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The Way Towards Getting Back Financial Benefits from Agroforestry Systems and Improving Food Security (The Case of Arasbaran Biosphere Reserve)

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ABSTRACT

Aims Food security depends on the sustainable use of natural resources. Recently, local communities have started planting sumac (*Rhus coriaria* L.) as an agroforestry system in Iran's arid and semi-arid regions. The financial benefit of converting sloping lands to the sumac agroforestry system was compared with cropping cereals land-use option based on wheat and barley production. The study site is located in a semi-arid area in the Eastern part of the Arasbaran Biosphere reserve in Hurand county, East Azerbaijan province, Iran.

Instruments & Methods Data were collected through a combination of socio-economic survey and field inventory. For the household questionnaire survey, 63 samples from four villages were purposively selected. Those who converted low yield croplands to sumac agroforestry system and collected it.

Findings Results showed that sumac collection varied from 144kg in Mollalu to 776kg in Tabestanagh per household annually. Sumac income contributes about 30-40% to total household income, followed by farming and off-farm activities. The net present value of sumac was 4.6 times higher than cropland. The inclusion of sumac income in total household income calculations considerably reduced income inequality among households by 0.36. The processing operations done on the sumac fruit were cleaning, drying, flouring, and packaging. It increased the processing benefit by 10.5USD per kg. The main marketing constraints were selling in raw form without grading and standardization, unawareness about prices, low marketing information, etc.

Conclusion expanding the sumac agroforestry systems by increasing the abundance and density of fruit-providing species is an important way of improving livelihood and security in rural areas.

Keywords Financial Benefit, Income Inequality, Iran, Semi-Arid Region, Sumac

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Introduction

Food security is a growing concern worldwide [1]. Ensuring food security in the world is one of the United Nations Millennium Development Goals [2]. Although food production has increased dramatically over the past 50 years, more than one in seven people still do not presently have access to sufficient food [3]. The United Nations Food and Agriculture Organization (FAO) estimates that about 795 million people worldwide were suffering from chronic undernourishment in 2015 [4]. Pimentel *et al.* [5] have estimated that 3.7 billion or more than half the world's population suffers from malnutrition, and over 40% of deaths are due to environmental degradation. Forest ecosystem services from natural and anthropogenic landscapes are critical for the rural poor's food security and livelihoods in developing countries [6]. Food security depends on the sustainable use of natural resources [7]. Pimentel *et al.* [5] reviewed studies of forest resource use's contributions and values and concluded that forests' integrity is vital to world food security, mostly because of the poor's dependence on forest resources. Reviewing peer-refereed literature on ecosystem services and food security shows that very few research or even case studies exist concerning this subject in Iran [8, 9].

Development practitioners, policymakers, and researchers understand that local communities depend heavily on forests because of multiple livelihood benefits such as nontimber forest products (NTFPs), environmental services, and various other resources [10, 11]. Rural people's income from forests can vary from less than 5% to over 90% [12]. However, rapid population growth results in the mass conversion of natural forests to agricultural lands in developing countries [13, 14]. The main driver for the high rate of forest clearing activities is assuming that crop production provides better income to resident rural populations [15]. There are exceptions. In some cases, local people are known to engage in agroforestry practices or plant trees among agriculture lands to ensure some degree of ecological stability and maximize ecosystem services while still participating in developing agricultural economies [16].

According to the United Nations, drylands take up 41.3% of the land surface area globally. Drylands are defined as arid, semi-arid, and dry sub-humid areas that generally exclude deserts in the context of development potential [17]. The African and Asian continents contain most of the world's arid zones, with 46% and 35%, respectively. In Iran, arid and semi-arid regions cover more than 60% of the land area, and like many similar regions across the globe, desertification is a significant and ongoing risk [18]. A combination of development over the last three decades with unsustainable agro-silvo-pastoral activities on increasingly marginalized lands that have contributed to the degradation of semi-arid and arid systems in Iran [19].

