141. Jahrgang (2024), Heft 1, S. 27–52

Austrian Journal of Forest Science
Centralblatt für das gesamte Forstwesen

Productivity and economic assessment of *Vaccinium arctostaphylos*

Produktivität und ökonomische Bewertung von *Vaccinium arctostaphylos*

Soleiman Mohammadi Limaei[1,2*], Neda Amiri[1]

Keywords: Caucasian whortleberry, Wild berries, Economic evaluation, Net present value, Non-timber forest products (NTFPs), Hyrcanian forests

Schlüsselbegriffe: Kaukasische Heidelbeere, Wildbeeren, Ökonomische Bewertung, Kapitalwert, Nichtholzprodukte, Hyrkanische Wälder

Abstract

Vaccinium arctostaphylos (Caucasian whortleberry) is one of the most important wild berries with remarkable properties that grows in Iran and the Caucasus region. The objective of this research is to determine the productivity and economic value of *V. arctostaphylos* fruits in Hyrcanian forests of Iran. We used a survey to determine the economic value and we conducted a forest inventory to estimate the fruit production. The inventory results revealed that the average number of bushes and fruit production were 3900 per ha and 137 kg per ha, respectively. The survey results showed that the total market margin of fruit production is 81.29%, which indicates that the intermediaries earn more profit than the local harvester. The profit gained from the forest due to harvesting of *V. arctostaphylos* fruit was 161 million IRR/ha or about 1238 USD per ha. The harvesting of this fruit has created job for 500 local people in the study area during the harvesting period. The net present value (NPV) of fruit production and timber harvesting was calculated for comparison. Results indicated that the NPV of fruit harvesting is 1.79 times higher than the NPV of timber harvesting.

[1] Department of Forestry, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Guilan, Iran
[2] Department of Economics, Geography, Law and Tourism, Mid Sweden University, Sundsvall, Sweden
*Corresponding author: Soleiman Mohammadi Limaei, soleiman.limaei@miun.se

Regarding to the harvesting moratorium in Iranian Hyrcanian forests, an optimal and sustainable harvest of *V. arctostaphylos* fruit can be an important source of income for forest dwellers and local people.

Zusammenfassung

Vaccinium arctostaphylos, die Kaukasische Heidelbeere, ist eine der wichtigsten Wildbeeren mit außergewöhnlichen Eigenschaften, die im Iran und der Kaukasus Region wachsen. Ziel dieser Arbeit ist es, die Produktivität und den ökonomischen Wert von *V. arctostaphylos* Früchte in den Hyrkanischen Wäldern im Iran zu bestimmen. Wir verwendeten eine Umfrage, um den ökonomischen Wert und eine Waldinventur um die Fruchtproduktion zu untersuchen. Die Ergebnisse der Inventur zeigten, dass die durchschnittliche Anzahl Büsche 3900 pro ha und die Fruchtproduktion 137 kg pro ha im Untersuchungsgebiet ist. Die Gesamtmarktmarge macht 81,29 % aus, was vermuten lässt, dass Zwischenhändler mehr Profit als die lokalen Ernter machen. Der Profit, der durch das Ernten von *V. arctostaphylos* Früchten entsteht, beträgt etwa 161 Million IRR/ha oder 1238 USD pro Hektar. Die Fruchternte schuf 500 Arbeitsplätze in der Untersuchungsregion während der Erntezeit. Der Kapitalwert (NPV) der Fruchternte und der Holzernte wurde berechnet und es zeigte sich, dass der NPV der Fruchternte 1,79-mal höher als jener der Holzernte war. Hinsichtlich des Holzernte-Moratoriums in den Hyrkanischen Wäldern wäre eine nachhaltige Nutzung der *V. arctostaphylos* Früchte eine wichtige Einkommensquelle für waldnahe Siedlungen und die örtliche Bevölkerung.

1 Introduction

Forest are complex ecosystems with diverse timber and non-timber production. Forest production contribute to economic results via profits and lead to the formation and continuous flow of products and services that directly and indirectly contribute to economic, environmental and social issues. Managing of forest as a source of raw material is became more important recent years due to climate changes, greenhouse gas emission, supporting and enhancing biodiversity and demand increasing for non-timber forest products (NTFPs). Therefore, economically, environmentally and socially beneficial goals should be considered in management of timber and NTFPs. The exploitation of NTFPs has long been of interest to humans and has found a close relationship to human life. The importance and value of NTFPs in providing of food, medicine and industrial materials etc. has caused to produce large quantities of NTFPs from forests and supplied to the local, national and international markets. Hence, it is important to determine the productivity and economics values of NTFPs in order to consider its important role in forest policy and management decisions.

According to FAO (2000), NTFPs play an important role in the daily life and welfare of millions of people worldwide. NTFPs include products from forests, from other wooded land and from trees outside the forest. "Rural and poor people in particular depend on these products as sources of food, fodder, medicines, gums, resins and construction materials. Traded products contribute to the fulfilment of daily needs and provide employment as well as income, particularly for rural people and especially women. Internationally traded products, such as bamboo, rattan, cork, gums, aromatic oils and medicinal plants, contribute to economic development" (FAO, 2000).

The role and contribution of NTFPs has been discussed in many studies and the aim is not to review all of them, but here we mention some: FAO, 2000; Stoian, 2005; Mavsar *et al.*, 2008; Toksoy *et al.*, 2010; Stryamets, 2012; Malleson *et al.*, 2014; Shackleton and Pandey, 2014; Wiersum *et al.*, 2018; Prokofieva *et al.*, 2019; Lovrić *et al.*, 2020; Weiss *et al.,* 2020; Zhang *et al.*, 2022.

Vaccinium arctostaphylos (Caucasian whortleberry) as one of the most important NTFPs with remarkable properties founds in Iran, Turkey, Armenia, Azerbaijan, Georgia, Russia and Bulgaria (Mohajeri Naraghi *et al.*, 2011). The fruits contain health beneficial nutrients and bioactive phytochemicals, which widely used in Iranian traditional medicine as an antidiabetic and antihypertensive agent (Sedaghathoor, 2007 and Ravan *et al.*, 2017). The *V. arctostaphylos* is the only member of *Vaccinium* genus in Iran and it is sold in herbal drug shops to maintain blood glucose level (Amin, 2005).

There have been a few studies about *V. arctostaphylos* such as Ayaz *et al.*, 2005; Latti *et al.*, 2009; Monavar Feshani *et al.*, 2011; Mohajeri Naraghi *et al.*, 2011; Soltani *et al.*, 2014; Ozgen *et al.*, 2014; Hassanzadeh, 2015; Ozturk *et al.*, 2016; Ozkan *et al.*, 2019. Worldwide interest in *Vaccinium* sp. fruits exist because of their high anthocyanin content, which has beneficial effects on human health (Nestby *et al.*, 2011 and Lagha *et al.*, 2015).

V. arctostaphylos grows in Hyrcanian or Caspian forests of Iran. Various studies showed that Hyrcanian forests have been degraded. "Rapid urbanization and industrialization, intensive grazing, over-utilization of forests for firewood production and farming in wooded areas are amongst the main causes of deforestation in Iranian Hyrcanian forests" (Mohammadi Limaei, 2006). Logging moratorium was proposed by Iranian Department of Environment in the early 2000s and due to socioeconomics and environmental issues in Hyrcanian forests of Iran, the logging moratorium is implemented in these forests in 2017 (Sotoudeh Foumani *et al.*, 2019). According to this plan, any kind of timber harvesting is banned from these forests over a period of 10 years. However, there is not any ban to collect the NTFPs such as wild berry in these forests. Hence, productivity and economic evaluation of by-products of Hyrcanian forests such as *V. arctostaphylos* could be important for policy makers and managers whereas the NTFPs can play as an economic source of alternative timber harvesting and reduce the forests degradation.

