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Cornelian cherry (*Cornus mas* L.) fruit as a non-timber forest product of Arasbaran biosphere reserve forests in Northwest of Iran

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Abstract. The present research aimed to quantitatively and economically evaluate Cornelian cherry (*Cornus mas* L.) fruit as a non-timber forest product for a resident rural community across three consecutive years. A forest stand of 50 hectares in Kalaleh village, Northwest of Iran (Arasbaran biosphere reserve), was selected. After estimating the number of stems per hectare, the rate of fruit production rate was determined. Forty five individuals were then selected and assessed for their vegetative characteristics, including total height (m), crown height (m), crown diameter (m), diameter at breast height (mm), number of coppice shoots and annual fruit production (kg). Relationships between the vegetative characteristics and fruit production were then determined using multiple regression analysis to estimate the total fruit production per ha (estimated number of stems per hectare x mean fruit production per stem). Questionnaires and interviews were conducted to determine the number of stakeholders, quantity of fruit harvested and their harvesting methods; in addition to the costs and revenues of the harvest. Our results indicated that in 2012, 2013 and 2014, the annual total fruit production and local harvesting rates were: (i) 17 500, 10 705 and 8 169 kg and (ii) 4 900, 6 540 and 6 700 kg respectively. The revenue from selling the fruit contributed from 3.6% to 7.3% to household livelihoods. Mean economic rent of Cornelian cherry utilization and the average expected value of the forest were US$ 52.9 and US$ 17.6 respectively, while the average marketing margin of utilization was 65.5%. We believe that the inflated harvest rate recorded in 2014, which was above the allowable quota, might be a crucial threat to viability and also the sustainability of the forest stand. In conclusion, launching and implementing non-timber forest products projects including tree domestication is required to help conserving biodiversity in one hand and to sustainably manage natural resources in the other hand.

Key words: Cornelian cherry, Arasabaran biosphere reserve, rural household's livelihood, vegetative characteristics, poverty.

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Introduction

Besides their potential to sustain and improve human life, forests are home for a diverse array of plant and animal species (Adedayo *et al*., 2010; Paul & Chakrabarti, 2011; Saha & Sundriyal, 2012). Forest products and services include wood, non-timber products and environmental and ecological services (Hasalkar & Jadhav, 2004). Non-timber forest products are defined as all physical forest products other than industrial wood, collected from forests for food and for trade (Ros-Tonen *et al*., 1995).

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Non-timber products, especially during famine periods, often provide food sources to households which they are the traditional foods consumed on a regular basis in many places (Pouliot & Treue, 2013). Based on WHO statistics, about 80% of population in developing countries relies on non-timber forest products for medicinal and healthcare purposes (Sadashivappa *et al*., 2006; Schumann *et al*., 2011; Saha & Sundriyal, 2012). The importance of non-timber products extraction, consumption, trade and poverty alleviation especially in forest based communities have strongly been emphasized (Chamberlain *et al*., 2001; Sinha & Bawa, 2002; Stoian, 2005; Quang & Anh, 2006; Saha & Sundriyal, 2012). On the other hand, unlike timber, the harvesting of non-timber products appears to be possible without major damage to the forest, its environmental services and biodiversity (Rostonen & Wiersum, 2003). Therefore, sustainable use of these products is an important approach to protect forests and regions with high biodiversity especially where local people rely on such forest products for supplementing their family income (Kumar, 2015).

Arasbaran forest with a total area of 164 000 hectares is found in the Caucasus Iranian highlands in the northwest of Iran and is a habitat of diverse plant and animal species. It has been recognized as a biosphere reserve combining both conservation and the sustainable use of natural resources. Rural households rely on exploiting wood, fuel wood and also non-timber products such as fruits to supplement their income. The predominant tree and shrub species of the forest stand include *Quercus macranthera* Fisch. et C.A.Mey. ex Hohen, *Carpinus betulus* L., *Acer campestre* L., *Corylus avellana* L. and *Cornus mas* L. (Sagheb-Talebi *et al*., 2014).

