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Livelihood Analysis and a New Inferential Model for Development of Forest-Dependent Rural Communities

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Abstract: The livelihood of many households and communities in the Central Zagros of Iran is strongly dependent on income from forests. While this has led to the widespread over-utilization of forests, poverty levels have remained high and rural development low. The objective of this study was to understand how households utilize forests and to what extent forests contribute to household income and alleviate poverty in order to develop strategies to raise families out of poverty and offer development perspectives to communities that avoid destructive forest utilization. To do so, semi-structured interviews were conducted in five rural communities, community poverty was quantified using several indices (e.g., the Census Ratio Index, Poverty Gap Index), the level of rural development was quantified using socio-economic indicators, and an inferential model was developed that combines household dependence on forests with the level of rural development to provide development perspectives. Local households earned income from nine livelihood strategies that involve forests. Forest-dependent strategies provided the second highest economic share (18.1%) of household income, averaging IRR 27.7 million (USD 657) annually, and moved 12% of households above the poverty line (76% still remained below). Without forest income, most indices of poverty decreased, income inequality increased by 11%, and poverty depth increased 1.54-fold. The low development index of most villages indicates that rural villagers are heavily dependent on forests to meet their livelihood. Our conceptual model indicates that communities should pursue different development strategies that consider whether households depend on forests to meet their livelihood or derive more supplemental income.

Keywords: forest income; poverty indices; rural development; Iran



Citation: Mahmoudi, B.; Zenner, E.; Mafi-Gholami, D.; Eshaghi, F. Livelihood Analysis and a New Inferential Model for Development of Forest-Dependent Rural Communities. *Sustainability* **2023**, *15*, 9008. <https://doi.org/10.3390/su15119008>

Academic Editor: Xuefeng Li

Received: 28 April 2023

Revised: 28 May 2023

Accepted: 1 June 2023

Published: 2 June 2023



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1. Introduction

Although the analysis of rural livelihood has previously focused on the economic factors of life, today, its relationship with other factors, such as the social, political, and cultural conditions of villagers and the overall sustainable and comprehensive rural development, has become very important [1]. In this approach, livelihood and its promotion are considered variables of sustainable rural development, and its linkage to sustainable development is now an accepted concept of sustainable livelihood [2]. This new concept is of particular importance for the analysis of the livelihoods of villages that depend on natural ecosystems such as forests, because here sustainable rural development is directly related to reducing livelihood dependence on forests. Whereas livelihood analyses of forest villages are thus inextricably linked with rural development strategies, the exact mechanisms of rural livelihood in the process of rural development have not been fully explored. If livelihoods are indeed the central element of development [3], then the mechanisms explaining their role in the rural development process must be clearly understood to justify

this centrality. In this study, we related several rural livelihood variables with the rural development index in order to derive inferential models that can clarify the role of various aspects of rural livelihood for rural development. It should be noted, however, that there is a feedback loop between rural development and rural livelihood in that rural development also strongly affects the livelihood of rural communities. This means that all livelihood variables are in some way dependent on the conditions and levels of rural development or lack thereof. The existence of rural development infrastructure can greatly minimize the livelihood dependence of the people and thus achieve forest protection in practice.

Livelihood is a broad concept that includes the presence of assets (i.e., natural, physical, human, financial, and social capital) as well as activities and access to these assets that determine the living conditions of individuals or households [4]. In many developing countries, forest resources provide a vital role in the livelihood of people or households living in and around forests, with estimates that about one billion poor people in the world are heavily dependent on forest ecosystems for their livelihood, which may provide up to 50% of the annual income of communities [5–11].