Despite previous studies about *V. arctostaphylos* in Iran (Hassanzadeh, 2015; Mohajeri Naraghi *et al.*, 2011 and Monavar Feshani *et al.*, 2011), there is still lack of insight about the production and socioeconomical values of *V. arctostaphylos*. Hence, the aim of this research is to determine the annual production per hectare, harvesting costs and income generated by *V. arctostaphylos* fruit. In addition, some products could have a small market size, but due to a high market price could generate a very high value added. Therefore, the value added of *V. arctostaphylos* fruit will be determined. Furthermore, the net present value (NPV) of fruit production and timber harvesting will be estimated to compare the economics values of these products.

2 Materials and methods

2.1 Materials

2.1.1 Distribution of V. arctostaphylos

V. arctostaphylos grows only in the high mountains at the northern part of Iran and in three provinces namely Guilan, Mazandaran and Ardabil (Sedaghathoor, 2011). Climatological studies show that most of these areas are cloudy and are located at altitudes of 1100 m to 1900 m (Sedaghathoor, 2011). The monthly average of coldest and warmest temperatures are 5 °C and 10 °C, respectively. The soil at this area has acidity properties (pH range from 4.2 to 5.5) and has with more than 5% high organic material content (Sedaghathoor and Saeidi-Mehrvarz, 2006).

2.1.2 Study area

In order to conduct this research, the booklets of forest management plans were investigated to identify the distribution of *V. arctostaphylos* in Guilan province, Iran. In addition, we collected information from the experts of Guilan Department of Natural Resources and Watershed Management for the distribution of this shrub in Guilan province (Table 1).

Table 1: Distribution of V. arctostaphylos in Guilan province, Iran.

Tabelle 1: Verteilung von *V. arctostaphylos* in der Provinz Guilan, Iran.

Forest management plan	Area	District
Nav	Asalem	2, 3, 14
Lumir	Rezvanshahr	5, 6, 7
Astarachay	Astara	4
Lavandavil	Astara	1, 2, 3, 5
Shanderman	Masal	5
Reshtehrood	Roodbar	3, 4
Shenrood	Siyahkal	Toteki

The *V. arctostaphylos* bushes predominantly grow in beech-dominated forests (Fagetum communities) and this species is resistance to the low temperature. The maximum height of this shrub could be 2.5 m. This species grows mostly in the shadow of beech and oak trees (Sedaghathoor, 2011).

Two areas of Nav-Asalem and Lumir-Rezvanshahr in Guilan province were selected for data collection based on the expert opinions from Guilan Department of Natural Resources and Watershed Management (Fig. 1).

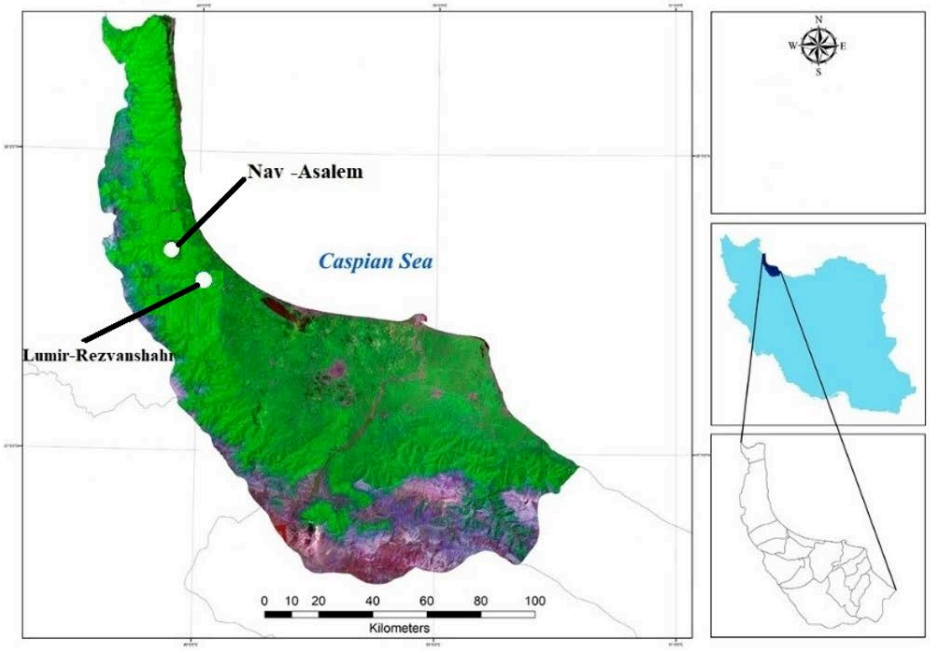

Figure 1: Study area.

Abbildung 1: Untersuchungsregion.

2.1.3 Nav-Asalem region

District # 3

Stands structures are uneven-aged silvicultural systems in district # 3. Total forest area in this district is 3770 ha and total harvestable area is 2119.5 ha. Planned harvesting was 26850 m³ during 10 years period. This district includes 74 compartments. The tree species are beech (*Fagus orientalis*), hornbeam (*Carpinus betulus*), Cappadocian maple (*Acer cappadocicum*), Persian maple (*Acer insigne*), wych elm (*Ulmus glabra*), oak (*Quercus castaneifolia*), alder (*Alnus subcordata*), wild cherry (*Cerasus avium*), wild service tree (*Sorbus torminalis*), Caucasian wingnut (*Pterocarya fraxinifolia*) etc. Shrub species are *V. Arctostaphylos*, *Crataegus monogyna*, *Ilex spinigera*, *Mespilus germanica*, *Prunus divaricate* (Guilan Department of Natural Resources and Watershed Management, 2010a).

- Compartment # 340: This compartment has an area of 62 ha and total harvestable area is 57 ha. Average altitude is 1600 m. Forest type is *Fagus orientalis- Carpinus betulus- Acer laetum*. Tree species are beech, hornbeam, Cappadocian maple,

Persian maple, wych elm and wild service tree. The stands structures are uneven-aged. Volume per ha is 475 m³ and number of tree per ha is 217.

- Compartment # 350: This compartment has an area of 100 ha and total harvestable area is 70 ha. Average altitude is 1650 m. Forest type is *Fagus orientalis*. Tree species are the same as mentioned in compartment# 340, but 89.83% of tree species are beech. The stands structures are uneven-aged. Volume per ha is 372 m³ and number of tree per ha is 193.5 (Guilan Department of Natural Resources and Watershed Management, 2010a) (Table 2).

District # 2

Stands structures are uneven-aged silvicultural systems. Total forest area in this district is 3559 ha and total harvestable area is 2140 ha. Planned harvesting was 24455 m³ during 10 years period. This district include 82 compartments. Tree and shrub species in this district are similar to those mentioned in district#3 (Guilan Department of Natural Resources and Watershed Management, 2010b).