Cornelian cherry (*C. mas*) belongs to the dogwood family (Cornaceae) widely distributed in a variety of environments, in subtropical, temperate and boreal regions of the northern hemisphere including central and southern Europe and Asia Minor (Da Ronch *et al*., 2016), as well as in the Andean Mountains of South America and the mountains of tropical Africa (Stanescu, 2013). The oldest known occurrence of fruits belonging to the Cornelian cherry group is from the Paleocene of North America (Manchester *et al*., 2010). Cornelian cherry is a deciduous shrub growing to 4–8 m tall, with small yellow flowers. They mostly grow on warm and dry slopes with calcareous soils (Sagheb-Talebi *et al*., 2014). Shrubs are typically light demanding plants preferring wet soils. The geographic distribution of Cornelian cherry in Iran extends from northwest, Azerbaijan (Arasbaran forest), Zanjan and Qazvin, to north, Guilan (Mozafarian, 2004). It has a wide range of vegetative characteristics, with reports of significantly greater diameter at breast height, crown diameter and height of the shrub found in northern and eastern areas of the Arasabran Biosphere Reserve those of shrubs growing on western and southern aspects (Alijanpour *et al*., 2011). Similarly, Alijanpour *et al*. (2013) found that the annual growth rings of trees were wider in the northern areas.

The oval shaped ripe fruit are dark red or a bright yellow with astringent and slightly sweet taste. Fruits are used as food and medicine. The fresh fruit also has important role in Iranian cuisine. Vitamin C content of the fresh fruits is twice that of orange. It is also known to increase appetite (Ercýslý, 2004). Ethno pharmacologically, fruits and leaves are also famous for their antidiuretic, astringent and antipyretic properties. There are also various trade names of beverages made of fresh fruit with health claims such as natural sources of minerals and antioxidants. Its unique taste made it a highly desired snack for youths. Fresh and dry Cornelian cherry fruit are widely harvested and sold by local people. Ghanbari *et al*. (2011) reported that Cornelian cherry fruit production in Arasbaran is about 914 kg per hectare and making an undeniable contribution to trade

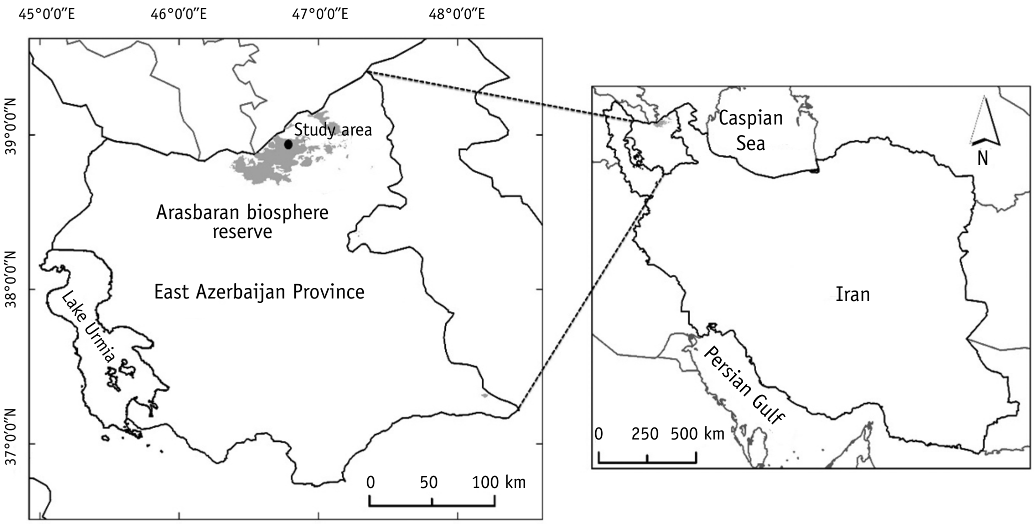

Figure 1. Arasbaran biosphere reserve in NW of Iran (study area).

and household livelihoods in the Arasbaran region. Market demand for high quality fruits such as Cornelian cherry is now being increased due to worldwide interest and demand for health foods. Therefore, protecting natural stands and cultivation of Cornelian cherry for its delicious and nutritious fruits and also for its attractive blossoms has become internationally recognized (Ercýslý, 2004; Da Ronch *et al.*, 2016). Despite its environmental importance both on national and international scales and its recognized economic value to the local people, there is a dearth of chronological information on the quantitative and financial data on fruit production, exploitation, economic importance and contribution to rural households' income.