One region where forests play a vital role in the livelihood of communities is the semi-arid Zagros region in Iran, where forests cover an estimated area of about 5.2 million hectares or 36% of Iran's entire forest area [12]. The Zagros region also hosts the reserves of Dena and Tangsiyad-Sabzkooh, which are registered on the list of Biosphere Reserves in Asia and the Pacific [13]. The Zagros region has always had a high human population density, with 0.53 hectares available per person. Although villagers and nomads have inhabited the Zagros forests for many hundreds of years [14], the record of human exploitation of the forests of the Zagros region dates back about 50 centuries [15]. Today, more than 9.8 million people (>10% of the country's total population) live in the region, with 1.5 million living in rural settlements surrounded by forests. The income of households depends on the larger environmental conditions, infrastructure and facilities available in the region, the broader culture in which families are embedded, and the lifestyle of each household [16–18]. In the Zagros region, economic challenges are severe due to many factors, such as a lack of access to fossil fuels, inability to provide livestock feed through industrial production, and the difficulty to engage in efficient agriculture due to rugged terrain, which have all led to widespread unemployment throughout the region [8]. Thus, villagers in the region often depend on the forest to meet their fuel needs, for grazing livestock, and to expand marginal farmlands [19]. Further, earnings derived from the forest are also an important component of the overall household income, underscoring the importance of the socio-economic function of the Zagros forests and the role of these vital resources for the livelihood and economy of rural and forest dwellers and for the economic and social development of entire communities [20,21]. According to the National Committee for Sustainable Development of the Environmental Protection Agency of Iran, every year, 63,000 hectares of the country's forests are lost, and this deforestation occurs mainly in the Zagros. In fact, among the five forested regions in Iran, the Zagros is the most threatened [22]. Estimates show that the area of Zagros forests in the recent past has declined from about 10 million hectares to 5.2 million hectares today [15]. Studies further show that in the Chaharmahal and Bakhtiari province of the Central Zagros region 399 thousand hectares of forest areas have been destroyed and turned into other uses, which is a loss of 54.4% of the province's forests [23].

Throughout the Zagros region, forests contributed about 12.5% of household income in the northern part [21], which increased to between 25% [20] and 30% [24] in the southern part. It appears that income from non-wood forest products strongly benefitted low-income households in North Zagros [21], while middle-income households benefitted most from the use of forests in South Zagros (based on the Kuznets environmental curve, [24]). However, the not insubstantial economic role of forests in improving the livelihood of local communities has also led to forest degradation in North and South Zagros [21,24].

The extent of dependence of household income on forests, the degree of poverty, and the resulting forest destruction are also dependent on the level of rural development [25].

In fact, poverty and rural underdevelopment are the two key factors underlying deforestation that can be alleviated through thoughtful policies for rural development. For example, whereas policies that sought to control fire and protect Amazonian rainforests in Brazil that ignored rural development issues were not successful [2], developing rural infrastructure through improved access to education and increasing rural income sources proved very effective in reducing pressure and clearing of Brazil's Amazon forests for agriculture [26]. Indeed, upgrading rural infrastructure, such as through the introduction of alternative energy sources, can help local people manage their natural environment more sustainably and reduce deforestation rates [27]. As a consequence, the objectives of effective forest management policy in Zagros and elsewhere are to reduce household poverty in forest-dependent communities as well as reduce the pressure exerted on forest resources to sustainable levels. These objectives may be aided through a planning process that emphasizes the sustainable production and sale of forest by-products [20]. To succeed, effective forest management policy and its successful application must be cognizant not only of the characteristics of the dependence of local communities on various wood and non-wood forest resources for their livelihood but also of the level of development of the local economy.

Considering that poverty and underdevelopment are two key factors of deforestation in developing countries such as Iran, the aim of this study was to test this theory with respect to the sustainability of the forest by developing an inferential model and determining how poverty and underdevelopment may influence the level of livelihood dependence on the forest and thus lead to the stability or lack of stability of the forest in the long run.

While the available information and evidence indicate that the livelihood of local communities is widely and complexly intertwined with the local forest resources, the dimensions of this complexity are still poorly understood, particularly in the Central Zagros region. An improved understanding of the relationship between livelihood and forests is particularly needed in Central Zagros, where forests cover only 12% of the area yet are home to more than half of the plant species diversity of the region [28]. In this study, our main objective was to expand livelihood analyses to Central Zagros by (1) identifying the livelihood strategies used by households in the region, (2) determining the extent to which forest use contributes to the micro-economics and incomes of individual rural households and the livelihood of local communities, and (3) assessing the relationship between poverty, income and rural development, and forest sustainability within a newly proposed inferential conceptual model that places the dependence of household incomes on forests in the broader context of indicators of the level of development of local communities.