During the second half of the twentieth century, many forest plantations were established across arid lands globally. Plantation programs have used myriad species and techniques ranging from low investment approaches (rainfed) to high investment systems (rainfed with land shaping or irrigated from the water table). The varied successes and failures of such plantations now constitute good sources of information for future activities. Many countries around the world (e.g., Chile, China, Denmark, France, Iran, Mauritania, Niger, Senegal, and Vietnam) have developed tree plantation techniques for facilitating environmental services, especially for controlling soil erosion, which is seen as one of the principal drivers in land degradation and a primary constraint to improve food security in developing countries [20]. In arid zones, both local and large national or international schemes apply such techniques to protect productive lands, infrastructures, and settlements. Many of the plantations were developed with the additional intent of producing both wood and non-wood products [21].

The forests of Iran are managed by the Forest, Rangelands, and Watershed Organization (FRWO). The main missions of FRWO are the formulation of policies and strategies for the management of natural resources and watershed, as well as the planning and implementation of sustainable development programs [22]. For this reason, one of its main policies has focused on developing the use of fruit, providing species such as Sumac (*Rhus coriaria*), Walnut (*Juglans regia*), and Cornelian Cherry (*Cornus mas*) on sloppy lands and rangelands [22]. Concerning the FRWO policies, local farmers in the northeast of Iran have recently begun to plant sumac trees in rangeland for grazing to control soil erosion and provide an alternative livelihood [15]. This system, called the "sumac agroforestry system", has been promoted by FRWO. However, FRWO provided sumac seedlings to farmers who wished to convert sloppy lands to the sumac agroforestry system. In the agroforestry system thus developed, most local farmers let their livestock graze on the plants that grow below and in-between the sumac trees, while some farmers collect the plants and feed their livestock at home.

Sumac's tree species (*Rhus coriaria* L.) with shrub typically reaching 3-4m high have been used in the study site's agroforestry system. The fruits are a drupe, globose, villose, and reddish when ripe, with one seed containing tannins, essential oils, various organic acids, anthocyanins, and fixed oil [23]. Sumac (also known as Tanner's sumac or Sicilian sumac) grows wild mainly in the Mediterranean bordering countries, South Europe, North Africa, Iran, and Afghanistan. New sprouts propagate sumac from rhizomes or seeds. Sumac fruit is widely used as a spice throughout the Middle East. Commonly, it is simply provided as a condiment to be sprinkled on food at the table.

Many scholars have assessed the importance of NTFPs for income generation worldwide, specifically in developing countries [8-11, 24-26]. More granular works have also compared NTFPs, and income from different land uses [15, 27-30]. Malekshahi County is a county of the Ilam Province of Iran and analyzed the quantitative contributions of oak-pistachio tree savannas to rural household incomes [8]. They estimated the contribution of NTFPs in total household income to 6%.

Based on a thorough literature review focusing on ecosystems services and food security, we have no comprehensive research featuring NTFPs role among Iranian communities. Meta-analysis has indicated that NTFPs and tree production can provide a higher income than alternative land uses in some parts of the world [31, 32]. Therefore, the study aimed to evaluate the financial benefits of this specific land use's financial benefits by comparing it to cereal cropping (wheat and barley), the main land-use option.

Instruments and Materials

Case study site

The study site is located in a semi-arid area at the Eastern part of the Arasbaran Biosphere reserve in Hurand county, (38°55′N-39°02′N and 47°22′E-47°27′E), East Azerbaijan province, Iran (Figure 1). This area is a part of the Arasbaran vegetation zone with an average annual rainfall of 290mm and a rainy season from November to May, followed by a dry season from June to October. About 85% of the study area has more than 15% slopes, which reaches more than 35% on about 26% of the study area. Human population density is relatively low with 12 inhabitants/km^2, and the ethnic group is Azeri, whose main livelihood is agriculture (wheat and barley). The farming system consists of alternating cycles of cultivation and fallow. Highly valued trees such as oak and walnut for sheltering and producing fruit are preserved on croplands. Grazing activities by cattle, sheep, and goat herds are extensive. During the last three years, sumac fruit has been purchased and processed by a small-scale processing factory located in the study area.