Material and Methods

Site description

Cornelian cherry shrubs grow at high density in Arasbaran region, Northwest of Iran. For this study a forest stand in Kalaleh village, located in Arasbaran Biosphere Reserve (Makhdoum, 2008) was selected (38–57° E longitude and 7–47° N latitude) (Figure 1) for economic and quantitative evaluations (Alijanpour *et al.*, 2011, 2013). The area which is covered by a 50 hectare of forest stand contains also other tree/shrub species including *Carpinus betulus, A. monspessulanum* L., *A. campestre, Quercus petraea* (Matt.) Liebl., *Taxus baccata* L. and *Fraxinus excelsior* L. The 15-year average annual rainfall of the study area is around 405 mm. This area has a semi-arid climate based on the de Martonne climate classification. The average slope is 35% with a general northerly aspect. The frequent soil types are mostly *Alfisol*, *Inceptsol* and *Mollsol* (Alijanpour *et al.*, 2011).

Vegetative characteristics and estimating fruit product

To estimate fruit production per hectare, the number of Cornelian cherry stems per hectare was determined using sampling transects, reported to be both high accuracy and also very cost-effective (Alijanpour *et al.*, 2003). A total of 15 transects with different lengths (55–165 m; Table 1) were established at evenly spaced parallel intervals (100 m) with a 90° azimuth. After randomly selecting a starting point on transect, each trunk or crown encountered was treated as a sample. Vegetative characteristics including total height (m), crown height (m), the largest and smallest diameter of crown (m), diameter at collar (mm), diameter at breast height (mm), the number of coppice shoots and distance of each stem from the previous sample were recorded. To determine the average number of stems per hectare (N, Equation 2), the number of stems per hectare of each transect (N_i) was calculated according to Equation 1 (Prodan, 2013):

$$N_i = \frac{10000}{\bar{a}^2}. \quad (1)$$

N_i: The number of stems per hectare of a transect;
$\bar{a}$: Average space between Cornelian cherry stems in each transect (meter).

$$N = \frac{\sum_{i=1}^{n} l_i \times N_i}{\sum_{i=1}^{n} l_i} \quad (2)$$

l_i: The length of each transect (meter).
N_i: The number of stems per transect.
N: Average number of stems per hectare.

The first 45 Cornelian cherry stems were selected by randomized-systematic method and vegetative characteristics and fruit production of stems were measured in the course of three consecutive years. Fruit production per hectare was estimated in mid-September 2012, 2013 and 2014.

Economic evaluations

Harvest, consumption and contribution to households' livelihood

A semi-structured questionnaire (open ended and closed questions) was designed to determine the number of stakeholders, harvesting rate and method, costs and revenue of harvest, household's income and harvested crops processing. Some demographic variables such as gender, age, educational attainment, income, household size and occupation along with respondents' opinion about the major constraints of forest exploitation were also included. To carry out economic analysis such as local average fruit price, variable and fixed costs of non-timber forest products harvesting, the average daily harvest, average harvest period and average annual income per household from other activities (i.e. agriculture and livestock sector, day labor and others) were evaluated. Finally, net and gross income of households and the contribution of revenue from selling Cornelian cherry fruit in their total income were calculated. In this survey, economic and social data were collected from July to September of each year during 2012, 2013 and 2014. Some pieces of information such as sale method was obtained by direct observations (Kalu & Rachael, 2006). For questionnaire testing and evaluation, surveys from 6 households were randomly selected (Coulibaly-Lingnai *et al*., 2009; Heubach *et al*., 2011). According to the target population and the nature of financial evaluation criteria (Murthy *et al*., 2005), 17 households (38% of total 45 households living in Kalaleh village) were randomly selected and interviewed (Heubach *et al*., 2011; Kar & Jacobson, 2012). According to total harvest and local sale price, revenue from the forestry sector was calculated and regarded as households' gross income. Finally, net income was calculated by subtracting harvesting costs (labor and transportation costs) from households' gross income.