Although various factors, including subsistence capital and natural capital [29], the presence of agricultural land, distance from markets [30], and ownership of physical assets [31] are known to be among the most important factors that determine the choice of livelihood strategy, this study expands previous knowledge by testing the relationship between the amount of people's income and the rural development index and relating the degree of dependence of forest dwellers on forest resources to forest sustainability.

2. Materials and Methods

2.1. Study Area

The Central Zagros region includes the entire area of the Chaharmahal and Bakhtiari province and parts of five other Zagros provinces that cover an area of 3.1 million hectares. The study area is located in the Chaharmahal and Bakhtiari province, whose forests cover 307,000 hectares, equivalent to 18.5% of the province's area [23]. The study was conducted in the five forest villages of Hosseinabad, Hajiabad, Ahmadabad, Aliabad, and Shahrak-Mamour, which comprise Lordegan township (Figure 1). Lordegan is in the Sardasht region, which is a region where local residents have traditional or customary rights to the use of natural resources in public forests. The villages are located in a mountainous area with an average altitude of 2040 m above sea level that encompasses about 5000 ha. The

main forest cover of the study area is Persian oak. The total population of the five villages is about 5824 people who belong to the Bakhtiari tribe and live in 906 forest households.



Figure 1. Location of the study area in the Zagros region of Iran.

2.2. Methodology Framework

This livelihood analysis study of local communities was based on semi-structured interviews of rural households that were executed in five stages and included the determination of (1) the types of household living strategies, (2) the income from each of the wood and non-wood products derived from the forest, (3) the status of poverty and inequality indicators and their relationship to household income from forest resources, quantification of (4) the rural development index, and (5) the development of an inferential model of the combined stimulus factors. The first and second steps were performed based on the analysis of data collected through a questionnaire. The third step was calculated by using the equations of poverty and inequality indicators. In the fourth step, the rural development index was obtained by selecting related criteria and indicators and using the Morris relationship. The last step involved the creation of a conceptual model that encompassed the two factors of household income and rural development index.

2.3. Survey and Questionnaire Analysis

A questionnaire was developed to elicit information on the various livelihood strategies used by the villagers, their income level, social and economic characteristics, and the kinds and amounts of forest products harvested and sold. A total of 170 questionnaires, corresponding to 18.7% of the total population of rural households, were completed through an in-person interview with the head of the household and with an acceptable marginal error of 7% based on Cochran's formula [32,33]. Households included in the sample were randomly selected in each village. The content validity approach based on Cronbach's alpha coefficient was used to determine the internal consistency or reliability of the questionnaire, which was computed to be 0.77 (on a scale between 0 and 1, values above 0.7 are considered acceptable in the social sciences; [34]). After determining the required sample size, households were randomly selected to complete the questionnaire in each village based on number of households in each village (Table 1). The questionnaire consisted of three parts: 1, the social and economic characteristics of the household; 2, subsistence characteristics; and 3, the type, amount of consumption, and income from forest resources. The questionnaires were completed in two months in the summer of 2020. After collecting and categorizing the data, we assessed the role of each livelihood strategy, especially the contribution of income from forests to the household economy and quantified the income derived from forests separately for wood-based and non-wood forest products. Data analysis was undertaken using SPSS 27 software.

Table 1. Number of selected questionnaires in each village.

Number of Questionnaires	Number of Households	Villages
24	126	Hosseinabad
9	54	Hajiabad
8	41	Ahmadabad
25	135	Aliabad
104	550	Shahrak-Mamour
170	906	Total

2.4. Calculation of Poverty and Inequality Indices

The effect of neglecting the contribution of income from forests in terms of the livelihood of forest-dwelling households was examined, and each poverty index was computed and compared with and without the income derived from forests. The significance of the contribution of forests to the average household income was assessed with a *t*-test. Using the poverty line (equal to IRR 38 million per person per year or USD 900) reported by the Iranian Parliamentary Research Center in (2020) [35] and pertinent information from the completed questionnaires, the indices of poverty and inequality consisting of the Census Ratio Index (CRI) or poverty rate, the Poverty Gap Index (PGI), the Foster, Greer and Thorbecke Index (FGTI), the Gini Coefficient (GC), and the Sen Poverty Index (SPI) were calculated for each study village.