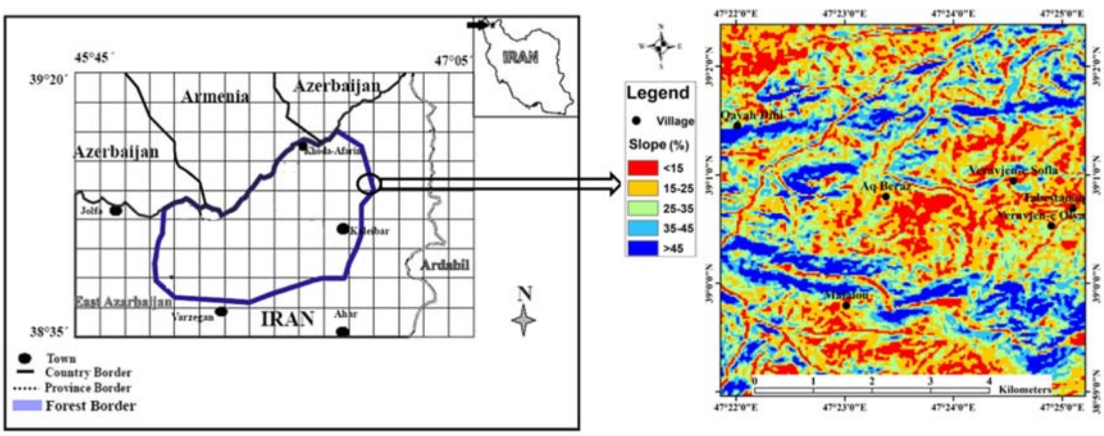

Figure 1) Study area position, Hurand County, East Azerbaijan Province, northwestern Iran

Data collection

Economic revenue from the compared land uses was based on the monetary values of the various physical inputs and outputs involved in their production systems. Data were collected through a combination of socio-economic survey and field inventory. The socio-economic survey involved various data collection techniques such as informal discussion, household questionnaire survey, and focus group discussion. For the household questionnaire survey, 63 samples from four villages (Rahimbayglu, Vurujan Sofla, Mollalu, and Tabestanagh) were purposively selected from the set of farmers who converted low yield croplands to sumac agroforestry system and who collected sumac fruits. The questionnaire was pretested on 18 randomly selected households, and the necessary adjustments were made before being used in the main data collection procedure. Reconnaissance surveys and informal discussions were conducted across the study site to gather essential information into the structured questionnaire for the household interview. Based on the information gathered from the reconnaissance survey, the structured questionnaire was designed to capture information on the history of land use, cropland size ownership, types of crop cultivated, size of land used for each crop, amount of annual inputs and outputs for farm activities by crop type (mainly for wheat and barley), area of cropland converted to sumac agroforestry system, the yield of sumac collected from the agroforestry system, costs and price of inputs and outputs and production and the selling constraints. Interviews were conducted in 2018 using the local language (Azeri). Besides, focus group discussions (FGD) involving 4-5 individuals were conducted with two groups in each village. The information obtained from the FGD was used to triangulate, check, and confirm the data collected through the household interview. Sumac agroforestry plots and harvested cereal crop fields were used for livestock; however, livestock grazes in very numerous places and ecosystems so that the contribution of both compared systems to livestock yield is very difficult to assess. This is why income from livestock grazing was not included in our calculations.

Data on the 63 samples of households' farm plots were used to estimate wheat and barley annual yield per hectare (farm plot yield was divided by farm plot area and extrapolated to one hectare). The mean stem density (stem number per hectare) and yield per tree and year were determined in the sumac agroforestry system [32]. Mean stem density was obtained by counting the number of productive sumac trees in each plot. Sumac yield (kg per hectare and year) was computed by multiplying the mean stem density per hectare calculated above with the mean yield per tree (kg/tree/year) [15, 32, 33]. The yield of trees was obtained through the focus group discussions.