- Compartment # 234: This compartment has an area of 44 ha and total harvestable area is 33 ha. Average altitude is 1220 m. Forest type is *Fagus orientalis- Carpinus betulus- Acer insigne*. The dominant tree species is beech with an uneven-aged stand structure. Other species are hornbeam, Persian maple, oak, Caucasian alder and wild cherry. Volume per ha is 306.2 m³ and number of tree per ha is 364.

- Compartment # 235: This compartment has an area of 37 ha and total harvestable area is 30 ha. Average altitude is 1400 m. Forest type is *Fagus orientalis- Carpinus betulus- Acer insigne* with an uneven-aged stand structure. The tree species are the same as mentioned in compartment# 234. Volume per ha is 223.24 m³ and number of tree per ha is 336.43. (Guilan Department of Natural Resources and Watershed Management, 2010b) (Table 2).

2.1.4 Lumir-Rezvanshahr region

District # 5

Stands structures are uneven-aged silvicultural systems, but shelter wood system was the main silvicultural system in the past at this district. Total forest area is 2415 ha and the total harvestable area is 1831.8 ha. Planned harvesting was about 40237 m³ during 10 years period. This district includes 32 compartments. The altitude ranges from 150-1300 m. Due to altitudinal changes, there are various forests types in this district such as mixed hardwood species, mixed beech stands, *Parrotia persica- Carpinus betulus*, *Carpinus betulus- Acer laetum etc*. Hence, there is a higher tree diversity in this district such as beech, hornbeam, maple, wild service tree, alder, box trees (*Buxus hyrcanus*), Persian ironwood (*Parrotia persica*), lime trees (*Tilia begonifolia*), ash

(*Fraxinus excelsior*), date-plum (*Diospyros lotus*) *etc*. (Guilan Department of Natural Resources and Watershed Management, 2010c).

- Compartments # 511: This compartment has an area of 75 ha and the total harvestable area is 52.68 ha. Average altitude is 1000 m. Forest type is mixed hardwood species with an uneven-aged stand structure and dominant species is beech. Other species are hornbeam, Persian maple, Persian ironwood, lime trees, ash, date-plum and wych elm. Volume per ha is 213.58 m³ and number of tree per ha is 80.42.

- Compartments # 514: This compartment has an area of 103 ha and total harvestable area is 84.39 ha. Average altitude is 650 m. Forest type is mixed hardwood species with an uneven-aged stand structure. Dominant species is hornbeam. Other species are Persian maple, lime trees, beech, ash, wild cherry, alder and wych elm. Volume per ha is 202.5 m³ and number of tree per ha is 113.89 (Guilan Department of Natural Resources and Watershed Management, 2010c) (Table 2).

Table 2: Summary of stand structure in the study area.

Tabelle 2: Zusammenfassung der Bestandsstruktur in der Untersuchungsregion.

Region	Nav-Asalem				Lumir-Rezvanshahr	
District	3		2		5	
Compartment	340	350	234	235	511	514
Area (ha)	62	100	44	37	75	103
Average altitude (m)	1600	1650	1220	1400	1000	650
Main tree species	Beech, hornbeam, Cappadocian maple, Persian maple, wych elm, wild service tree	Beech, hornbeam, Cappadocian maple, Persian maple, wych elm, wild service tree	Beech	Beech	Beech	Hornbeam
Volume per ha (m^3)	475	372	306.2	223.24	213.58	202.5
Number trees per ha	217.06	193.5	364	336.43	80.42	113.89
Number of plot	4	2	3	1	3	4
Management system	Uneven-aged	Uneven-aged	Uneven-aged	Uneven-aged	Uneven-aged	Uneven-aged

2.2 Methods

2.2.1 Field inventory and measurements

In Nav-Asalem region, 10 plots were selected from compartments # 234 and 235 in district # 2, as well as from compartments # 340 and 350 in districts # 3. In addition, 7 plots were selected from compartments # 511 and 514 in district # 5 from Lumir-Rezvanshahr region (Figure 2 and Table 2).

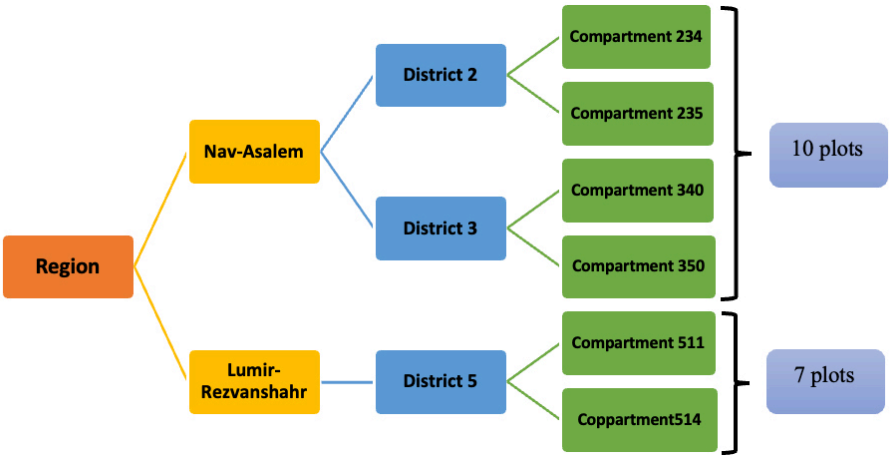

Figure 2: Overview of field inventory points.

Abbildung 2: Übersicht der Inventurpunkte.

The plots were selected according to a systematic random network of 100 x 100 m. The shape of plots were a square with an area of 100 m². Number of bushes per ha and fruit production per ha were determined based on the forest inventory.

Furthermore, in each sample plot, three bushes were measured along the plot diagonal line relative to slope (from the upper right to the lower left corner) to determine the amount of fruit production. Three bushes were selected in such a manner as A was the closest plant to the upper right corner, C was the closest plant to the opposite corner, and E was the closest plant to the plot center. Fruit of each bushes was collected and its weight was measured. Then, total and mean fruit in three bushes were calculated. The fruit per plot was estimated from the three bushes and consequently the fruit per hectare was estimated based on the determined fruit per plot. Dried fruit weight in each crown diameter classes was determined (Hassanzadeh, 2015 and Packalen *et al.,* 2023).

Questionaires

A descriptive questionnaire was used to determine the amount of fruit harvesting, collecting and harvesting cost, price of fresh and dried fruit, demand and the use of the fruit. Before implementing the survey, 15 pre-questionnaires were completed by respondents. The information obtained from the pre-questionnaires was used to determine the reliability and validity of the questionnaires. The reliability of the questionnaires was calculated using Cronbach's alpha (Cochran, 1951). The obtained number of 0.839 indicates the acceptable reliability level of the questionnaire. The experts' opinions were used to determine the validity of the pre-questionnaires.

The final questionnaires were 110 in this study. The questionnaires were distributed among the forest dwellers, wholesalers in the region and the retailers of herbal medicines in the provinces of Guilan, Ardabil, East Azerbaijan and Tehran in 2019.

2.2.2 Economics analysis

Marketing channels and market margin models

According to Palmatier *et al.* (2016), marketing channel is "a set of interdependent organizations involved in the process of making a product or service available for use or consumption". The marketing channel of *V. arctostaphylos* fruits was investigated using a questionnaire.

The marketing route of *V. arctostaphylos* fruits has a structure starting from local harvester and ending to the final consumer. Wholesaler and retailer act as the intermediaries in this supply chain (Fig. 3).

