

The Economic and Biological Benefits of Non-wood Forest Products to Local Communities in Iran

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This study estimates the value per hectare of the Arasbaran deciduous forest based on returns from 17 fruit-providing species and mapping their economic value. We also studied the main influencing social drivers of collecting non-wood forest products (NWFPs). A biological inventory was carried out for all fruit-providing trees within the 6,484 hectares (ha) with registration of the geographical position of trees. Based on total fruit produced annually per hectare and the market price of each species, the economic value of each species in terms of the fruit produced was calculated and depicted. Results showed that the distribution area of fruit-providing species was about 10 percent (684 ha) of the studied forest area. In total, the annual sustainable production of all species was 52.6 thousand kilograms. The economic value varied from USD 6 to USD 983 per ha in different areas. The revenue of collected fruit-providing species varied from USD 0.9 to USD 14,903 per year for all involved households. The average contribution of NWFP income to household income was 21 percent. The collection of NWFPs had a negative correlation with the education of the household head, opportunity cost, and household wealth; on the other hand, NWFP collection had a positive relation with fruit price and yield. Forest management strategies can focus on the areas with the highest economic value. This research can help inform decision-makers regarding the selection of eligible forest areas for conservation and enforcement of regulations.

Key Words: Annual sustainable production, economic value map, fruit-providing species, forest management strategies, ethnobotany.

Introduction

There is increasing interest to have a better understanding of the importance of non-wood forest products (NWFPs) for myriad uses including as food, but also for economic, cultural, and medicinal applications (Babulo et al. 2006). NWFPs can serve as a primary source of nourishment and as income during times of crises or famine (Heubach et al.

2011). Specifically, they can contribute significantly to the livelihood of local people (Mamo et al. 2007) and as an important source of cash income for rural households in or near forests (Kamanga et al. 2009; Paumgarten and Shackleton 2009). In developing countries, 20–25 percent of the income of rural peoples is derived from natural resources (Kamanga et al. 2009). The contribution of NWFPs in total household cash income varies from less than 5 to over 90 percent (Shackleton and Pandey 2013). By analyzing 54 case studies in the different parts of the world, Vedeld et al. (2007) showed that these products have contributed 22 percent of total household income. These and other

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studies identify NWFPs as playing a main role in household incomes (Cai et al. 2011; Croitoru 2007; Fu et al. 2009; Heubach et al. 2011; Illukpitiya and Yanagida 2010; Mahapatra and Tewari 2005; Mamo et al. 2007).

A principal element in the sustainable management of NWFPs is the collection of information about the stock of harvested products (Eroğlu et al. 2009). Both biological and economic factors must be considered in working toward sustainable cultivation and harvests of NWFPs. Also, valuation of fruit-providing species requires a thorough understanding of the spatial distribution of economic values of these species, which provides insights regarding specific benefits that local people can obtain from forests. A valuation can inform policymakers and aid decision-making regarding the selection of forested areas that are suitable for the conservation and the enforcement of regulations (Gould et al. 1998; Schaafsma et al. 2012). Many researchers have studied NWFPs in terms of economic and biological benefits. Some researchers have focused on the economic aspects and the role of these products in rural household economics (Croitoru 2007; Damnyag et al. 2011; Heubach et al. 2011; Kamanga et al. 2009; Mahapatra and Tewari 2005; Mamo et al. 2007; Saha and Sundriyal 2012; Shone and Caviglia-Harris 2006), whereas others have investigated biological aspects (Dejene et al. 2013; Kainer et al. 2007; Mahapatra and Tewari 2005; Sinha and Bawa 2002). For instance, Mahapatra and Tewari (2005) studied the annual sustainable harvest of trees in dry deciduous forests of India, where the valuation of timber products was not effective in limiting ecologically and economically detrimental land-use conversion. They showed that 1 hectare (ha) of dry deciduous forest in India had a net present value of USD 1,180 from NWFPs, which compared favorably against the USD 268 per hectare value assigned as potential timber revenue. To date, no similar endeavor focusing on the inventory of fruit-providing species in the Arasbaran forests of Iran (Alijanpour 2014) has been undertaken.

The Arasbaran region is one of the most important biodiversity hotspots in Iran. This area has about 1,334 plant species from 493 genera and 97 families (Sagheb-Talebi et al. 2014). Unfortunately, deforestation is a major threat to forests in this region. Factors influencing deforestation include the conversion of forests to other land uses, overharvesting of fuelwood, lack of infrastructure and facilities in rural areas, and traditional

agriculture and animal husbandry (Sagheb-Talebi et al. 2004).

This paper aims to fill the current knowledge gap in the economic and biological assessment of NWFPs in the Arasbaran forests. We estimate the value per hectare of Arasbaran deciduous forests based on returns from fruit-providing species. The annual harvest levels, market prices, and production of 17 fruit-providing species are measured through yield assessment, household, and market surveys. The data allow for estimations of the annual value from fruit-providing species and provides a map of their current economic value per hectare. This study also examines the collection and sale of these products by households in the region.

Materials and Methods

STUDY AREA

Arasbaran forests are natural, mixed, hardwood deciduous forests. Five main vegetation types (i.e., *Quercetum*, *Quercus-Carpinetum*, *Quercus-Fraxinu-Acerutum campestre*, *Quercus-Fraxinu-Acerutum ibericum*, and *Paliurus spinachristi* Mill.) are found along the elevational gradient of Arasbaran forests that are characterized by a high plant species diversity of more than 84 woody plants (Sagheb-Talebi et al. 2004). Arasbaran forests cover a land area of 153,000 ha and the forest type is classified as broad-leaved deciduous. This region is situated on the border of Armenia and Azerbaijan between 38° 35' N–39° 00' N latitude and 45° 45' E–47° 05' E longitude. The climate is semihumid, with an average annual temperature of 14 °C and an average rainfall of 400 mm per year. The main species in these forests are oak (*Quercus macranthera* Fisch. & C.A.Mey. ex Hohen.), hornbeam (*Carpinus betulus* L.), maple (*Acer campestre* L.), yew (*Taxus baccata* L.), wayfaring tree (*Viburnum lantana* L.), reddish-black berry (*Ribes petraeum* Wulfen), and walnut (*Juglans regia* L.). The occupations of the local people in the target watershed are primarily based on combinations of animal husbandry, farming, carpet-weaving, beekeeping, and cultivation or extraction of forest products. In the Arasbaran region, local people collect firewood, poles, fruit, and medicinal ingredients; they also consume a variety of these products. Fruit products were the focal point of this research.