Figure 2) Planting sumac and sumac woodlands at the sloppy lands

The farm gate price was used at the village for prices of inputs and outputs. It was determined through a direct survey of the market for prices and costs of outputs and inputs, respectively [24]. The sumac agroforestry system's total cost was the establishment cost for planting the sumac trees, including the cost of seeds or seedlings, labor, and water during the first year of growth. There was not any annual cost for sumac production, such as fertilizing, plowing, or spraying. The types and quantities of inputs for the land use options were obtained from the information gathered through household surveys and FGD. The total monetary values of the outputs or inputs on a per hectare and year basis were computed by multiplying the number of outputs or inputs per hectare and year with the corresponding unit price of each of the output or input, respectively.

Data analysis and decision criteria

Based on interviews, we computed the compared variables in the two different land uses, and we compared the Net Present Value (NPV) and the equal annual equivalent (EAE) as indicators of profitability. The gross financial revenue of each land-use option was evaluated using Equation 1 following [34].

(1) $GR = (Q \times P)$

GR is gross financial revenue, Q is the number of products harvested, P is the unit price of the products (in Iranian Rial ≈ IRR), all on a hectare basis. The IRR value was converted into USD equivalent according to the current exchange rate at the study (1 USD = 42000 IRR in 2016). Outputs of farming were annual while sumac began production on year five after planting. Starting sumac yield from five years is considered the time of activity in the calculations. Net Present Value (NPV) is used to determine each activity's present value by the discounted sum of all cash flows received from it.

(2) $NPV = -C_0 + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i}$

In the formula, the $-C_0$ is the initial investment, which is a negative cash flow showing that money is going out instead of coming in. C_i is the cash flow earned in each year. r is the discount rate applied for employment creating activities by Iranian banks in rural areas and is equal to 4% [35], and T is the time of activity.

Projects with unequal lengths can be compared using equal annual equivalent (EAE) because infinity is assumed in investment horizons [36]. EAE is the net revenue (or cost) that you can obtain (or will incur) annually, over the life of an investment, given the applied discount rate.

(3) $EAE = \frac{r \times NPV}{1-(1+r)^{-n}}$

Where EAE is equal to annual equivalent, r is the project discount rate, and n is the project life (in years). EAE was applied to 1 year for cereal cropping and to 5 years for sumac agroforestry.

Also, we computed the income diversification index by using the inverse Simpson index of diversity [27]. In general, it is easier to confront income shortcomings such as unfavorable market conditions, if you have diversified livelihood strategies and different income sources than if you have only one income activity.

(4) Index of diversification= $1/\sum_{i=1}^{N} P_i^2$

Several different income sources (N) were recorded from which they generated income Pi.

(5) $\sum_{i=1}^{N} P_i^2 = (\frac{I_1}{I_T})^2 + (\frac{I_2}{I_T})^2 + (\frac{I_3}{I_T})^2 + (\frac{I_4}{I_T})^2 + (\frac{I_5}{I_T})^2$

Total household income (I_T) is the sum of the incomes from different sources such as cropland (I_1), sumac (I_2), animal husbandry (I_3), gardening (I_4), and off-farm employment (I_5). Sumac dependency was measured as the share of sumac income in total household income.

Also, Gini coefficients were calculated for total household income both without and with sumac income [10, 24]. The Gini index measures the degree of income inequality and ranges from 0 (perfect equality) to 1 (maximum inequality).

Findings

Household survey results

Table 1 shows some basic information about the sampled villages. Household size was relatively small compared to the mean household size in the country (4.7 individuals). The four villages were quite similar in terms of household characteristics and assets. The income of our respondents corresponds to different activities. These activities were similar across the sampled villages, but the share of activities varied among villages. It led to a high index of diversity. Villages of Vurujan Sofla (4.2) and Tabestanagh (3.9) have the highest and lowest index of diversity, respectively (Table 2).