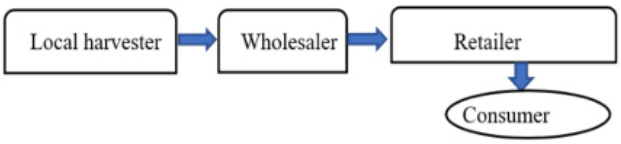

Figure 3: Marketing channels of V. arctostaphylos fruits.

Abbildung 3: Vermarktungswege von *V. arctostaphylos* Früchten.

Marketing margin is a part of commodity price that producer cannot gain it. In order to supply a product to the market, there are usually some stages such as processing,

packaging, transportation and warehousing. Hence, the value of a product increases through these stages. Thus, there is a difference between the producer price and consumer price. Increasing the size of marketing margin causes dissatisfaction of producers and consumers. Therefore, by examining the market margin, the factors affecting it can be modified and dissatisfactions can be reduced. Eq. 1 was used to calculate the market margin:

$$M_m = P_r - P_f \quad \text{(Eq. 1)}$$

where, M_m is market margin, P_r is consumer price and P_f is producer price.

The ratio of market margin to the percentage of produced price is called the market margin coefficient (Eq. 2):

$$r = \frac{(P_r - P_f)}{\mathrm{P_r}} \times 100 \quad \text{(Eq. 2)}$$

where, *r* is the market margin coefficient. This coefficient is related to kind of services to supply a commodity to the market, amount of deterioration, speed of selling and competition in market (Koopahi, 2006).

Value added

The value added of *V. arctostaphylos* fruits are calculated using Eq. 3:

$$VA_p = F_p - F_v - nLC_p \quad \text{(Eq. 3)}$$

where, VA_p is the average value added of fruit (Iranian Rials "IRR"/kg), F_p is the value of processed fruit in retailer market (IRR/kg), F_v is the value of raw fruit on site (IRR/kg) and nLC_p is the non-labor costs of processed fruit (IRR/kg).

Net present value (NPV) of fruit harvesting

The NPV of fruit harvesting was determined based on the identical cash flows over time until infinity using Eq. 4:

$$NPV_f = \frac{R - C}{i} \quad \text{(Eq. 4)}$$

where, *R* is the income during the harvesting process of *V. arctostaphylos* fruits until supplying it to the retailer market, *C* is the harvesting and transportation costs and *i* is the real interest rate.

Economics value of timber harvesting

Economics value of timber harvesting calculated in order to compare with the economics value of fruit harvesting. The amount of timber harvesting, stumpage price and real rate of interest rate were used to determine the NPV of timber harvesting.

Timber harvesting

There are some socioeconomics problems (animal husbandry, illegal harvesting etc.) in the Hyrcanian forests of Iran. Hence, a logging moratorium is imposed in the Hyrcanian forests of Iran in 2017 to protect these forests (Sotoudeh Foumani *et al.*, 2019). Therefore, there is currently no legal or commercial harvesting in the study area. In order to estimate the NPV of timber harvesting, we assumed that the volume of harvested timber is equal to the amount of forest growth rate in the study area. We did not investigated forest growth in our research, as the main aim of our research was to determine the economics value and productivity of *Vaccinium* fruit.

Bonyad (2005) estimated annual increment in Shafarod uneven-aged forests in northern Iran. He determined volume (m^3/ha) and annual increment (m^3/ha/year) in three different altitude levels (low, middle and high). He used an increment borer to determine the growth of various species. The average annual forest increment was 3.37 m^3/ha/year considering different species such as beech, hornbeam etc. (Bonyad, 2005, Mohammadi Limaei *et al.*, 2011). This increment considered as the amount of annual harvesting at the current study. The harvesting of increment ensures sustainable management, as only the amount of wood that regrows is removed. One cubic meter of standing timber in Hyrcanian forests contains 60% round wood, 7% pulpwood, 23% firewood and 10% harvesting loss (Bonyad, 2005). The assumption is that all kind of woods are harvested and the harvested wood volume is over bark. In addition, we do not remove all parts of the stem from the forest. It means the pieces of the trunk remains in forest after harvesting (included in 10% harvesting loss).

Stumpage price

The stumpage price data was obtained from round wood, firewood and pulpwood prices at forest road side and subtracted from the variable harvesting costs during 1993-2019. Subsequently, it was adjusted using consumer price index (CPI) of Iran for the base year 2016 (Table 3) (Central Bank of Iran, 2021 and Statistical Centre of Iran, 2021). Regression analysis was used to determine the parameter values of the predicted stumpage price.

The following first order autoregressive model was used to predict the stumpage price:

$$P_{t+1} = \alpha + \beta P_t + \varepsilon \qquad \text{(Eq. 5)}$$

where, P_{t+1} is stumpage price at time t+1 and P_t is stumpage price at time *t*.

We assumed that ε is a series of normally distributed errors with mean zero and autocorrelation zero. In this case, the time series is a purely random or white noise. This kind of time series has constant mean, constant or homoscedastic variance, and is serially uncorrelated (Gujarati, 2014). We also assumed that $0< \beta<1$. Then, the mean of the price process was calculated based on the following relation (Mohammadi Limaei, 2006, and Mohammadi Limaei and Lohmander, 2007).

$$P_{eq} = \alpha/(1-\beta) \qquad \text{(Eq. 6)}$$

where, P_{eq} is the expected mean price process, α and β are estimated parameters from the regression analysis.

Table 3: Historical nominal and real stumpage price deflated by CPI for the base year 2016.

Tabelle 3: Historische nominelle und reale Holzpreise korrigiert mittels CPI für das Jahr 2016.

Year	CPI	Historical nominal stumpage price (10 thousands IRR/m^3)	Historical adjusted stumpage price (10 thousands IRR/m^3)
1993	1.814	19.119	1053.969129
1994	2.456	22.649	922.1905537
1995	3.665	64.127	1749.713506
1996	4.52	96.966	2145.265487
1997	5.298	118.459	2235.919215
1998	6.258	157.366	2514.637264
1999	7.516	202.32	2691.857371
2000	8.463	279.095	3297.82583
2001	9.427	276.24	2930.306566
2002	10.915	273.739	2507.915712
2003	12.624	331.517	2626.085234
2004	14.544	364.453	2505.864961
2005	16.048	378.769	2360.225573
2006	17.955	425.675	2370.788081
2007	21.265	467.28	2197.41359
2008	26.66	578.686	2170.615154
2009	29.527	569.564	1928.959935
2010	33.188	633.535	1908.927926
2011	40.321	980.1	2430.743285
2012	52.635	1177.51	2237.123587
2013	70.916	1479.73	2086.595409
2014	81.948	1892.53	2309.42793
2015	91.714	2318.11	2527.542142
2016	100	2657.466	2657.466
2017	109.6	2728.73	2489.717153
2018	138.4	3860	2789.017341
2019	190.9	6445	3376.113148

NPV of timber harvesting

The NPV of forest harvesting was calculated using the following function:

$$NPV_w = \frac{V \times P_{eq}}{i} \quad \text{(Eq. 7)}$$

where, V is the volume of timber harvesting (m³/ha), P_{eq} is stumpage price (IRR/m³) and i is real interest rate. The average real interest rate was 6.23%, which was estimated based on the differences between deposit interest rate and inflation rate (Central Bank of Iran, 2020).