METHODOLOGY AND DATA ANALYSIS

This study was conducted in the Ilgana-Chay watershed in the Arasbaran forest, which is one of the 11 watersheds in this region. This particular watershed was selected because of a relatively high number of villages (35 villages), a high percentage of forested area (58 percent), significant variation in elevation (between 400 and 2,400 meters (m)), and a high diversity of forest types (15 types). Villages were grouped based on biological and socioeconomic indicators and using principal component analysis and cluster analysis. Subsequently, a village was randomly selected from every 200-m altitude band that captured groups of villages. A total number of 15 villages were selected. After choosing the sample village by the mentioned indicators in the study area, the local authorities at the study area helped us establish the first contact with the head of villagers and NWFP collectors. We shared full disclosure on the nature of the research, received authorization from local authorities in each village, explained the objectives of the study, requested prior informed consent from all participants, and ensured the confidentiality of the participants by anonymizing their identities in databases and publications. The interviewer language was the Azeri language, which was the same language as the local people. They were familiar with the researcher from previous years.

The following describes the method of collection for both the social and economic data. Elevation has a major effect on biodiversity and species richness (Pourbabaei and Haghgooy 2013). The sample villages were stratified based on factors such as elevation, the percent forest cover, the number of livestock per household, employment rate, literacy rate among women, and irrigated land area for farming per household within each village. We collected data about elevation from field observation of villages, the percent forest cover, employment rate, and literacy rate among women from government census of statistical center of Iran, and the number of livestock per household and farmland areas from interviews. These factors were used in clustering the villages. After clustering, 15 of the 35 villages were randomly selected to collect social and economic data. Then, we classified four villages with 30 households for village group 1, eight villages with 65 households for village group 2, and

three villages with 25 households for village group 3. In the second stage, households were randomly sampled within the selected villages. To modify the questionnaires and determine the sample size, pilot surveys were conducted among 34 households before conducting the main household survey. After administering the a priori surveys, the sample size was estimated to be 96 respondents per household based on Cochran's formula (Soltani et al. 2012). To minimize problems related to missing values and to improve the accuracy of the research, the final sample size was increased to 120 households, out of a total of 287 households living in that area. At the household level, a comprehensive questionnaire was used to collect information on key socioeconomic elements including household size, education, landholdings, occupation, sale and consumption of NWFPs, processing of NWFPs, and income earned from NWFPs and other activities (Cai et al. 2011; Mamo et al. 2007). In order to identify the dependence of households on NWFPs, NWFP dependency was measured as the contribution that income from NWFPs made toward total household income (relative NWFP income) (Heubach et al. 2011). Other sources of household income included animal husbandry, farming, beekeeping, and off-farm employment. In order to obtain the annual household income from each source of livelihood, we asked some questions about the number of livestock, the number of hives in beekeeping, farmland areas per household, and income from off-farm employment. Then, we asked the income and cost of each activity during past production periods for each activity. Finally, we estimated the annual household income from different sources of livelihood. In addition, value addition of these products before and after processing was computed and compared. To determine the profitability of processing activities, the processing efficiency was determined as the subtraction of raw fruit weight from processed fruit weight. To further explore the distributional effects of NWFP income, a Gini coefficient, indicating the level of income inequality, was computed for household income for all three groups (Heubach et al. 2011; Mamo et al. 2007). The Gini index measures the degree of income inequality and ranges from 0 (perfect equality) to 1 (maximum inequality). The data were gathered from the heads of households. Other people surveyed included village council members, knowledgeable village elders, and some local people (Soltani et al. 2012).

Several factors influenced the household collection of NWFPs such as household size, education of

the head of household, household wealth, fruit price, opportunity cost, and yield in the distribution areas. Expected relationships between key household factors and NWFP collection are summarized in Table 1 with reference to research that examined such relationships. Opportunity cost was estimated based on different activities for the village. Hourly opportunity cost was averaged. In order to analyze the relationship between collecting NWFPs and the characteristic and external factors of households, we ran an ordinary least square (OLS) regression of the NWFP collection against these variables.

A biological inventory of all fruit-providing trees was carried out within the 6,484-ha study area. After field observations and asking from local people, the distribution area of fruit-providing species was determined. The distribution area of this species was about 10 percent of the study area—about 648 ha. While conducting the inventory, the geographical position of all these trees was registered in the UTM coordinate system by GPS. In so doing, the distribution area of each species was determined using ArcGIS 10.3 software (Schaafsma et al. 2014). Sustainable harvest rate was considered to make sure that the collection is ecologically sound and sustainable. Sustainable harvesting is essential not only for the conservation of the plant species but also for the livelihoods of many rural people. The sustainable harvest rate for each tree was estimated at 80 percent to take into account losses for wildlife, regeneration, and wastage. We counted the number of edible fruit trees; then we calculated the number of each fruit-providing species per hectare. Next, the yield of fruit-providing trees was measured using transects to survey 40 sample trees for each species. We had a total of 27 transects at the studied villages, with about two transects for each village. Transect lines averaged 97 m in each distribution area. The total number of fruits on individual sample tree species was quantified (Sinha and Bawa 2002). We counted fruit only once during fruiting season. Fruit yield of trees exhibits annual variation, however, so we consulted with local collectors regarding variation per year. Some species were not observed along transects because of the low density per hectare. The yield of species not sampled was obtained through local community groups of five individuals per species (Damnyag et al. 2011). The market prices of different species were collected through interviews with 37 local collectors of NWFPs, which are the same samples in the household interviews, and direct observation at local