Economic rent

The economic rent (ER) is referred to the annual economic profit obtained from selling one product per unit area (Kant & Alavalapati, 2014) was calculated by subtracting overt (transport) and hidden costs (laboring) from the gross income and finally dividing the remnant by the surface area (Equation 3, Daneshvar Ameri & Yazdani, 2007):

$$ER = \frac{TR - TC}{S} \quad (3),$$

where ER was the economic rent, S indicated distribution area (ha), TR represented the gross income (total revenue) and TC was the overt and hidden costs. TR from selling the fruit was calculated by multiplying the quantity of fruit sold by its price. TC was also the product of adding variable costs to total fixed costs.

Marketing margin
The difference between retail and wholesale prices, known as marketing margin, is an important index for analyzing the economic attractiveness of exploiting by-products. Marketing margin for by-product yield and forage production is calculated using Equation 4 (Wohlgenant, 2001; Achike & Anzaku, 2010). The index represents the prices paid for marketing services and includes purchasing, processing, packaging, transportation and warehousing (Daneshvar Ameri & Yazdani, 2007).

$$r = \frac{P_r - P_w}{P_r} \times 100 \quad (4),$$

where r is the marketing margin, P_r is the retail price (i.e. the price in market), and P_W is the wholesale price (i.e. the price in the forest).

Annual employment
To estimate area-wide employment, the number of required individuals, days-labor for harvesting the fruit was divided by the number of working days per year (250 days) and therefore the employment based on person – year was obtained (Equation 5).

$$E = \frac{n \times d}{250} \quad (5),$$

where E was employment, n indicated the number of employed people per day and d was the number of days during exploitation period.

Expected value of the forest
As annual net revenues per unit area for one hectare up to infinity (Zhang & Majumdar, 2013) was calculated by dividing economic rent (ER) by the real interest rate (r) (Equation 6) (Moradi *et al.*, 2017).

$$REV = \frac{ER}{r} \quad (6)$$

Statistical analysis
The relationship between vegetative characteristics and fruit production was investigated using Pearson product-moment correlation coefficient. Such correlation was also applied to total household's income and family fruit consumption. A stepwise multiple regression was performed between fruit weight (g) as a dependent variable and crown diameter (m), crown height (m), total height (m), main collar diameter (mm), number of coppice shoots and diameter at breast height (mm) as independent variables. Before running the regression analysis, preliminary analyses were conducted to ensure there were no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. With the use of a $p < 0.001$ criterion for Mahalanobis distance, no outliers were found. All statistical analyses were performed using SPSS (version 19, SPSS, Inc., Chicago, IL, USA) statistical software package at the significance level of $p < 0.05$. Results were reported as mean ± SE. All financial evaluations were conducted in Microsoft Excel spreadsheet, 2010 environment.

Results

Vegetative characteristics and estimating fruit production
Transect properties, the number of stems per transect and average distance between individuals in the study area are shown in Table 1. According to Equation 2, the number of Cornelian cherry stems in Arasbaran biosphere reserve was estimated around 530 shrubs per hectare.

$$\bar{N} = \sum L_i \times N_i / \sum L_i = \frac{882617.3}{1665} = 530.1$$

Table 1. Transect properties, number of stems and average distance between stems in Arasbaran Cornelian cherry (*Cornus mas* L.) forest stand.