2.3 Results

2.3.1 Properties of bushes and their fruit production

Based on the collected data from forest inventory, bush height, bush crown diameter and number of bushes per ha were estimated (Table 4).

Table 4: Statistical analysis of forest inventory.

Tabelle 4: Statistische Auswertung der Inventurdaten.

	Bush crown diameter (cm)	Bush height (cm)	Number of bushes per ha
Mean, min and max*	62.03 ± 22.79 (25-125)	116.14 ± 39.28 (40-215)	3900 ± 1800 (316-5377)

*The value after the mean shows standard deviation and the values in the parentheses show minimum and maximum.

Fresh fruit weight and dried fruit weight

A total of 223 bushes of *V. arctostaphylos* (128 bushes at Nav-Asalem and 95 bushes in Lumir – Rezvanshahr region) were selected in various crown diameter classes. More than 34,000 fruits from 223 bushes have been counted. The weight of 1000 fruits was measured from the selected bushes. The results were used to measure the fresh fruit weight and dried fruit weight. The ratio of fresh to dried fruit weight was determined with 6.08. The mean fresh fruit weight and the mean dried fruit weight were 39.83 and 6.88 grams per bush, respectively (Table 5).

Table 5: Fresh and dried fruit weight per bush and bush dimensions.

Tabelle 5: Frisch- und Trockengewicht der Früchte pro Busch und Buschdimensionen.

Variable	Fresh fruit weight (g)	Dried fruit weight (g)	Crown cross section (m^2)	Crown diameter (cm)	Height (cm)
Mean, min and max*	39.83 ± 11.00 (7.7-128.73)	6.88 ± 2.30 (0.89-14.87)	0.34 ± 0.20 (0.05-1.23)	62 ± 20 (25-125)	117 ± 36 (40-215)

*The value after the mean shows standard deviation and the values in the parentheses show minimum and maximum.

Relationship between fresh fruit weight and crown diameter

Various functional forms were tested to investigate the relationship between the fresh fruit weight and the crown diameter of *V. arctostaphylos*. The most significant relationship between these two aforementioned variables was a linear relation with $R^2 = 0.83$ (Fig. 4).

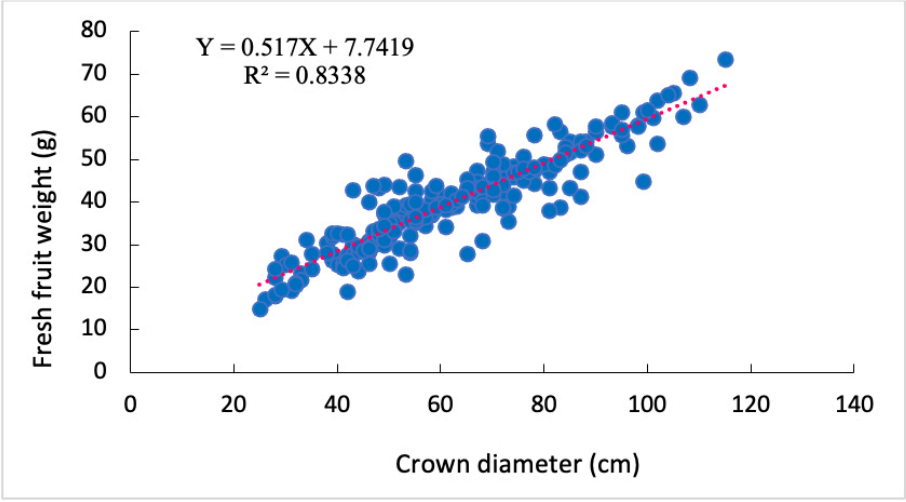

Figure 4: Relation between fresh fruit weight and crown diameter of V. arctostaphylos (N = 223).

Abbildung 4: Zusammenhang zwischen Fruchtfrischgewicht und Kronendurchmesser von *V. arctostaphylos* (N = 223).

The mean fruit production of three bushes was 32.65 grams and the amount of *V. arctostaphylos* fruits was 137 kg per ha (Table 6).

Table 6: Estimated fruit production per three bushes.

Tabelle 6: Geschätzte Fruchtproduktion pro drei Büsche und pro Hektar.

	Mean fruit production in three bushes (g)	Estimated fruit production per ha (kg)
Mean, min and max*	32.65 ± 8.43 (16-73)	137 ± 94 (3.16-537)

*The value after the mean shows standard deviation and the values in the parentheses show minimum and maximum.

Relationship between fruit fresh weight and bush height

The relationship between the fresh fruit weight and bush height is shown in Fig. 5. The most significant relationship between these two aforementioned variables among various fanctional form was a linear relation with $R^2 = 0.87$ (Fig. 5).

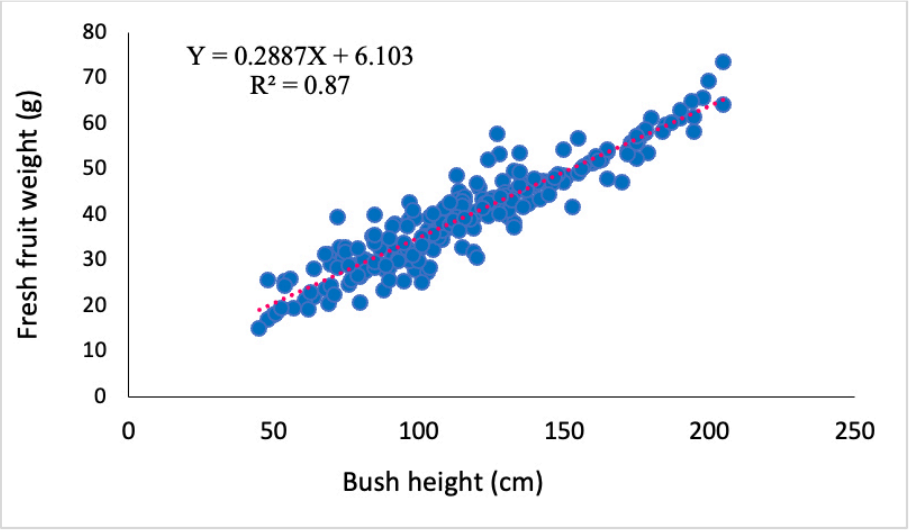

Figure 5: Relation between fresh fruit weight and bush height of V. arctostaphylos (N=223).

Abbildung 5: Zusammenhang zwischen Fruchtfrischgewicht und Buschhöhe von *V. arctostaphylos* (N=223).

Table 7 shows the data in various crown diameter classes. There is a relation between mean cross-sectional area of the crown and fruit production as the bushes with higher cross-sectional area produce more fruit (Table 7).

Table 7: Relations of crown diameter with bush properties of V. Arctostaphylos.

Tabelle 7: Zusammenhang zwischen Kronendurchmesser und Busch Eigenschaften von *V. arctostaphylos*.