markets (Cai et al. 2011). When market prices were not available, a cost-based method was used (Croitoru 2007; Saha and Sundriyal 2012). The fruit price was calculated by dividing daily wages given to the collectors with per capita quantum harvested per day (Saha and Sundriyal 2012). Based on total fruits produced annually per hectare and the market price of each species, the economic value of each fruit-providing species in terms of the fruit produced was computed. The annual economic value of fruit-providing trees per hectare was estimated by summing up the annual value of all these trees per hectare in the study area (Damnyag et al. 2011; Peters et al. 1989). These values were calculated for just the areas where fruit trees were found in forests. Five of these species are being cultivated or actively managed by villagers and 12 of them were only found “wild.” Fruit products in the cultivated areas were not included in our calculations. After determining the distribution area of species in ArcGIS 10.3 and the economic value of each species, minimum and maximum values for each species were computed. Finally, a map of the economic value of each species was assembled (Schaafsma et al. 2012).

Results

We found a total of 17 fruit-providing species in our study (see Table 2). Fruit-providing trees were dispersed within the 6,484 ha at the study area. The mean density of fruit providing species was 23 trees per hectare. Based on our estimates of density, cornelian cherry (*Cornus mas* L.) had the highest density. Some species (e.g., cornelian cherry [*Cornus mas* L.], hawthorn [*Crataegus* sp.], and plum [*Prunus* spp.]) had a higher frequency than the other species. Subsequently, walnut, cornelian cherry, and plum were the three most important species in terms of gross value. In total, the annual sustainable production of all of species was 52.6 thousand kilograms in the study area. The overall spatial pattern of fruit-providing species was aggregated and not distributed evenly across the forested area. Results showed that the distribution area of fruit-providing species only made up 10 percent (684 ha) of the studied forest area. The number of trees for walnut was not the highest in the study area (about one tree per ha), but they had the highest yield in the region due to the high mass production of individual trees. The gross total annual value of the fruit-providing trees is described in Table 2.

TABLE 1. FRUIT COLLECTION AGAINST THE HOUSEHOLD CHARACTERISTICS AND EXTERNAL FACTORS.

Factor	Exp. sign	Assumption	References
Household size	+	More people; more labor accessed; higher opportunity for collecting NWFPs	Kamanga et al. (2009), Mamo et al. (2007)
Education of household head	-	High-educated households have more access to a wider range of income opportunities; low dependency on collection of NWFPs	Coulibaly-Lingani et al. (2009), Heubach et al. (2011), Kamanga et al. (2009), Mamo et al. (2007)
Household wealth	-	More wealth; less need for collection of NWFPs and vice versa	Heubach et al. (2011), Kamanga et al. (2009), Vedeld et al. (2007)
Fruit price	+	High price of fruits; high collection of NWFPs	Adam et al. (2013), Mahapatra and Tewari (2005)
Opportunity cost	-	High opportunity cost of households; low collection of NWFPs	Coulibaly-Lingani et al. (2009), Illukpitiya and Yanagida (2010)
Yield in the distribution areas	+	Higher yield of fruit-providing species in the distribution areas; easy access and greater collection of the products	Coulibaly-Lingani et al. (2009), Schaafsma et al. (2014)

Walnut (*Juglans regia*) and hazelnut (*Corylus avellana* L.) had the highest (USD 49.60 per ha) and lowest (USD 0.003 per ha) values in the region, respectively. The most valuable medicinal product of these forests was a reddish-black berry known locally as Ghareh-ghatt (phonetic pronunciation) (Amiri and Joharchi 2013). Its fruit was worth about USD 8.90 per kilogram (kg). This species

had the potential to generate about USD 0.40 per hectare annually.

Based on the potential sustainable harvest of fruit products, the value of the distribution areas per hectare was computed (Table 3). In the distribution areas, the annual average value per hectare varied from USD 0.0003 for hazelnut to USD 222.92 for walnut. The same situation was found for the

TABLE 2. VALUATION SUMMARY OF FRUIT-PROVIDING SPECIES.

Row	Scientific name	Common name	Number of trees total	Total sustainable production (kg)	Price (USD per kg)	Gross value per ha (USD)
1	<i>Berberis</i> sp.	Barberry	133	14	2.91	0.06
2	<i>Cornus mas</i>	Cornelian cherry	3,285	3,590	0.83	4.35
3	<i>Corylus avellana</i>	Hazelnut	40	5.36	0.42	0.003
4	<i>Crataegus</i> sp.	Hawthorn	2,158	1419	0.63	1.37
5	<i>Ficus cariria</i> L.	Fig	62	397	0.47	0.27
6	<i>Juglans regia</i>	Walnut	682	27,179	1.25	49.58
7	<i>Malus orientalis</i> Uglitzk.	Wild apple	531	1,307	0.80	1.52
8	<i>Mespilus germanica</i> L.	Medlar	717	237	0.44	0.15
9	<i>Pistacia mutica</i> Fisch. & C.A.Mey.	Pistachio	161	257.6	0.47	0.18
10	<i>Prunus</i> spp.	Plum	2,226	10,090	0.47	6.90
11	<i>Punica granatum</i> L.	Pomegranate	402	1,189	0.16	0.28
12	<i>Pyrus</i> sp.	Pear	588	1,780	0.30	0.77
13	<i>Rhus coriaria</i> L.	Sumac	67	13.7	1.17	0.04
14	<i>Ribes petraeum</i>	Reddish-black berry	191	30.6	8.90	0.40
15	<i>Rosa canina</i> L.	Dog rose	2,422	2,369	1.14	3.94
16	<i>Rubus</i> sp.	Raspberry	1,779	2,491	0.91	3.33
17	<i>Vitis</i> sp.	Common grape	61	244	0.47	0.17

TABLE 3. ECONOMIC VALUE PER HECTARE OF FRUIT-PROVIDING SPECIES AT DISTRIBUTION AREAS.