Transect No.	Length of transect	The number of Cornelian cherry stems in each transect	Distance between stems in meters ($\bar{\alpha}$)	The number of stems per hectare (Ni)	Li×Ni
1	95	14	6.7	222.8	21163
2	142	33	4.3	540.8	76798
3	140	54	2.6	1479.3	207101
4	120	22	5.4	342.9	41152
5	136	25	5.4	342.9	46639
6	115	18	6.4	244.1	28076
7	165	48	3.4	865.1	142734
8	115	38	3	1111.1	127778
9	127	19	6.7	222.8	28291
10	105	20	5.2	369.8	38831
11	85	12	7.1	198.4	16862
12	55	11	5	400	22000
13	60	11	5.4	342.9	20576
14	110	21	5.2	370	40681
15	94	15	6.3	251.9	23936
Total	**1665**	**361**	**-**	**-**	**882617.3**

To evaluate fruit production and relationship between fruit yield with vegetative characteristics of shrubs, 45 stems were selected and measured in 2012, 2013 and 2014 (Table 2).

The correlation coefficient between fruit production and vegetative characteristics are shown in Table 3. Statistical analysis revealed that the number of coppice shoots, crown diameter and diameter at collar were significantly correlated with fruit production of an individual plant.

Results from stepwise multiple regression regarding the number of coppice shoots (S), crown diameter (CD) and diameter at collar (MC) are included in the models (Table 4).

The total variance explained by the model as a whole was 75.1% ($F_{3,41}$ = 41.26, p = 0.000), 72.4% ($F_{3,41}$ = 35.83, p = 0.000) and 73.2% ($F_{3,41}$ = 37.38, p = 0.000) in years 2012, 2013 and 2014, respectively. The crown diameter had the highest *beta* values (0.55, 0.59 and 0.60 in 2012, 2013 and 2014, respectively), a criterion of total variance explained by the variable after controlling the contribution of other independent variables, indicating that the effect of crown diameter on fruit production of Cornelian cherry shrubs was more considerable than that of other vegetative characteristics.

Table 5 shows the fruit production per hectare and the study forest area. Total fruit production was extrapolated with regard to estimated fruit production from the respective regression models developed for 361 surveyed stems, the number of individuals per hectare and total forest area covered by Cornelian cherry in Kalaleh village (i.e. 50 hectares).

Table 2. Vegetative characteristics of Cornelian cherry (*Cornus mas* L.) stems in Arasbaran biosphere reserve during study period.

Characteristic	Average (Std Error) Year 2012	Average (Std Error) Year 2013	Average (Std Error) Year 2014
Fruit weight (g)	446.97 (57.85)	318.69 (32.24)	253.37 (29.94)
Total height (m)	3.62 (0.14)	3.82 (0.14)	4.04 (0.15)
Crown diameter (m)	3.08 (0.21)	3.28 (0.21)	3.48 (0.21)
Crown height (m)	3.55 (0.15)	3.65 (0.14)	3.81 (0.15)
Diameter at collar (mm)	22.19 (1.83)	22.28 (1.80)	22.4 (1.8)
Diameter at breast height (mm)	4.86 (0.29)	4.95 (0.28)	5.06 (0.29)
The number of coppice shoots	2.49 (0.23)	2.57 (0.22)	2.6 (0.24)

Table 3. Pearson correlation coefficient between fruit production and vegetative characteristics of Cornelian cherry (*Cornus mas* L.) during study period. S, CD and MC denote the number of coppice shoots, crown diameter and diameter at collar, respectively.

Year	Characteristic	(S)	(S×CD)	(S×CD×MC)
2012	R2	0.62	0.71	0.75
	p-value	0.000	0.000	0.000
2013	R2	0.61	0.68	0.72
	p-value	0.000	0.000	0.000
2014	R2	0.55	0.69	0.73
	p-value	0.000	0.000	0.000

Table 4. Outputs of stepwise multiple regression analysis between fruit production and vegetative characteristics of Cornelian cherry (*Cornus mas* L.) stems in Arasbaran biosphere reserve. S, CD and MC denote the number of coppice shoots, crown diameter and diameter at collar, respectively.

Year	Regression model	r^2
2012	Y=140.34+113.14S+151.22CD-7.23MC	0.75
2013	Y= -41.67+90.548CD+57.21S-3.789MC	0.72
2014	Y= -86.750+84.605CD+48.665S-3.613MC	0.73

Table 5. Estimated fruit production per hectare and the study area.