Crown diameter classes (cm)	Mean crown diameter (m)	Mean cross-sectional area of the crown (m^2)	Mean bush height (cm)	Number of bushes per class (number)	Mean fresh fruit weight (g)	Mean dried fruit weight (g)	Ratio of fresh to dried fruit
25-40	0.33	0.12	70	27	24.45	4.32	5.66
41-55	0.48	0.19	96	70	33.10	6.04	5.48
56-70	0.63	0.32	118	56	41.08	7.08	5.80
71-85	0.78	0.48	140	40	47.01	7.99	5.88
86-100	0.92	0.67	164	21	54.75	8.98	6.10
101-120	1.06	0.88	194	9	63.78	9.88	6.46

2.3.2 Economic analysis

Marketing channels of V. arctostaphylos fruits

According to the results of survey from the forest dwellers in the study area (Nav-Asalem and Lumir-Rezvanshahr in Guilan province) and wholesalers in the region, local people in the forest areas collect about 500 kg of fruit daily. The harvesting period of fresh fruit is one month, usually in August. Each rural household collects about 30 kg fruit per year during the harvesting period.

Results of questionnaires also indicated that 500 local people in the regions were involved in the harvesting and collecting of the fresh fruit from forests. Local harvesters collected about 15 tons of fresh fruit in 2019. Collected fruits by local harvesters are sold to the wholesaler in the areas. After drying process, the wholesaler sells the dried fruits to the herbal retailers in various provinces. The retailers in the market sell the product to the final consumer after packaging.

Price of fruit in different market stages

The results of questionnaires showed that there are various prices for *V. arctostaphylos* fruit such as the price received by local harvester (producer price), the wholesaler price and the retailer price in the market (Table 8).

Table 8: Values of V. arctostaphylos fruit in the marketing process in 2019.

Tabelle 8: Wert von *V. arctostaphylos* Früchte im Vermarktungsprozess im Jahr 2019.

Price of fresh fruit on site (IRR/kg)	Price of dried fruit on site (IRR/kg)	Price of dried fruit in wholesaler market (IRR/kg)	Price of dried fruit in retailer market (IRR/kg)
200,000	1,216,000	1,800,000	6,500,000

Market margin

Wholesaler purchases fresh fruits from the local harvester and sell it to the retailer after drying it. The price of dried fruit is equal to 1,216,000 IRR/kg and the wholesaler price was 1,800,000 (Table 8). Then, the differences of these two prices are wholesaler market margin and it was 584,000 IRR/kg.

Retailer market margin was 4,700,000 IRR/kg that calculated based on the differences between price of dried fruit in retailer market (price paid by consumer) and price of dried fruit in wholesaler market (Table 8). Finally, the total market margin was calculated using Eq. (1) by subtraction of retailer price in the market and price received by local harvester or price of dried fruit on site and it was 5,284,000 IRR.

The market margin coefficient of dried fruits calculated using Eq. (2) and it was 81.29%, which indicates that intermediaries receive the most profit and local harvesters gain less from harvesting of this forest by-product.

Profit and expected value

Results of questionnaires indicated that the total income during the harvesting process of *V. arctostaphylos* fruits until supplying it to consumer in the market is equal to 16.25 billion IRR. If we subtract this value from the harvesting and transportation costs, which is 150,000,000 IRR, the profit will be 16.1 billion IRR. Hence, if we divide the profit to the harvest area of *V. arctostaphylos* fruits in the forest (100 ha in this study), the profit gained from the forest due to the production of this fruit is 161 million IRR per ha per year.

Value added

Results of survey indicated that the processing cost is equal to 60,000 IRR/kg. Then, the average value added of *V. arctostaphylos* fruit using Eq. (3) and data from Table 7 was calculated as it was 5,224,000 IRR/kg.

NPV of fruit harvesting

As it was mentioned before, the profit earned from the forest due to the production of *V. arctostaphylos* fruit is 161 million IRR/ha/year. By dividing the profit to the discount rate of 6.23% (real interest rate) using Eq. (4), the expected NPV of the forest resulting from the harvesting of *V. arctostaphylos* fruit is 2,584,269,663 IRR/ha or about 2.58 billion IRR/ha.

Stumpage price

Regression analysis was used to estimate the stumpage price using Eq. (5). The results showed that there is a significant relation between P_{t+1} and P_t at the significance level of 5% (Table 9).

Table 9: Parameters based on the stumpage price data for the first order autoregressive process during the period 1993-2019.

Tabelle 9: Parameter basierend auf Holzpreis des Erste-Ordnung autoregressiven Prozesses für die Periode 1993–2019.

	α	β
Parameter value	638.745	0.760
Standard deviation	276.095	0.118
t-statistics	2.313	6.465
P-value	0.0295	1.0975E-06

Using a one-sided test, the probability that the true value of $\beta > 1$ is less than 5%. The estimated β value is 0.760. Hence, we can reject the null hypothesis that $\beta = 1$, which would made that the process is a nonstationary time series. If $\alpha > 0$ and $0 < \beta < 1$, there estimates indicate that the process is stationary. Therefore, we can predict the stumpage price using regression analysis and consequently determine the stumpage mean price process.

The mean of stumpage price process or equilibrium price is calculated based on the first order autoregressive model using Eq. (6). Hence, if we use the estimates of α and β from Table 9, the mean of the stumpage price process is 26,669,970 IRR.

NPV of timber harvesting

The mean of stumpage price, amount of timber harvesting and real interest rate were plugged in Eq. (7). Then, the NPV of timber harvesting was determined and it was

1,442,661,000 IRR or about 1.44 billion IRR. The ratio of NPV between the fruit production and timber harvesting was calculated and this ratio was about 1.79.

3 Discussion

The aim of this research was to determine the production and economics values of *V. arctostaphylos* fruit. Results of inventory indicated that the number of bushes and fruit production were 3900 per ha and 137 kg per ha, respectively. Hassanzadeh (2015) showed that the productivity of *V. arctostaphylos* fruit in Hyrcanian forests of Iran was 119.57 kg per ha which is rather similar to the results of this study.

Local people in the study area harvest about 15 tons fruit per year and sell it to the wholesalers. The profit gained from harvesting of fruit during the marketing process is 16.1 billion IRR and its economic value added is 5,224,000 IRR/kg. High market price of dried fruit in the retailer market and low processing costs significantly increases the value added of this product. Shackleton and Pandey (2014) and Stoian (2005) showed that processes of drying, clearing and packaging can increase the value added of NTFPs, and eventually it will multiple the local income. In the study area of this research, drying and packaging of *V. arctostaphylos* fruit performed in a traditional way, which has an effective role in cost reduction.

The profit gained from forest due to production of *V. arctostaphylos* fruits was 161 million IRR/ha or about 1238 USD per ha (using the exchange rate in the free market as 1 USD was about 130,000 IRR in February 2019). Damnyag *et al.* (2011) estimated the gross value per ha of forest from the production of edible forest fruits in Ghana and it was $777. This result also show the high value of forest fruits.

Results indicated that the total market margin of *V. arctostaphylos* fruit is 81.29%. This indicates that intermediaries earn the most profit and local harvester gain less. The local harvester or producer price and the consumer price in the market for this product show a large difference. Hence, the local buyers (intermediaries) receive higher marketing margins and higher profits. Due to the current marketing conditions, inappropriate distribution channels and supply chain, the share of rural communities and forest dwellers for this wild berry fruit is low and the consumer buy it at higher price. Ajewole and Aiyeloj (2006) showed that the transportation cost is the main reason for the low marketing margin for local producers in Nigeria.