Row	Common name	Average value (USD)	Minimum value (USD)	Maximum value (USD)
1	Barberry	0.02	0.001	0.041
2	Cornelian cherry	1.34	0.01	161.5
3	Hazelnut	0.0003	0	0.0003
4	Hawthorn	0.41	0.001	2.25
5	Fig	39.19	0.06	102.4
6	Walnut	222.92	0.26	1610
7	Wild apple	0.28	0.05	0.9
8	Medlar	0.43	0	3.3
9	Pistachio	41.83	0.24	85.3
10	Plum	10.90	0.02	75.6
11	Pomegranate	10.80	0.78	27
12	Pear	0.53	0.001	2.3
13	Sumac	9.99	10	10
14	Reddish-black berry	0.09	0.09	0.086
15	Dog rose	8.84	0.02	68.5
16	Raspberry	5.66	0.01	46.7
17	Common grape	2.83	0.041	7

maximum value per hectare of each species in the distribution areas.

Figure 1 depicts the annual economic value of 17 fruit-providing species in the Arasbaran forests. The economic value for these species varied from USD 6 to USD 983 per ha in the different distribution areas. Across the distribution area, the annual average value was estimated at about USD 136 per hectare. The number of species in the distribution area was different and varied from three to eight species. The aggregation of all fruit-providing trees is shown in Fig. 2. Also, we showed the position of the three most important species in terms of frequency.

COLLECTION OF NWFPs BY HOUSEHOLDS

Fruit of NWFP-providing species was collected from July through November, and the collection pattern varied for different species. A total of 120 households were interviewed to determine dependency on NWFPs. Plum was collected by 57.5 percent of households because of its wide distribution. In contrast, 0.8 percent of households were engaged in the collection of sumac and hawthorn because its distribution is limited to only a few villages. Nearly 42 and 33 percent of households were engaged in the collection of cornelian cherry and walnut, respectively. Cornelian cherry has high market demand and local people are interested in the cultivation of this species in

farmlands. In spite of the high price of reddish-black berry, its collection was confined to 10 percent of households. The cornelian cherry fruit was collected in the greatest quantity, with about 359 kg per household collected annually. The households derived the highest annual income from cornelian cherry followed by walnut, plum, and barberry (Table 4). In total, 13 out of 17 regionally available species were harvested in the study area. The monetary value of different fruit-providing species varied from USD 0.94 to USD 4,903 per year for all the involved households in the fruit collection. The mean income of individual households from these products was USD 250.32.

As we found from village classification into three groups based on different factors, there were four villages with 30 households for village group 1, eight villages with 65 households for village group 2, and three villages with 25 households for village group 3. A high percentage of the total quantity of collected fruits (58.6 percent) was sold raw by the households of village group 1. The same value for the villages of village group 2 and village group 3 was 48 and 0 percent, respectively. The total quantity that was sold raw decreased from village group 1 to village group 3, while the percentage of raw fruits consumed increased concurrently from villages in village group 1 (0.2 percent) to village group 3 (17 percent). The same trend was observed for the

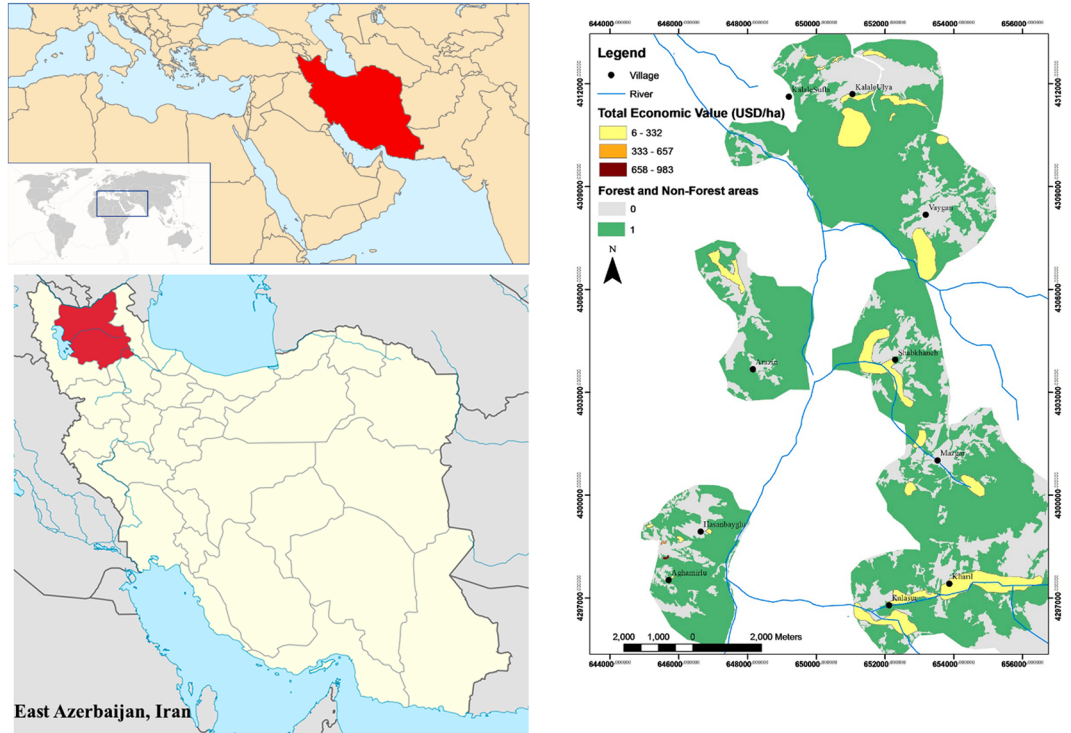


Fig. 1. Location of the study area and total economic value of fruit-providing species in Arasbaran forests, Iran.

percentage of consumption of processed fruits. In the villages of village group 3, all of the fruits were processed for consumption (Table 5).