Year	Estimated fruit production of 361 stems according to the models (kg)	Estimated number of stems per hectare	Fruit production per hectare (kg)	Total fruit production of the studied area (kg)
2012	238.2	530	349.6	17500
2013	145.8	530	214.1	10705
2014	111.3	530	163.4	8169

Economic evaluations

Personal and social characteristics of respondents

Our results showed that of the 17 respondents, 16 (95%) were male and only one respondent was female. The average size of households was 5 people. The average age of the respondents was nearly 48 years with a range of 35 to 55 years. About 65% of all respondents (n = 11 people) were illiterate and 35% (n = 6) were literate. The results showed that 90% (n = 15) of respondents was engaged in agriculture and livestock sector, one person was a civil servant and one person was a casual laborer. There were no governmental constraints regarding forest exploitation, meanwhile they declared that government aimed to launch and implement participatory forest management program. The beneficiaries were suspicious of governmental engagement in forest exploitation. There was no need to acquire harvesting licenses from any governmental organizations and people did not pay for forest exploitation and fruit harvest. There was no predefined time table for fruit harvest from any organizations and beneficiaries could harvest any time they desire.

Estimation of fruit harvest, family consumption, sale and household income

Total harvest, annual family consumption and sale of Cornelian cherry fruit in the forest stand per household in years 2012, 2013 and 2014 are shown in Table 6. Most of the harvested fruit was sold (94.6, 93.6 and 97%) and only a small proportion (5.4, 6.4 and 3%) of the collected fruit was used by households. The fruit was usually sold right after harvest without any processing. However, fruits for family consumption were dried or even pickled by households. Pearson correlation analysis showed that families with higher annual income tended to have higher family consumption (r^2 = 0.94, *p*-value = 0.000).

According to respondents and our personal observations the local sale price per kilogram of ripe fruit were US$ 0.42, 0.62 and 0.71 in years 2012, 2013 and 2014, respectively (Table 7). As shown in Table 7, household's revenue from selling the fruit was greatly varied in the studied time period. For instance, average annual gross value of harvested fruit per household in 2014 was 22.79 times greater than that of year 2012.

Table 6. Total fruit harvest, annual family consumption and sale by households.

Parameters	The number of households	2012		2013		2014	
		Average	Total	Average	Total	Average	Total
Total harvest (kg)	17	288	4900	384.7	6540	394	6700
Annual family consumption per household (kg)	17	15.5	264	24.7	420	11.8	201
Annual sale per households (kg)	17	272.7	4636	360	6120	382	6499

Table 7. Household revenue (US$) from harvesting and selling Cornelian cherry (*Cornus mas* L.) fruit.

Parameters	2012		2013		2014	
	Total	Average per household	Total	Average per household	Total	Average per household
Annual Gross value of fruit harvested by households	2100	123.5	4111	241.8	4786	281.5
Annual Gross value of fruit consumed by households	113.1	6.7	264	15.5	143.6	8.4
Annual Gross value of fruit sold by households	1987	117	3847	226.3	4642.1	273.1
Harvesting expenses (includes labor and transportation costs)	528.3	31.1	986.6	58	1045	61.5
Net income (harvesting and selling fruit)	1458.6	86	2860.3	168.2	3597.3	211.5
Net income (consumption and selling fruit)	1571.7	92.4	3124.3	184	3612.3	220

Table 8. Annual net income gained from Cornelian cherry (*Cornus mas* L.) fruit harvest in proportion to incomes from other activities from 2012 to 2014.

Parameters	The number of households	Minimum	Maximum	Average
Household's economic benefit from consumption and sale of fruits (US$)	17	31.8	204.7	165.4
Household's income from other activities (US$)	17	857.1	2571.4	2200
Household's total income (US$)	17	889	2776.2	2365.4
Contribution of harvesting Cornelian cherry fruit to household's total income (%)	17	3.6	7.3	6.9

Table 9. Key indices of Cornelian cherry (*Cornus mas* L.) utilization in Kallaleh village (three years period).