The CRI was computed using Equation (1) [36]:

$$H = q/n \quad (1)$$

where *H* is the census ratio index or poverty rate, *q* is the number of poor people, and *n* is the total number of people in the community.

The PGI is based on the overall difference or distance of the income of a poor person/household from the poverty line, which is an indicator of the depth of poverty. The poverty gap for all poor households (*q* households) was computed using Equation (2) [33]:

$$P_{gap} = \frac{1}{n} \sum_{i=1}^q \frac{(z - x_i)}{z} \quad (2)$$

where P_{gap} is the poverty gap, *n* is the number of people in the community, *q* is the number of poor people, *z* is the poverty line, and x_i is the income of the *i*th poor person/household.

The FGT index [37] is a measure of the inequality among the poor that enables placing different weights on income levels when calculating poverty; the FGT index is thus a decomposable poverty measure that allows investigations of poverty levels in different population subgroups. The FGT was computed using Equation (3):

$$FGT_a = \frac{1}{n} \sum_{i=1}^q \frac{(z - x_i)^a}{z^a} \quad (3)$$

where FGT_a is the Foster, Greer and Thorbecke Index, *n* is the number of people in the community, *q* is the number of poor people, *z* is the poverty line, and x_i is the total household income and, when *a* is equal to 2, it is the lowest (whole) parameter to weigh income inequality along with poverty and is interpreted as the poverty escape coefficient of the community.

The GC is the most famous and most commonly used index of income distribution inequality [38]. Although different methods to compute the Gini coefficient exist, the method of Mills and Zandvakili [39] is now most widely accepted and was also used in the present study. The GC was computed using Equation (4):

$$G = 1 - \sum_i^n (X_i + X_{i-1})(P_i + P_{i-1}) \quad (4)$$

where G is the Gini coefficient, X_i is the cumulative percentage of households in the income group, P_i is the cumulative percentage of income in the income group, and n is the number of income groups which was set to 9 in this study.

The SPI considers the relative deprivation of poor people compared to other people in society [40]. The SPI is sensitive to the number of poor people, the severity of poverty, and the income inequality among the socio-economic characteristics of the poor households studied. The SPI was computed using Equation (5) [36]:

$$SPI = H[I + (1 - I)]G \quad (5)$$

where SPI is the Sen Poverty Index, H is the percentage of the poor, I is the relative income gap (poverty gap), and G is the Gini coefficient of the income distribution.

2.5. Rural Development Index

The selection of the criteria and indicators used to measure village/rural development depends on the scale and purpose of the study and the availability of reliable local data and information rather than a predetermined theoretical framework [41,42]. We selected 5 criteria and 18 indicators recognized in previous rural development assessments, and for which local data were available, to describe the village development [22,43,44] (Table 2). The quantification of rural development indicators was carried out using information from the Lordegan city governorate, rural management, and rural health houses.

Table 2. Criteria and indicators for measuring rural development.

Criteria	Indicators
Social	Number of population
	Household size
	The rate of migration outside the village
	The rate of migration into the village
Education	Percentage of literate population
	The ratio of female to male literate population
	Number of primary schools
	Number of middle schools
Political-administrative	Existence of village council
	Existence of a rural management office in the village
	Existence of a rural cooperative company
Health and Medical	Existence of an active health house
	Existence of an active health center
Infrastructure	Existence of asphalt roads
	Existence of gas in the village
	Access to radio and television networks
	Access to telecommunication network and mobile phone
	Existence of sports facilities

2.6. Degree of Rural Development

The degree of the development of the study villages was determined using the Morris method [45], which is one of the most common methods for grading the level of development of areas [46]. The method determines village development status using the available information of the chosen development criteria and indicators (i) of each village (j). For indicators with a positive effect, Equation (6) was used:

$$MII_{ij} = \frac{x_{ij} - x_{ijmin}}{x_{ijmax} - x_{ijmin}} \quad (6)$$

where MII_{ij} is the value of the Maurice mismatch index for the i th indicator in village j , X_{ij} is the numeric value of indicator i in village j , X_{ijmin} is the minimum value of indicator i , and X_{ijmax} is the maximum value of indicator i in village j .