THE CONTRIBUTIONS OF NWFPS TO RURAL LIVELIHOODS

Figure 2 shows the share of different activities relative to total household income. Total household income was USD 10,222 (SD = USD 7,258) per year. The average contribution of NWFPS to total household income was 21 percent (USD 2,147) (SD = USD 461). Animal husbandry, farming, and beekeeping were the other and primary sources of household income (Fig. 3). Animal husbandry activity represented the largest proportion of forest-related income (30.6 percent), followed by farming (19.6 percent). Results showed that the share of NWFPS in total household income decreased from village group 1 to village group 3.

Table 6 shows the Gini coefficient for household income with and without NWFPS income for all

three village groups. The inclusion of NWFPS income in total household income reduced inequality among households. In the villages of village group 1, the Gini coefficient increased by 0.11 when we removed NWFPS-generated income. In general, NWFPS-based income had an equalizing effect on the distribution of total household income. The highest and lowest Gini coefficients were for village groups 1 and 3, respectively. The impact was much smaller for villages of village groups 2 and 3, but was in the same direction.

The collection of NWFPS was negatively correlated with the education of household head and opportunity cost ($p < 0.05$) and household wealth ($p < 0.001$). The collection of NWFPS was positively and significantly associated with fruit price and yield in the distribution area ($p < 0.001$) (Table 7).

PROCESSING AND ITS VALUE ADDITION

Results showed that most of the collected fruit was locally processed and consumed. In

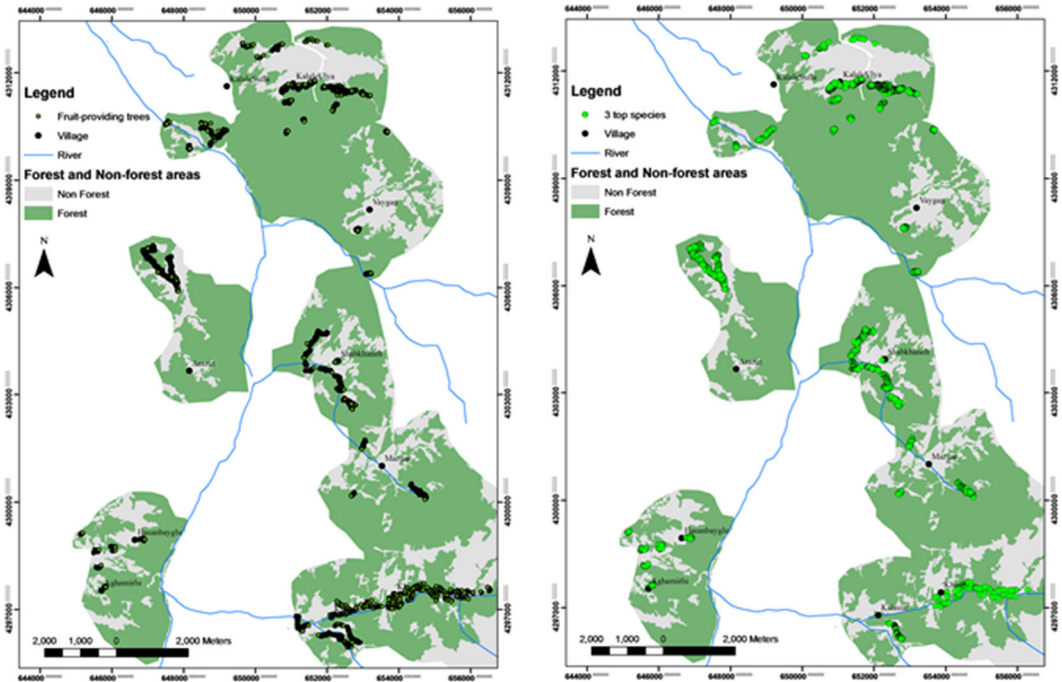


Fig. 2. The distribution map of all fruit-providing species (left) and top three fruit-providing species (right).

some species, investments in processing increased income by sixfold (Table 8). The most increase was in three species—cornelian cherry (6 times), plum (5.2 times), and reddish-black berry (4.2 times). In regard to processing efficiency, plum, cornelian cherry, and sumac exhibited the highest processing efficiency.

Discussion and Policy Implications

DIVERSITY OF NWFP

Many factors influence the economic value of deciduous forests. A major or even primary factor is high biodiversity (Mahapatra and Tewari 2005).

TABLE 4. QUANTITY AND INCOME FROM DIFFERENT FRUIT-PROVIDING SPECIES AT THE STUDY AREA.

Row	Species scientific names	Households engaged (%)	kg/HH/year	USD/total HH
1	<i>Cornus mas</i>	41.7	359.3	14,903.02
2	<i>Juglans regia</i>	33.3	236.9	11,823.21
3	<i>Prunus</i> spp.	57.5	56.8	1,835.06
4	<i>Berberis</i> sp.	15.8	8.5	467.72
5	<i>Ribes petraeum</i>	10	4.1	440.76
6	<i>Rosa canina</i>	11.7	13.4	212.78
7	<i>Punica granatum</i>	3.3	153.1	100.33
8	<i>Pyrus</i> sp.	19.2	11.9	81.14
9	<i>Rubus</i> sp.	5	12.2	66.73
10	<i>Rbus coriaria</i>	0.8	50	58.49
11	<i>Mespilus germanica</i>	5.8	8.6	26.53
12	<i>Malus orientalis</i>	4.2	5.6	22.32
13	<i>Crataegus</i> sp.	0.8	1.5	0.94

HH = household.

TABLE 5. QUANTITY OF RAW AND PROCESSED CONSUMPTION AND SALE OF NWFPS AT THE HOUSEHOLD LEVEL.