Indices /year	2012	2013	2014	Average
Economic rent of by product (US$ per hectare per year)	31.4	62.5	64.9	52.9
Expected value of by product (US$ per hectare)	10.5	20.8	21.6	17.6
Marketing margin (%)	66.7	64.3	65.4	65.5
Annual employment	0.98	1.4	1.3	1.2

Estimating the contribution of Cornelian cherry exploitation in households' income

As shown in Table 8, net household income from consumption and selling Cornelian cherry fruit ranges from US$ 31.8 to 204.8 and average net profit per household was estimated to be US$ 165.4 in the study time period from 2012 to 2014. According to households' self-declaration, average annual household's income from other activities (i.e. agriculture and livestock sector, day labor and others) was US$ 2 200. The proportion of income from harvesting Cornelian cherry fruit to total household's income varied from 3.6 to7.3% with an average value of 6.9%.

Key economic indices

The average economic rent from Cornelian cherry was about US$ 52.91 (Table 9). The average expected value of the forest, assuming the discount rate of 3 percent, was estimated to be US$ 17.6. The marketing margin of Cornelian cherry utilization was 65.4 percent and the annual employment of Cornelian cherry utilization was estimated about 1.2.

Discussion

Our analyses of three vegetative characteristics of Cornelian cherry canopy diameter, diameter at collar of the main stem and the number of coppice shoots found that they were significantly correlated with fruit production. This implies that such traits could be used as determinant factors in the management and silviculture operations of the forest stand and even for the purpose of selective breeding of the species and for pomological purposes. However, more biomolecular studies including quantitative trait locus analysis (QTL) are also warranted (Miller & Gross, 2011). For example, each stem characterized with higher crown diameter and healthier coppice shoots should be protected for future breeding. Wälder & Wälder, (2008) reported a significant correlation between stem vegetative characteristics and its effectiveness in the management of multi-purpose trees.

Our results agree with the findings of Ghanbari *et al*. (2011) who also stated that the harvest rate of Cornelian cherry fruit by local people was 25% of total fruit production in the same location. Such increase in fruit harvest coincided with lower fruit production of the forest stand and may be due to a lower average annual precipitation in recent years.

It can be concluded that the higher price was the driving force behind increased harvest rate; especially when it is seen that the sale price increased from US$ 0.42 in 2012 to US$ 0.71 in 2014 (circa 169%). According to maximum allowable harvest rate of 80% (FRWO, 2006), the harvest rate in 2012 and 2013 were within the allowable ranges, while the greater harvest rate in 2014 might be a crucial threat to viability and also sustainability of the forest stand. This may require the engagement of Government and NGOs for monitoring and sustainable management of the forest stand.

Loss of biodiversity is often recognized to be due to unsustainable exploitation of natural resources and can be more rapid and severe in regions with low annual income. In addition, conserving biological diversity can help reducing poverty and improving local population's lives (Sheppard *et al*., 2010; Christie *et al*., 2012). However, according to Cunningham (2001), the harvesting of leaves is less harmful than exploitation of reproductive organs such as flowers and fruits or roots. Therefore, sustainable harvest requires careful species selection, yield studies, monitoring of regeneration and harvesting adjustments (Vodouhe *et al*., 2016).

Our finding that the contribution of average net income from harvesting Cornelian cherry fruit to total average annual households' livelihood was 6.9 (ranging from of 3.6 to 7.3%) differs from that of Ghanbari *et al*. (2011) who reported that in households with lower annual income, the proportion of income from fruit harvesting and sale to annual income was about 31%. Although a study on the contribution of non-timber forest products to annual income of the family has been reported to be more than fifty percent (Sharma *et al*., 2015). In another investigation, Melaku *et al*. (2014) found that the contribution of forest coffee, honey and spices was 47% of annual household income. Considering the value of time spent on collecting fruit, Ghanbari *et al*. (2011) also found that for some households the net contribution of fruit harvest to household's economy was negative especially for those who tended to collect the fruit just for the fun.