The main activities of households were sumac collecting, and farming contributed to household income. Almost all households interviewed were intensively involved in sumac collecting. The relatively large farmland area (ha) was an opportunity for sumac planting, especially on sloping farmland. Each household had farmland for expanding sumac lands. The extent of sumac collection varied from 144 kg per household in Mollalu (as the lower household harvest of the whole sample) to 776 kg per household in Tabestanagh (as the whole sample is higher household harvest) annually. Those three villages (Rahimbayglu, Vurujan Sofla, and Tabestanagh) have started converting sloping lands to sumac lands (about 2001) before Mollalu village (2006). Because extension services and governmental supports were provided lately for Mollalu village. Except in Mollalu village, where sumac contributed only 10% of the total income and where livestock is the most important income source, sumac income was the most important income source in all villages and contributed about 30-40% to total household income, followed by farming and off-farm activities (Table 2). In these three villages, people know well the importance of sumac in their income. The contribution of sumac income to the total income indicates the heavy dependence of rural people on sumac.

The economic comparison of the two land-use options shows that sumac's annual gross revenue is significantly higher than cropland income. NPV of sumac is 4.6 times higher than cropland. Croplands have low cost and revenue compared to sumac. EAE indicator values for sumac (238) and croplands (239.8) are equal.

Table 1) Households characteristics of studied villages

The household characteristics	Village			
	Rahimbayglu	Vurujan Sofla	Mollalu	Tabestanagh
Household number per village	65	33	68	129
Number of households interviewed	14	8	14	27
Average household size	3(0.78*)	3.7(1.38*)	3.7(0.93*)	3.4(1.2*)
The major age group of household head (years)	45-55	45-55	35-45	45-55
Average education of household head (years)	8	10	12	12
Year of extension	2001	2002	2006	2001
Household involved in sumac (%)	80	85	80	94
Household involved in farming (%)	92	92	85	94
The average area per household in farming (ha)	3.46(2.09*)	3.1(1.16*)	7.1(7.2*)	12.7(8.3*)
The average area per household in sumac (ha)	2.1(1.36*)	2.1(1*)	1.35(0.66*)	1.05(1.3*)
Mean number of cattle per household	4.7(1.7*)	3.6(1.2*)	2.78(1.6*)	3.18(2.35*)

* Standard deviation in parenthesis

Table 2) Average annual household income (USD) and share of income by income sources and villages

Income source	Rahimbayglu		Vurujan Sofla		Mollalu		Tabestanagh	
	AHI/yr	Share (%)	AHI/yr	Share (%)	AHI/yr	Share (%)	AHI/yr	**Share** (%)
Farming	1000	18.8	1438	23.6	623	12	1470	19.8
Sumac collecting and sale	1952	36.6	1829	30	550	10.6	2958	39.8
Gardening	357	6.7	457	7.5	794	15.3	559	7.5
Animal husbandry	952	17.9	1664	27.3	1931	37.2	1140	15.3
Off-farm	1071	20.1	707	11.6	1292	24.9	1303	17.5
Total	5333	100	6095	100	5190	100	7431	100
Index of diversification	4.1		4.2		4		3.9	

AHI/yr: Average household income per year

Table 3) Economic analysis of two land-use options (USD/ha/year) at the farm gate

Land-use option	Sumac	Cropland
Yield/year/ha	533	3928
Density/ ha	1280	-
The period used for each system	5	1
Gross revenue	1404.8	381
Total cost	95.2	135.7
NPV (USD)	1059.4	230.6
EAE	238	239.8

The Gini coefficients with and without sumac showed that sumac has a substantial income equalizing effect among rural households. The inclusion of sumac income in total household income considerably reduce inequality among households by 0.36 (Table 4).

The processing operations done on the sumac fruit were cleaning, drying, flouring, and packaging. Sumac processing contributes to household food security and nutrition, generates additional employment and income, and offers opportunities for processing enterprises and improving marketing channels. Sumac processing appears to be a profitable commercial activity for sumac harvesters and traders. It increases the processing benefit as a value addition by 10.5USD per kg (Table 5).