V.G. ^a	N. of V. ^b	N. of HH ^c	Per capita annual quantity harvested (kg) ^d [se]	Per capita annual raw consumption (kg) ^b	Per capita annual processed consumption (kg) ^b	Per capita annual raw sale (kg) ^b	Per capita annual processed sale (kg) ^b
1	4	30	558.9 [65.96]	1.01 (0.18)	28.8 (5.15)	327.5(58.6)	17.3 (3.1)
2	8	65	236.3 [18.11]	12.1 (5.12)	15.23 (6.4)	113.6(48)	28.9 (12)
3	3	25	23.8 [1.72]	4.06 (17)	5.96 (25)	0 (0)	0 (0)
Total	15	120	272.7 [19.07]	7.66 (2.8)	16.7 (6.1)	143.4(52.6)	20 (7.3)

^a Village group.

^b Number of villages.

^c Number of household, standard error is in [brackets].

^d In parentheses, we calculated the percentage of different variables from per capita of annual quantity harvested in each category.

The high diversity of species per unit area gives an indication of the high biodiversity in Arasbaran forests relative to other forest regions of Iran. Further, tree density, specifically the density of high value species, further increases the economic value of forests. Some species from our study area (e.g., walnut, reddish-black berry, and cornelian cherry) were found growing at high density (Table 2), consequently increasing the value of a relatively small parcel of forested area. Another factor influencing valuation is the market price of each species (Mahapatra and Tewari 2005). The market price of an NWFPS can be increased through investments in processing before sale or by entering the products into national and international markets.

In order to manage forests sustainably and empower local people, ecological necessities have to be

considered. Total sustainable production of all fruit-providing species in this study was found to be about 52.2 tons per year. Multiple studies have shown that fruit harvest tends to have high potential for sustainability (Shackleton et al. 2015). At the same time, other researchers have reported overexploitation due to high levels of demand (Mamo et al. 2007; Sinha and Bawa 2002; Ticktin 2004). High market demand for fruit products may lead to overexploitation and even to local extinction of some rare species that provide highly desired products (Heubach et al. 2011). The fruit of reddish-black berry (Azeri name: “Ghare-ghatt”) is used as food as well as a hypotensive agent in the traditional medicine of the study region (Delazar et al. 2010), resulting in high demand for the berry. Because of the low density of this species, long-term

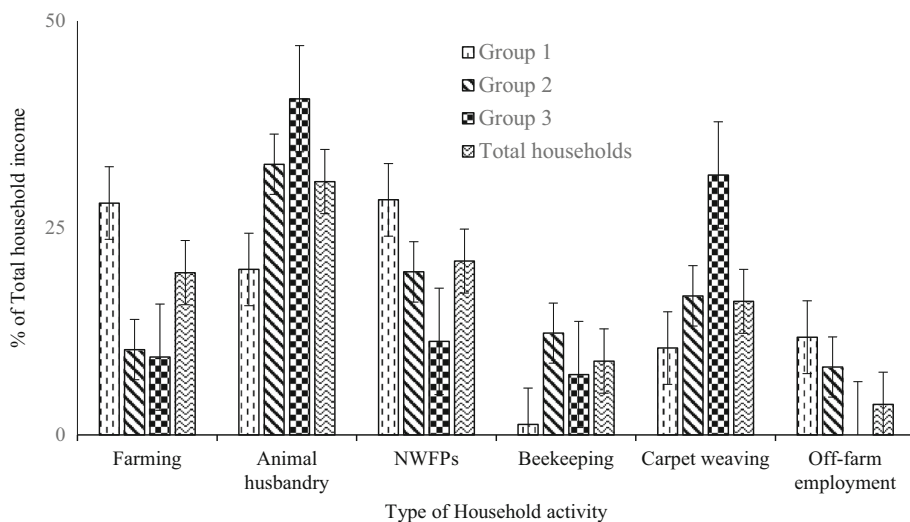


Fig. 3. Share of different income sources in total household income at the three village groups.

TABLE 6. GINI COEFFICIENT WITH AND WITHOUT NWFPs.

Village groups	Number of households	With total income	Without NWFP income	Change (units)
Village group 1	30	0.33	0.44	0.11
Village group 2	65	0.40	0.43	0.03
Village group 3	25	0.29	0.30	0.01
Total	120	0.38	0.44	0.06

overexploitation could conceivably lead to destruction of this species. Other highly collected species in this region were cornelian cherry and walnut. In order to increase both the sustainability and economic value of these forests, there are two management options to consider. The first is to increase the supply area of fruit-providing species (Mahapatra and Tewari 2005). Although forest resource ownership in Iran is public and all people have access to these resources, nevertheless, in each village, access priority is with that village. In this situation, increasing the supply area through forest enrichment (i.e., planting of these commercially and ecologically valued species) and increasing tree density through more intensive silvicultural practices would help to increase the forest's economic value, thereby helping to lift people out of poverty because of low-return-dependent activity of NWFP extraction (Heubach et al. 2011). For this reason, local communities have high motivation for increasing the supply area. In our study area, the density of fruit-providing species was relatively low for other species such as Persian oak and hornbeam, but the spatial distribution of these species was aggregated (Fig. 1). This factor results in the intensification of harvesting activities at the specific supply area and increases the harvest efficiency of these products while decreasing harvest costs. Other studies have stated that the intensity of harvesting is influenced by resource

abundance and market demand (Avocèvou-Ayisso et al. 2009; Fu et al. 2009; Gould et al. 1998).

ECONOMIC VALUE OF NWFP

The economic value of fruit-providing species varied from USD 6 to USD 983 per ha in the different distribution areas in our study region. Croitoru (2007) showed that the average value of NWFPs in the Mediterranean countries was USD 6 per ha and the highest value was USD 430 per ha in Lebanon. The average estimate for Arasbaran forests (USD 135 per ha) is considerably higher than for northern (USD 41 per ha) and eastern (USD 20 per ha) Mediterranean forests. The economic value is influenced by tree density per hectare, species' yield, fruit price, and the number of species per unit of land area. All these factors can be manipulated by silvicultural operations, specifically through facilitating regeneration, regulating harvesting, and tending strategies that adapt to species productivity environmental tolerance thresholds.

