play an important role in harvesting forest products. Besides taking care of their children, women may focus their efforts on post-harvesting
activities, mainly the shelling of cones and seed extraction [13]. Another interesting finding is that extension services could play an important role in providing local populations with effective forest practices. In this context, attending more extension days would increase the likelihood that local households will collect APS. On the other hand, people who participate in training programs tend to improve their technical and economic performance to better valorize the NWFPs. Households with animal husbandry are expected to reduce the probability to collect APS. This finding confirms that assets owned by households are negatively associated with engaging in NWFPs business activities, which is consistent with the notion that poor households tend to be reliant more on natural resources than the rich [55]. Consistent with previous research studies [26,55], as expected distance to the nearest market has a positive impact on collecting APS, suggesting that respondents who live closer to the market are more likely to collect and depend more on NTFPs compared to those that do not. Hence, access to markets is an important determinant of households’ participation in NWFPs. Accordingly, selling APS locally through intermediaries is more suitable with the rural communities’ philosophy, since it helps reduce transport costs and other transactions costs, such as gathering information on the regional market. This could be part of their economic viability strategy, which is supported by the food security findings provided in the next section. Consistently, creating local markets close to vulnerable forest zones, which are often characterized by a lack of appropriate infrastructure, would support households to sell forest products [56]. Finally, the household size has a positive and significant impact. In line with the findings in [26,57], large families are likely to collect APS to meet their food requirements. A large family size may indicate the presence of descendants (children) that could enhance the economic viability of rural populations.

Complementary analysis of the food security indicators is provided throughout this section. FCS scores reveal that about 79% of sample households have acceptable food security with scores strictly above 42, while 19% of the interviewed sample have a score between 28.5 and 42, which corresponds to moderate food security. The remainder (only 2%) are perceived as a low food secure population. In addition, the HDDS scores indicate that half of households have a moderately diversified diet (4 < HDDS ≤ 8) compared to about 44% of households showing a high food diversity (HDDS > 8). Indeed, household diets consist of cereals, vegetables, sauces or condiments and fat products. Legumes were not a common diet among households. Animal proteins are consumed by 62% of targeted households and fruits are also consumed in small quantities among 52% of the sample. Milk and dairy products are used by only 46% of respondents. Hence, households have a very-low-diversified diet, mainly based on basic foods (cereals, vegetables, and sugar). Furthermore, 79% of households declared that they consumed three meals a day while 10.5% of the interviewed families are content with two meals and more than three meals a day.

Findings indicate that households with the lowest food consumption mostly work in the construction sites and the harvesting of forest products. Those with poor food consumption make greater use of food adaptation strategies. To meet their food needs, households pursue coping strategies according to their vulnerability (Table 5). The higher the CSI score, the more households use these coping strategies. Hence, households are classified according to five groups of coping strategies. The first group did not use coping strategies (18%), the second type of households tries to use mild strategies (40%), the third one used moderate coping strategies (28%), including collecting forest product (APS) (6%), the fourth class adopts severe strategies (12%) and the last household group resorts to following emergency strategies (2%), which are mainly households with severe food insecurity.
According to the HFIAS index, more than half of households in the study area (54%) live in food security, 17% are mildly food insecure, 23% of the population live in a moderate food insecurity situation and 5% of households are characterized as severe food insecure. These values are relatively close to those found by [3], suggesting that 40% of the interviewed households in Nigeria are food insecure. Finally, the HHS index shows that 73% of households are households categorized as “little to no hunger in the household”, 23% as “moderate hunger in the household” and 4% as “severe hunger in the household”.

Income stability and reliable sources of revenue are prerequisites for food security. High and stable incomes are a necessary (but not sufficient) condition for accessing rich and varied foods [58]. Empirical findings provide supporting evidence of the structural link between food security and income level. Results indicate that the household food situation improves with an increasing income level (Table 6). Food-secure households display higher average total income (10,797 TND ≈ 3779 US Dollar) than those characterized as mild (5587 TND ≈ 1955 US Dollar) and moderate (4507 TND ≈ 1577 US Dollar) food insecurity, respectively. Findings suggest that the contribution of extra-agricultural income to food security is more important than the forest income.

### Table 5. Households’ distribution (%) according to adopted coping strategies.

| Severity Category | Adaptive Coping Strategies | %  |
|-------------------|----------------------------|----|
| Mild (39.5%)      | To reduce the overall amount of food in each meal | 40% |
|                   | To reduce the number of meals                  | 29% |
|                   | To rely on less preferred and cheaper foods    | 46% |
|                   | To be restricted to non-preferential foods     | 44% |
| Moderate (27.63%) | To borrow food                               | 42% |
|                   | To buy food on credit                         | 62.5% |
|                   | To Harvest Forest products (APS)              | 6%  |
|                   | To practice early harvest                     | 0%  |
| Severe (12.38%)   | To send household members to eat elsewhere    | 6%  |
|                   | To send household members begging             | 4%  |
|                   | To reduce meals for adults                    | 37.5% |
|                   | To have illegal activities                   | 2%  |
| Very severe (2%)  | To sell the house or plot or breeding animals | 4%  |
|                   | To remove children from school                | 0%  |
|                   | To send one of the family members looking for work elsewhere | 2% |

Source: Own elaboration based on survey data.