Results indicated that 500 person engaged in harvesting of *V. arctostaphylos* fruits for a period of 30 days annually. A few studies have addressed the rural household engagement in harvesting of NTFPs (Kalu and Rachael, 2006; Stoian, 2005). Stoian (2005) stated that processing of NTFPs in Bolivian Amazon creates direct employment for 2814 people, of which 74% are women and 26% are men. The job creation in Stoian

(2005) study was higher than our study area and the reason could be due to the low diversity of harvested species in our study area, which was limited to one crop with a limited harvesting time. Ravi *et al.* (2006) investigated the forest dependence of Jenukurubas, a primitive tribe, in South India. They estimated that annual employment in NFTPs sector was about 135 people and concluded that NTFPs play an important role in the life and economy of the tribal community.

Results of this study indicated that the NPV ratio of fruit production to wood production is about 1.79. Of course, one may not generalize this result to the whole Hyrcanian forests or similar forests in other region as *V. arctostaphylos* only grows in some limited forests area (see Table 1). However, this results show the economics importance of NTFPs in Hyrcanian forests of Iran. The 2017 logging ban in Iran's Hyrcanian forests represents a considerable forest policy change, which was proposed following the development of other major policies to improve natural resource management (Sotoudeh Foumani *et al.*, 2021). However, there is not any ban to collect the NTFPs such as wild berry in these forests. Prior the implementing of logging moratorium in Hyrcanian forests of Iran, *V. arctostaphylos* fruits could be produced and harvested parallel to the timber production but it was less attention to the production of this fruit due to the importance of wood production in regional economy. Currently there is not any commercial harvesting in these forests due to the logging moratorium and local people those have been engaged in forest harvesting activates lost their job due to such changes in forest policy. Hence, based on the results of this study we can conclude that regarding to the logging moratorium in Iranian Hyrcanian forests, an optimal and sustainable harvest of *V. arctostaphylos* fruits can be a suitable source of income for forest dwellers and local people in the forests margins. There is also a great potential to develop further the fruit production, harvesting and processing of this wild berry in the region.

4 Conclusions

This study shows that NTFPs can create substantial job and income opportunities for forest dwellers and intermediaries. However, intermediaries have a major role in determining prices due to the inadequacy of market mechanisms, by controlling the market and creating a kind of monopoly. They always gain a large share of the price paid by consumer and earn high profits. Therefore, increasing the relationship between producers or local harvesters and consumers will lower the marketing costs and increase the share of producers in the price paid by consumers, which will be possible through the formation of marketing groups. In fact, by creating marketing groups, some of the profits that were gained by intermediaries will be shifted to the producers and the producer surplus will increase. In addition, consumer will be able to buy the final product with lower price that eventually will increase the consumer surplus. Moreover, it will create more jobs for local communities and eventually it increases the social welfare.

Acknowledgments

The authors would like to acknowledge the financial sponsorship provided by co-founding of Kharazmi University and Ministry of Science, Research and Technology (MSRT) of I.R. Iran under IMPULSE Iran-Austria Projects.

References

Aiyeloj AA, Ajewole OI (2006) Non-timber forest products' marketing in Nigeria. A case study of Osun state. Educational Research and Reviews, 1(2):52-58. https://doi.org/10.1186/s13717-017-0090-8

Amin G (2005) Popular medicinal plants of Iran. University of Tehran Press, Tehran, p 126.

Ayaz FA, Hayirlioglu-Ayaz S, Gruz J, Novak O, Strnad M (2005) Separation, characterization, and quantitation of phenolic acids in a little-known blueberry (*Vaccinium arctostaphylos* L.) fruit by HPLC-MS. Journal of Agricultural and Food Chemistry, 19;53(21):8116-8122. https://doi.org/10.1021/jf058057y

Bonyad, AE (2005) Measurement and statically analysis of forest growth at three altitude classes in Shafarod forests. Report of Research Plan, University of Guilan, Iran, p 73.

Central Bank of Iran (2021) CPI and Inflation. Retrieved October 22, 2021, from https://www.cbi.ir/Inflation/Inflation_en.aspx

Central Bank of Iran (2020) Economic statistics. Retrieved October 22, 2021, from https://cbi.ir/simplelist/1418.aspx

Cronbach, LJ (1951) Coefficient alpha and the internal structure of tests. Psychometrika 16 (3): 297–334. https://doi.org/10.1007/BF02310555

Damnyag L, Tyynelä T, Appiah M, Saastamoinen O, Pappinen A (2011) Economic cost of deforestation in semi-deciduous forests, a case of two forest districts in Ghana. Ecological Economics, 70(12):2503-2510. https://doi.org/10.1016/j.ecolecon.2011.08.012

Guilan Department of Natural Resources and Watershed Management (2010a) Forest management plan, District 2, Nav watershed, Rasht, Iran.

Guilan Department of Natural Resources and Watershed Management (2010b) Forest management plan, District 3, Nav watershed, Rasht, Iran.

Guilan Department of Natural Resources and Watershed Management (2010c) Forest management plan, District 5, Lumir (Visadar), Rasht, Iran.

Gujarati, D (2014) Econometrics by example 2nd edition, Red Globe Press, p 446.

FAO (2000) Global forest resources assessment. Retrieved May 2019, http://www.fao.org/3/y1997e/y1997e00.htm#Contents

Hassanzadeh F (2015) Evaluation of *Vaccinium arctostaphylos* as a non-timber forest products (Case study: District No.3 Nav - Asalem). M.Sc. thesis, Faculty of Natural Recourses, University of Guilan, Iran, p 108.

Kalu C, Rachael E (2006) Women in processing and marketing of non-timber forest products: Case study of Benin City, Nigeria. Journal of Agronomy, 5(2): 326-331. https://doi.org/10.3923/ja.2006.326.331

Koopahi M (2006) Introduction to agricultural economics. University of Tehran, Iran, p 561.

Lagha BA, Dudonne S, Desjardins Y, Grenier D (2015) Wild blueberry (*Vaccinium angustifolium* Ait.) Polyphenols target *Fusobacterium nucleatum* and the host inflammatory response: Potential innovative molecules for treating periodontal diseases. Journal of agricultural and food chemistry, 63:6999-7008. https://doi.org/10.1021/acs.jafc.5b01525

Latti AK, Kainulainen PS, Hayirlioglu-Ayaz S, Ayaz FA, Riihinen KR (2009) Characterization of anthocyanins in Caucasian blueberries (*Vaccinium arctostaphylos* L.) native to Turkey. Journal of Agricultural and Food Chemistry, 57:5244–5249. https://doi.org/10.1021/jf9005627

Lovrić M, Da Re R, Vidale E, Prokofieva I, Wong J, Pettenella D, Verkerk PJ, Mavsar R (2020) Non-wood forest products in Europe, a quantitative overview. Forest Policy and Economics, 116(2020), 102175. https://doi.org/10.1016/j.forpol.2020.102175

Malleson R, Asaha S, Egot M, Kshatriya M, Marshall E, Obeng-Okrah K, Sunderland T (2014) Non-timber forest products income from forest landscapes of Cameroon, Ghana and Nigeria–an incidental or integral contribution to sustaining rural livelihoods. International Forestry Review, 16(3):261-277. https://doi.org/10.1505/146554814812572449

Mavsar R, Ramcilovic S, Palahi M, Weiss G, Rametsteiner E, Tykkä S, Apeldoorn RV, Vreke J, Wijk MV, Janse G (2008) Study on the development and marketing of non-market forest products and services (FORVALUE); Study Report for DG AGRI No.30-CE-0162979/00-21); European Commission, Brussels, Belgium.