In similar research in other study regions (Mamo et al. 2007; Saha and Sundriyal 2012), we determined that NWFPs contribute significantly to rural household income in the Arasbaran forests. Specifically, our research determined the average contribution of NWFPs to total household income to be 21 percent in the study area. In the villages of village

TABLE 7. OLS REGRESSION OF HOUSEHOLD COLLECTION OF FRUIT PRODUCTS AGAINST SOCIOECONOMIC CHARACTERISTICS.

Factor	Coeff.	SE	<i>t</i> value	<i>p</i> value
Intercept	- 1.83	24.5	- 0.075	0.94
Household size	0.258	1.39	0.185	0.854
Education of household head	- 0.575	0.269	- 3.57	0.037
Household wealth	- 0.0001	- 5 × 10 ⁸	- 0.271	0.001
Fruit price	+ 0.004	0.001	4.23	0.000
Opportunity cost	- 0.001	0.0002	- 2.42	0.08
Yield in the distribution areas	+ 0.09	0.006	15.02	0.000

The overall model: $y = - 1.83 + 0.258$ (Household size) - 0.575 (Education) - 0.0001 (Household wealth) + 0.004(fruit price) - 0.001 (opportunity cost) + 0.09 (yield). $N = 120$; $R^2 = 0.818$; R^2 adj = 0.803; $F = 52.569$; $p < 0.001$.

TABLE 8. VALUE ADDITION OF NWFPS AND PROCESSING EFFICIENCY.

Common name	Price before processing (USD/kg)	Price after processing (USD/kg)	Value addition (ratio after to before processing)	Processing efficiency
Plum	0.40	2.10	5.2	3.83
Cornelian cherry	0.72	4.30	6	3.6
Walnut	1.08	1.63	1.5	1.9
Barberry	2.50	4.03	1.6	2.38
Reddish-black berry	7.68	32.27	4.2	2
Raspberry	0.79	1.21	1.5	2.6
Sumac	1.01	1.41	1.4	3

group 1, the time frame for collection did not coincide with the period of farming activities, and this may have increased the share of NWFP income to total household income, in times when there are no other income sources. In contrast, collection in village groups 2 and 3 coincided with the period of farming activities and fodder harvesting in rangelands. For these reasons, harvesting NWFPs was a focus for village group 1 more so than for village groups 2 and 3. In fact, employment in other activities substantially reduced the importance of NWFPs in total household income. Similarly, the spread of small-scale commercial tea cultivation has led to a decline in the role of NWFPs in household income (Fu et al. 2009). In addition, the villages of village group 1 had better access to national and international markets, which increased the impact of NWFP harvesting in this group. NWFPs can easily be sold to middlemen in rural areas (Ghanbari et al. 2014). In line with other studies (Adam et al. 2013; Kamanga et al. 2009), we found that villages located close to markets have greater incentives for harvesting. However, the economic significance of NWFPs differed among villages with respect to diversity and abundance of species, diversity of household income sources, household size, and market access (Avocèvou-Ayisso et al. 2009; Kar and Jacobson 2012).

The computation of the Gini coefficient showed that the inclusion of NWFP income in total household income reduced income inequality among households. These results reflect the findings reported in other case studies that NWFPs reduce inequality among household yields, the changes were much smaller for the villages of village groups 2 and 3, although they paralleled the impacts in village group 1. As highlighted by Babulo et al. (2009), the low Gini coefficient can also be explained by the fact that all households participate in the extraction of

NWFPs. However, they found that NWFP income has an equalizing effect on the distribution of total income in rural economies. Also, Mamo et al. (2007) have noted that the true equalizing effect of forest resources will depend on the optional activities available to households; that is, how they would have acted in the absence of forests, and the income thus derived.

Several factors have an influence on NWFP collection. Fruit price is one of the most important factors in increasing a forest's economic value. The growing demand for organic products is observed in several developed countries. This has created a new market opportunity for the export of NWFPs to these countries. In the study area, however, most of the products are not traded in markets. Thus, a lack of market information and market access limits the economic benefits of NWFPs for these communities. Just 5 out of 17 species (cornelian cherry, walnut, plum, pomegranate, and reddish-black berry) are sold in local markets, while these products could be exported to national and international markets. Other scholars have also found that these factors influence the trading of NWFPs (Paumgarten and Shackleton 2009; Saha and Sundriyal 2012). Further, the supply of NWFPs depends on the fruit price, which directly impacts the income of households. Similar findings have been observed in a study of *Garcinia gummi-gutta* fruit in India (Rai and Uhl 2004). Our results showed that the price of fruit is statistically significant and positively correlated with the collection of NWFPs by households. This is consistent with other recent studies on the relationship between fruit price and the NWFP collection (Adam et al. 2013; Mahapatra and Tewari 2005). Due to the increasing price of fruit, the demand for the collection of NWFPs is likely to increase. Thus, fruit-providing species are prone to overexploitation

(Heubach et al. 2011; Mahapatra and Tewari 2005). Greater yield of fruit-providing species would increase the availability of these species for collecting.