### Table 6. Income distribution by food security category.

| Income Source               | Food Security | Mild Food Insecurity | Moderate Food Insecurity |
|-----------------------------|---------------|----------------------|--------------------------|
|                             | Mean  | Max    | Min    | Mean | Max    | Min    | Mean  | Max    | Min    |
| Total income (TND)          | 10,797| 43,820 | 2200   | 5587 | 12,845 | 1820   | 4507  | 10,420 | 2400   |
| Agricultural income (TND)   | 3371 | 43,820 | 950    | 485  | 2520   | 260    | 295   | 1180   | 0      |
| Off-farm income (TND)       | 6675 | 24,000 | 800    | 2894 | 9960   | 2160   | 2602  | 7000   | 808    |
| Forest income (TND)         | 750  | 7000   | 1400   | 2208 | 5040   | 1440   | 1610  | 2240   | 1120   |
| Households collecting Aleppo pine | 39%  | 43%    | 18%    |

Source: Own elaboration based on survey data.
Food security results ascertain that NWFPs are important for rural households in the Kesra region, which contribute directly by providing food for consumption (e.g., milled APS, sweet pudding “Assida-Zgougou”) and indirectly by generating income, which could be used to meet their basic needs and to ensure food security [3,59].

On the other hand, households revealed that they are still facing challenging difficulties to collect and valorize APS, which could affect their livelihood strategies. Problems are mainly associated with pests, forest fires and deforestation, pursuit of forest agents, accidents during the collection of APS due to high heights of Aleppo pine trees, injuries caused by animals (e.g., wild pigs and wolves) and thorns and accelerated deterioration of natural resources [45]. Furthermore, all households are suffering from drought and rainfall deficits, which have caused a shortfall of Aleppo pine yield, leading to lower benefits.

4. Conclusions

Despite the relevant contribution of Non-Wood Forest Products (NWFPs) to alleviate poverty, to improve household livelihood and to assure food security for the local population in Tunisia, empirical applications that examine the determinant factors of collecting and valorizing NWFPs are still very scarce in this country. In this context, this study attempts to investigate the socio-economic relevance of Aleppo pine in livelihood strategies of rural communities through determining its contribution to income generation and food security.

Consistent with previous research studies, the results support evidence that there is a significant difference between the alternative sources of revenues. The findings of this study indicate that NWFPs support local households’ livelihoods and provides a safety net throughout the year. Consistently, APS collection contributes 25%, on average, to the total household incomes in the study area. Compatible with previous research [26,50,57], the economic significance of APS differs among participating households with regard to their annual income, indicating that the poorest households are the most dependent on NWFPs, with a maximum contribution of 100%. The lower the total household income is, the higher the share of NWFPs income (40%). Therefore, the higher the relative dependency on NWFPs products would be to meet their basic consumption needs. APS could be an important source of cash income to help those forest communities that only have a few opportunities for income generation and less coping strategies to deal with food security.

Household size, attending extension days and agricultural training program, distance to nearest market, positively and significantly increase the likelihood of collecting APS, while gender and livestock activity had a negative and significant effect on the decision of APS collection in the study area. Results also reveal that access to markets could increase the likelihood of households to participate in NWFPs. Accordingly, policy interventions would be oriented to ease access to marketing points through creating local markets close to forest communities and to diversify the market channels of Aleppo pine seeds. In this regard, such a strategy may help APS producers to face the higher transactions costs (information, role of intermediaries and retailers in the marketing chain and logistics) and to endure times of economic distress. Forests policies that aim to improve the working conditions for collecting APS and their commercialization through promoting a private-label of the local products, at an increased price premium, could be viewed as a rural development strategy for sustainable household food security and to enhance the livelihood of forest populations. Furthermore, providing collectors with information and training courses on how to adequately collect APS could enhance the skills and adaptive capacity of local populations, which, in turn, could increase the contribution of NWFPs to a household’s income.

Collecting NWFPs is one of the coping strategies used to enhance economic access to food and to improve the food security of rural households. They provide a diversity of food that might supply the necessary nutrients, especially when other food sources are not available. However, households revealed that they are still facing challenging difficulties to collect and valorize APS, which could affect their livelihood strategies. At the political level, more flexible laws governing forest heritage, organized forest access for local people and
supporting NWFP commercialization, e.g., by addressing the possible barriers to entry and reducing the fees for state-owned forest harvesting rights, are needed to boost sustainable forest development and management, to achieve the desired sustainable development goals. In this way, further research could be carried out to take into consideration the effect of policy interventions that aim at improving the livelihood strategies of rural communities and promoting local economic development. Finally, including additional information on APS production in different agro-ecological zones in Tunisia would be useful to understand the contribution of NWFPs to rural livelihoods and food safety and to increase the reliability of the results.

**Author Contributions:** Conceptualization, I.T., E.O., B.G.; methodology, I.T., E.O., B.G.; validation, I.T., E.O., B.G.; formal analysis, I.T., E.O., B.G.; investigation, I.T., E.O.; data curation, I.T.; writing—original draft preparation, I.T., E.O., B.G.; writing—review and editing, I.T., E.O., B.G.; project administration, I.T.; funding acquisition, I.T. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the project “Eating the wild: Improving the value-chain of Mediterranean Wild Food Products (WFP)”—Wild Food (Reference Number: 2019-SECTION2-29) and the Laboratory of Management and Valorization of Forest Resources—Ministry of Higher Education and Scientific Research, Tunisia, as well as the Tunisian Ministry of Agriculture.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available upon request from the corresponding author.

**Acknowledgments:** The authors gratefully acknowledge the technical and financial support provided by the project “Eating the wild: Improving the value-chain of Mediterranean Wild Food Products (WFP)”—Wild Food (Reference Number: 2019-SECTION2-29) and the Laboratory of Management and Valorization of Forest Resources for providing field and technical help for research conduction. The authors also thank two anonymous referees for their valuable comments and suggestions, which significantly improved this article.

**Conflicts of Interest:** The authors declare no conflict of interest.

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