If the indicator has a negative effect, Equation (7) is used:

$$MII_{ij} = \frac{X_{ijmax} - X_{ij}}{X_{ijmax} - X_{ijmin}} \quad (7)$$

In the next step, the average Maurice mismatch index was computed for each village across all indicators (Equation (8)) and used as a criterion to determine the rank or development status of each village:

$$MII_j = \frac{1}{n} \sum_{i=0}^n MII_{ij} \quad (8)$$

where MII_j is the development index for area j and n is the number of indicators considered. If the development index is between 0 and 0.5, the region has a low level of development, between 0.5 and 0.8, the region has a moderate level of development, and between 0.8 and 1, the region is developed.

2.7. Inferential Model

Finally, an inferential model of stimulus factors was developed that combines the rural development index with household income, enabling the determination of the position of each village in the inferential model (Figure 2). Low levels of development and low household income lead to a severe dependence of people's livelihoods on forest resources (lower left quadrant [1]). Increased levels of household income, along with a lack of development in the area, provide context and increased motivation for migration to larger villages or surrounding cities (upper left quadrant [2]). Low levels of income combined with high levels of development in the region reduce people's dependence on forest resources for their livelihood, but the incentive to earn more income nonetheless causes a dependence on forest resources (lower right quadrant [3]). High levels of both income and rural development reduce dependence on forest resources and promote forest sustainability (upper right quadrant [4]). The poverty line (vertical line) is used to separate the left and right quadrants in the figure.

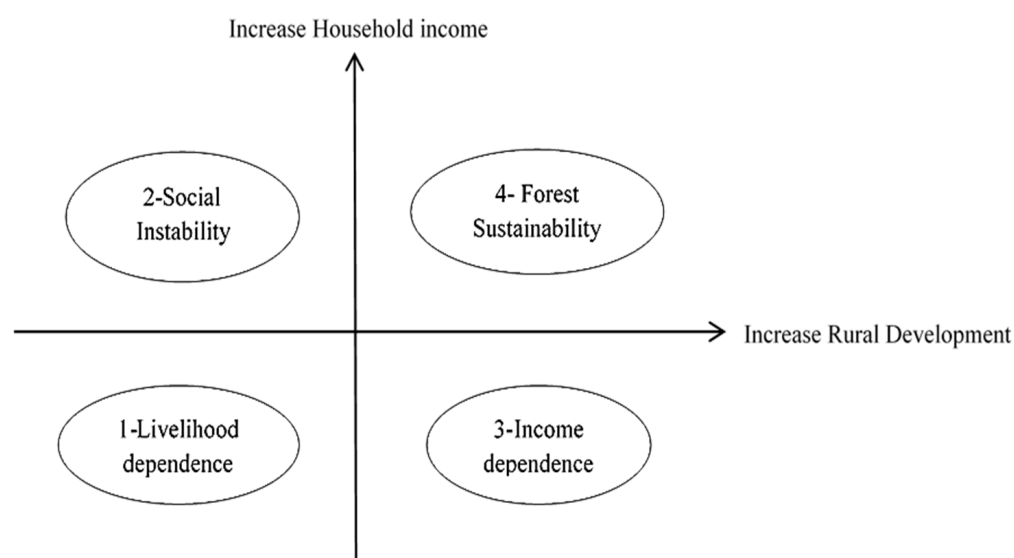


Figure 2. Inference pattern of stimulus composition for determining the position of each village within the conceptual model.

3. Results

3.1. Socio-Economic Characteristics of Households

The vast majority of the surveyed heads of households were male (94%). Most of the interviewees were 40–49 years old (32%), followed by 30–39-year-old interviewees (26%). The average household size in the region was 6.2 people; 79.4% of households were permanent residents, and 20.6% were nomads. The majority (45%) of respondents were illiterate, and 8% held a bachelor's degree (Table 3).