The larger the household size of a respondent in our study area, the higher the likelihood of NWFP collection. The influence of household size on NWFP collection is in line with other studies, where NWFP collection was found to be positively related with household size (Kamanga et al. 2009; Mamo et al. 2007). Large families have more workers and greater opportunities to carry out labor activities. Moreover, households with higher education levels often have more external sources of income-generating opportunities. In previous studies, education has been shown to reduce forest dependency (Mamo et al. 2007). A higher level of education provides a wider range of employment opportunities, thus making NWFP collection less lucrative due to the higher opportunity costs of collection. Therefore, our results indicate that education level substantially influences the motivation of individuals to collect NWFPs. This result is similar to the findings by Coulibaly-Lingani et al. (2009), Kamanga et al. (2009), and Mamo et al. (2007), all of which concluded that education is a major determinant of access to NWFPs. For those with formal education, lower access may also be indicative of higher opportunity costs of time for collecting NWFPs. The assumption related to household wealth is supported in the findings. Households with medium and upper income levels are remarkably less engaged in the collection of NWFPs. These findings on the stronger dependency on NWFPs within households with lower wealth are consistent with the findings of Kamanga et al. (2009) and Vedeld et al. (2007), while contrasting with the results of Heubach et al. (2011), who found wealthier households generate more cash income from NWFPs than poorer ones. For example, in Shabkhaneh village, residents with higher opportunity costs and households that were wealthier collected just 13 percent of total sustainable production.

Recommendations

A strategy for enhancing the economic value of a natural forest is to increase the density of economically important, indigenous tree species by planting seeds or seedlings for future harvest, which can be accomplished with strategic enrichment planting

(Mahapatra and Tewari 2005). Cornelian cherry, for instance, has been planted by villagers in Kalaleh village. The fruit of cornelian cherry is collected by villagers and its benefits are shared among all households. A similar situation has been mentioned for *Illicium griffithii* in India (Saha and Sundriyal 2012). To make progress through forest-tending activities, a change is required among perceptions and positions of villagers regarding the planting of other fruit-providing species in native forests. Most people have planted poplar (*Populus* sp.) for timber production, and they have low motivation for replacing this species with fruit-providing species such as cornelian cherry, sumac, and walnut. This shift among the perceptions of villagers will require an understanding that additional fruit diversity through enrichment planting will supplement post-harvest processing activities and subsequently the creation of new market opportunities in order to increase value addition.

The second strategy is to increase the yield of existing fruit-providing species through tending activities. In some studies, a positive correlation has been found between crown tree volume and fruit yield (Snook et al. 2005). Therefore, we posit that crown thinning of non-fruiting species could increase light resources for fruit-producing species, where crown volume increases would correspond to increased fruit yield per hectare.

The results showed that most of the collected fruit was locally processed and consumed. Processing of the fruit is simple, as it is typically dried, preserved (e.g., salted, pickled, jam), shelled, and stored. The processed products included sauce from pomegranate, jams from fig and hawthorn, fruit bars from hawthorn, and pickled products from cornelian cherry. Just two species, cornelian cherry and sumac, were processed by small-scale industries in the Arasbaran region. Our findings showed that the fruit of cornelian cherry, the most preferred species for harvesting, was sold fresh and unripened in the local markets at low prices. Value addition to NWFPs through semiprocessing, drying, and grading can increase substantially the income of the local people (Avocèvou-Ayisso et al. 2009; Saha and Sundriyal 2012). The fruits of reddish-black berry and sumac were dried and sold in the market. In contrast, fruits of cornelian cherry and pomegranate were sold fresh in the local markets with lower prices. Several other researchers have stated the importance of processing in value addition (Coulibaly-Lingani et al. 2009). However, as noted by other scholars, processing activities are not always

profitable. NWFSP processing profitability is highly dependent on the relative levels of the different costs involved, such as labor and the use of specialized technology (Avocèvou-Ayisso et al. 2009). Most of the fruits and other plant parts studied in this project received limited processing. Regarding NWFSP diversity, the motivation of local people can be increased by the installation of local processing facilities for fruits (Saha and Sundriyal 2012). Processing activities are profitable and it is recommended economically for some species such as plum, cornelian cherry, and reddish-black berry. For products of other species, including walnut, barberry, sumac, and raspberry, it is better to sell before processing to maximize earnings.

Conclusion

This study illuminates the biological and economic situation of NWFPS for Iran's Arasbaran region. The results showed that intact Arasbaran forests make a significant contribution to rural household income through 17 economically important fruit-providing species. Across the distribution area, the annual average value was estimated to be about USD 136 per ha. Cornelian cherry is a primary species of economic importance in our study area. We suggest this species would be highly suitable for agroforestry systems in other woodlands as it could provide economic value and other ecosystem services. Regional development activities should consider the cultivation of NWFSP-providing species as a suitable strategy for lifting people out of poverty. However, policy and development initiatives should entail focusing on NWFPS in terms of their ability to provide cash income and the intensity of household use of NWFPS. For example, emphasis on protection of species that provide NWFPS linked with subsistence use would help to maintain and conserve forest resources for the future needs of the local people.

Fruit-providing species represent a high potential income source for locals in the Arasbaran forests; they already engage in annual harvesting activities to a substantial degree. Increasing accessibility to forests for these communities would be beneficial; however, regulating that increase is necessary. Thus, forest management plans can be a useful resource toward sustainable management of NWFPS in the Arasbaran region. Further, opportunity cost is the main influencing factor for fruit collection. For this reason, creating an alternate source of income to

local communities by providing adequate off-farm employment opportunities may help to reduce pressure on forests and improve household incomes.

Expanding agroforestry systems by increasing the abundance and density of fruit-providing species is another method of economic improvement. However, there are means to increase income generation locally without altering forest composition. Our study found that there was no local processing industry, which could increase revenue with simple inputs to the post-harvest process. Generating income from the NWFSP trade alone does not lead to rural development, but the creation of small-scale processing industries and cooperatives, focusing on species of high abundance and increasing market information and connections to markets, would make a positive impact on poverty alleviation at the rural household level.

Finally, our total economic value map (Fig. 1) identifies the differing value of fruit-providing species in the study area, ranging from USD 6 to USD 983 per ha. Future forest management strategies can utilize this information to focus on the areas with high economic value for commercialization or lower values for enrichment or development activities. Ultimately, the map (Fig. 1) can highlight for decision-makers the forested areas that are most suitable or eligible for conservation and enforcement of regulations.

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