In recent years, due to higher prices and also the presence of middlemen, harvesting and also processing (drying) of fruit is very common and have gained considerable popularity amongst the local population, although when the primary occupation of local people is agriculture or livestock farming, the contribution of income from harvesting and selling fruit is little more than a short-term job especially during the late summer. In India, the average annual household income ranges from US$ 2.8 in mountainous area to US$ 112 per hectare for humid deciduous forest dwellers (Narendran *et al*., 2001). This can be compared with the net value of fruit harvest in the Pendjari biosphere reserve in Sudanian savannah forest of Africa which has been reported to be US$ 89 ha^{-1} (Vodouhe *et al*., 2016). However, globally non-timber products accounts for 15 to 50% of annual per capita income of rural households depending on the type and the quantity of harvested by-product and ownership interest (Narendran *et al*., 2001; Ticktin, 2004). It is worth mentioning that the Government is not interested in the ownership of harvested fruits in the study area.

An income of US$ 170 from Cornelian cherry in Kalaleh village compares with reports from evergreen zones (US$ 72.3) and dry deciduous zones (US$ 26) of the Western Ghats, Karnatakam, India (Murthy *et al*., 2005). While the global value of non-timber products of forest in 2005, was estimated to be 18.5 million US$ (i.e. US$ 50 ha^{-1} year^{-1}) (The Global Forest Resources Assessment, 2010). Thus NTFPs are known to be an important component of villagers' livelihoods, especially contributing to employment and income in local communities (Osman *et al*., 2000). For example total annual income from non-timber products has been reported to be 72 and 115 million US$ in Medhayapradesh and Maharashtra, respectively. This compares with values of income of commercial wood of 72 and 29 million US$ in Medhayapradesh and Maharashtra, respectively. Schaafsma *et al*. (2014) and Ndoye (2016) have also reported that non-timber forest products play an important role in sustainable development and livelihood of families both in local and national scales. Our findings reveal that the share of fruit harvesting employment in household income in Arasbaran Biosphere Reserve was about 7%, while that in Bangladesh has been estimated to be 18 percent (Mukul *et al*., 2016). In Mediterranean region annual benefits of non-timber products such as fuel wood, honey, fodder, mushrooms, etc. have been said to be about US$ 54.84 or equivalent to a quarter of the total economic value of the forests (Croitoru, 2007). However, it seems clear that households with higher incomes have lower dependence on revenue from selling NTFPs; likewise their consumption of these products is lower.

With regard to the economic rent of Cornelian cherry unitization was US$ 52.91 ha^{-1} year^{-1}. This compares with that of NTFPs in central Zagros forests in Iran is about US$ 33 ha^{-1} year^{-1} (Moradi *et al*., 2017). However, the economic value of non-timber forest products is dependent on many factors, such as the weather, especially precipitation and temperature, which affect the supply, method of exploitation, market potential, as well as the age and education of the consumers. Values have also been shown to differ depending on the objectives of the study. Its methodology, assumptions, study area, and the type of management (Croitoru, 2007).

The marketing margin of Cornelian cherry was about 65.5 percent. It has been well documented that many factors such as a shift in retail demand, supply, risk, processing, transportation, waste in the distribution network, and many others, affects the marketing margin of goods (Wohlgenant, 2001). Lack of processing and packaging facilities might be major determinants of much larger losses as fruits with a short shelf life have to be sold in a short period of time right after harvest to avoid spoiling. Harvesters therefore minimize the risk of fruit loss by accepting lower prices.

Our results indicate that people harvest the fruit when it suits them and that a lack of harvesting leads to over exploitation. We therefore conclude that launching and implementing projects to conserve non-timber forest products would protect biodiversity and promote the sustainable management of natural resources. These outcomes are made possible by promoting dialogue, organizing and supporting scientific research and engaging in training and advocacy which lead to the improvement of the livelihoods of poor people. We also recommend that selective breeding for higher productivity would be enhanced by evaluating the diversity of the genetic resources of these open pollinated native genotypes. Another tropic is the practice of developing horticultural cultivars using vegetative propagation (Leakey *et al*., 2012; Leakey, 2014).

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