Table 4) Comparison of Gini coefficients of total household income without and with sumac income

Parameters	Gini coefficient
With sumac income	0.21
Without sumac income	0.57
Change units	0.36

Table 5) Impact of sumac processing in its value addition (USD per kg)

Parameters	Sumac
Fruit price before processing	3.8
Fruit price after processing	14.3
Value addition of processing	10.5

Discussion and Conclusions

Assessment of community dependence on different income sources and the contribution of sumac to farmers' livelihood engaged in sumac agroforestry systems was investigated in the Arasbaran region, Hurand County. Our results showed that our respondent household's dependency on sumac in all of the studied villages except Mollalu was more important than on other livelihood sources such as farming, animal husbandry, and off-farm activities. It can be related to the time since the first planting of the sumac agroforestry system, which differs among the four villages. The extent of its collection differed among households widely. The sumac dependency as income of sumac varied from 10% to 40% in the four villages. Our figure of sumac income was comparatively high. Sumac harvesting is the most important income source of respondents households in the three villages (Rahimbayglu, Vurujan Sofla, and Tabestanagh), but in Mollalu, it has a low contribution to total household income. The same action has been done in the rural areas of Konitsa and Kolindros in Greece [37], where the high income of sumac activity and governmental support policies were identified as the main drivers for the conversion of sloping farmlands to sumac lands. Subsidies and grants are seen as financial incentives for converting farmlands to other land uses [37]. In most parts of the world, forest conversion into farmlands and agricultural expansion is considered the main factor of deforestation [38], while we observed the conversion of derelict land into agroforestry systems in our study area.

The economic assessment of the two land-use options shows that sumac can compete in financial terms with agricultural productions. One of the main reasons for the rapid conversion of farming on sloping lands is the economic returns. Factors that may affect the decision to convert sloping lands to sumac lands include awareness regarding realistic possible economic returns of the alternatives and the low economic returns of farmlands compared to the sumac land-use option's economic and ecological returns [15].

According to the Gini coefficient, the inclusion of sumac income in total household income considerably decreased income inequality. It reduced inequality among households by 0.36. Compared with our study, this is identical to the decrease of 0.38 found in northern Benin [24]. Our figure of the Gini coefficient was higher than the increase of 0.13 found in Ethiopia [29] and comparable to the decrease of 0.10 found by Kamanga *et al.* [10]. In general, our study confirms the important role of sumac in food security and improving livelihoods among the rural dwellers. Babulo *et al.* [39] highlighted that participating in all households in NTFPs collection will lead to a low Gini coefficient. In similar to other researches [10, 39], sumac income has an equalizing effect on the distribution of total income in the rural household economy.

Processing can substantially increase local people's income through value addition [34, 40, 41]. Processing creates a value addition of 10.5 USD per kg for the local people. High sumac income and its profitability are highly dependent on the relative levels of the different costs involved, labor, use of specialized technology for processing, and marketing. In contrast, a conclusion was drawn by Avocèvou-Ayisso *et al.* [34] that processing activities are not always profitable due to the high value of these costs. Sumac produced in this region is less known for consumers at the national level. Albeit, the potential profit of sumac can be increased by market development through advertisement. The motivation of local people can be increased by the installation of processing equipment [40]. Also, suitable technologies provide higher prices for products and develop new products for large markets [38]. As some authors claimed, processing creates employment opportunities, especially for women [38, 42, 43].

Our results also showed that local markets were the final destination of sumac, and it has been purchased and processed by a small scale processing factory in the study area. It has been a financial incentive to plant and expand the sumac agroforestry system. Mahapatra and Tewari [28] concluded that market demand leads to a high dependency on collection. The market extension to more remote areas increases both the demand for these products and the opportunity for the income of rural people [38]. Providing new opportunities by market development has been emphasized by other researchers [24, 38, 44].

Identifying and understanding challenges is an important issue in developing marketing strategies with the highest possible success chance. The major constraints in the selling of sumac were collection in small quantity by traditional methods, marketing in raw form without grading and standardization, unawareness about prices prevailing in the markets, absence of notification for sale in regulated markets of the country, and lack of infrastructural facilities like transport, storage, and processing.

We conclude that expanding the sumac agroforestry systems by increasing the abundance and density of fruit-providing species is an important way to improve livelihood and security in rural areas. However, there are means to increase income generation locally without altering forest composition. Our study found a weak local processing industry, which can increase revenue with simple inputs to the post-harvest process. Also, expanding markets, especially at the national and international levels, can increase household income from sumac production.

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