Mohajeri Naraghi S, Mardi M, Hasanloo T, Pirseyedi SM, Mahmoodi P (2011) Isolation and characterization of novel microsatellite loci in *Vaccinium arctostaphylos* L. Conservation Genetics Resources, 3:441-444. https://doi.org/10.1139/cjfr-27-3-415

Mohammadi Limaei S (2006) Economically optimal values and decisions in Iranian forest management. Ph.D. Thesis, Swedish University of Agricultural Sciences, Umeå, Sweden, p 110.

Mohammadi Limaei, S., Lohmander, P. 2007. Stumpage prices in the Iranian Caspian forests, Asian Journal of Plant Sciences, 6 (7): 1027-1036. https://doi.org/10.3923/ajps.2007.1027.1036

Mohammadi Limaei S, Naghdi, R, Namdari, S and Bonyad AE (2011) Economically optimal cutting cycle in a beech forest, Iranian Caspian Forests, Caspian Journal of Environmental Sciences, 9 (2): 181-188.

Monavar Feshani A, Monatasser Kouhsari Sh, Mohammadi S (2011) *Vaccinium arctostaphylos*, a common herbal medicine in Iran: Molecular and biochemical study of its antidiabetic effects on alloxan-diabetic Wistar rats. Journal of Ethnopharmacology, 133(1): 67-74. https://doi.org/10.1016/j.jep.2010.09.002

Nestby R, Percival D, Martinussen I, Opstad N, Rohloff J (2011) The European blueberry (*Vaccinium myrtillus* L.) and the potential for cultivation. A review, The European Journal of Plant Science and Biotechnology 5:5-16. https://doi.org/10.17660/ActaHortic.2009.838.10

Ozgen M, Celik H, Saracoglu O (2014) Less known Vaccinium: antioxidant and chemical properties of selected Caucasian whortleberry (*Vaccinium arctostaphylos*) fruits native to black sea region of Turkey. Acta Scientiarum Polonorum Hortorum Cultus, 13(2):59-66.

Ozkan G, Ercişli S, Ağar A, Sağbaş HI, Ilhan I, Gündoğdu M (2019) Some Morphological and Biochemical characteristics of wild grown Caucasian whortleberry (*Vaccinium arctostaphylos* L.) Genotypes from Northeastern Turkey, Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 47(2):378-383.

Ozturk HA, Yarılgac T, Guler SK, Karakaya M, Celik SM, Karakaya O, Ozturk B (2016) The effect of cold storage on the bioactive components and physical propertıes of Caucasian whortleberry (*Vaccinium arctostaphylos* L.). A preliminary study. Acta Scientiarum Polonorum Hortorum Cultus, 15(2):77-93.

Packalen P, Strunk J, Maltamo M, Myllymäki M (2023) Circular or square plots in ALS-based forest inventories - does it matter? Forestry: An International Journal of Forest Research, 96(1): 49–61. https://doi.org/10.1093/forestry/cpac032

Palmatier RW, Stern LW, El-Ansary AI (2016) Marketing channel strategy 8th Edition. New York, Routledge, p 496.

Prokofieva I, Bouriaud L, Corradini G, Górriz E, Kouplevatskaya-Buttoud I, Nichiforel L (2019) Policy framework for NWFPs, demands and barriers. In non-wood forest products in Europe – Seeing the forest around the trees; Wolfslehner B, Prokofieva I, Mavsar R, What Science Can Tell Us series; European Forest Institute: Joensuu, Finland, p 55–75.

Ravan AP, Bahmani M, Ghasemi Basir HR, Salehi I, Oshaghi EA (2017) Hepatoprotective effects of *Vaccinium arctostaphylos* against CCl4-induced acute liver injury in rats. Journal of Basic and Clinical Physiology and Pharmacology, 28:463-471. https://doi.org/10.1515/jbcpp-2016-0181.

Ravi PC, Mahadevaiah GS, Muthamma M (2006) Livelihood dependence on Non Timber Forest Products (NTFPs)-A study of Jenukuruba tribes in south India, 2006. Annual Meeting, August 12-18, 2006, Queensland, Australia. International Association of Agricultural Economists.

Sedaghathoor, S, Saeidi-Mehrvarz Sh (2006) Botanical and phytochemical characteristics of *Vaccinium arctostaphylos* (Vacciniaceae), Journal of Science (University of Tehran), 32(4): 191-194.

Sedaghathoor S (2007) Seed dormancy and germination of *Vaccinium arctostaphylos* L. International Journal of Botany, 3:307-311. https://doi.org/10.3923/ijb.2007.307.311

Sedaghathoor S (2011) Medicinal and aromatic trees and shrubs (propagation, garden construction and breeding), Islamic Azad University, Rasht, Iran.

Shackleton CM, Pandey AK (2014) Positioning non-timber forest products on the development agenda. Forest Policy and Economics, 38:1-7. https://doi.org/10.1016/j.forpol.2013.07.004

Soltani R, Hakimi M, Asgary S, Ghanadian SM, Keshvari M, Sarrafzadegan N. (2014) Evaluation of the effects of *Vaccinium arctostaphylos* L. fruit extract on serum lipids and hs-CRP levels and oxidative stress in adult patients with Hyperlipidemia: A randomized, double-blind, placebo-controlled clinical trial. Evidence-Based Complementary and Alternative Medicine, 2014: 1-6. https://doi.org/10.1155/2014/217451

Sotoudeh Foumani B, Mohammadi Limaei S, Rostami Shahraji T (2019) Assessment of logging moratorium using analytical network process in Iranian Hyrcanian forests. Journal of Sustainable Forestry, 38(2):130–148. https://doi.org/10.1080/10549811.2018.1527234

Sotoudeh Foumani B, Kolahi M, Mohammadi Limaei S, Fisher J. Rostami Shahraji T (2021) Multiple streams framework and logging policy change in the Hyrcanian forests of Iran, Australian Forestry, 84(4):191–199. https://doi.org/10.1080/00049158.2021.1989848

Statistical Center of Iran (2021) Price indices, Retrieved October 22, 2021 https://www.amar.org.ir/english/Statistics-by-Topic/Price-indices

Stoian D (2005) Making the best of two worlds: rural and peri-urban livelihood options sustained by nontimber forest products from the Bolivian Amazon. World Development, 33(9):1473-1490. https://doi.org/10.1016/j.worlddev.2004.10.009

Stryamets N (2012) Use and governance of non-wood forest products in transition and market economies: Case studies in Ukraine and Sweden. Licentiate Thesis, Swedish University of Agricultural Sciences, p 86.

Toksoy D, Alkan S, Hacisalihoglu S (2010) Usage of non-timber forest products by women in forest villages of Trabzon, Turkey. Journal of environmental biology, 31(6):1013.

Weiss G, Emery MR, Corradini G, Živojinović I (2020) New values of non-wood forest products. Forests, 11:165. https://doi.org/10.3390/f11020165

Wiersum KF, Wong JLG, Vacik H (2018) Perspectives on non-wood forest product development in Europe. International Forestry Review, 20(2):250-262. https://doi.org/10.1505/146554818823767546

Zhang T, Yu L, Man Y, Yan Q, Zhang J (2022) Application of stubble and root cutting in artificial cultivation of Non-Timber Forest Products (NTFPs): A Study Case of *Aralia elata* (Miq.) Seem. Forests, 13(4):612. https://doi.org/10.3390/f13040612