Table 3. Socio-economic characteristics (estimated using questionnaire analysis) for each study village.

Indicators		Hosseiniabad	Hajiabad	Ahmadabad	Aliabad	Shahrak-Mamour
Average household dimension		6	6.30	6	6.20	6.50
The average age of people		42	36.30	35.80	48.30	45.10
Gender (%)	Female	70	77.80	75	28	26
	Male	30	22.20	25	72	74
Residence (%)	Permanent residence	95.80	100	100	56	77.90
	Nomadism	4.20	0	0	44	22.10
Education (%)	Illiterate	58.30	44.40	25	44.40	43.30
	elementary	29.20	33.30	50	33.30	26.90
	Sixth elementary	8.30	11.10	25	11.10	13.50
	Diploma	0	0	0	0	7.70
	Bachelor	4.20	11.10	0	11.10	8.70

3.2. The Economic Role of Forests

3.2.1. Livelihood Strategies

Villagers depend on nine livelihood strategies to earn a living. Income is most frequently derived from forests, agriculture, and by providing labor (Figure 3). Note that these frequencies do not add up to 100% because individual household income may be derived using several strategies. For example, while 14.7% of households earn some money from driving, for some households, this may be the main job, and for others, it may be a second or third job. The meaning of agricultural income is the income derived from cultivation activities under the forest canopy, and the meaning of gardening income is the income derived from the cultivation of fruit trees. Livestock income means the income is derived from the sale of light and heavy livestock (i.e., sheep, goats, and cows).

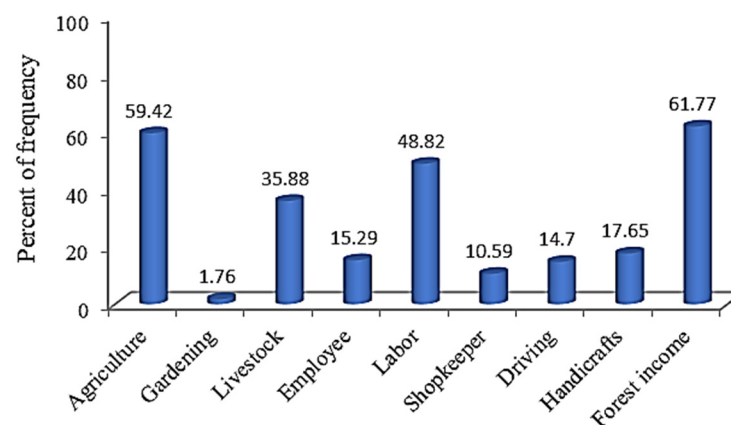


Figure 3. Household living strategies (extracted from questionnaires) averaged across the five study villages.

Table 4 shows the share of each source of income in the household economy. The average annual household income was IRR 153, with a minimum of 20 million and a maximum income of IRR 384 million. The greatest share of the average income of these rural households is derived from labor (26.9%). The average income from forests accounts for an additional 18.1% and is the second largest source of income in terms of meeting rural livelihoods.

Table 4. The role of different livelihood strategies in the annual income of households averaged across the five study villages.

Livelihood Strategies	Average Income (IRR Million)	Maximum Income (IRR Million)	Standard Deviation (IRR Million)	Total Household Income (%)	Rank
Agriculture	14.71	100	23.69	9.60	5
Gardening	0.29	2	0.23	0.02	10
Livestock	24.07	200	42.75	15.68	3
Employee	11.82	240	37.04	7.71	6
Labor	41.31	200	48.73	26.93	1
Shopkeeper	11.38	150	29.36	7.40	7
Driving	15.03	170	37.38	9.80	4
Handicrafts	5.54	200	19.75	3.61	8
Forest income	27.72	180	41.38	18.07	2
Other	1.80	100	12.22	1.18	9
Total income	153.42	384	75.08	100	----

3.2.2. Forest Income

Income from the forest is derived from several products (Figure 4). The sale of firewood is the most frequent source of forest-based household income (30%), followed by the sale of edible plants, which include 14 species, and the sale of medicinal plants, which includes a further seven species. Seeds and fruits include oak, coriander, cumin, hawthorn, and barberry.

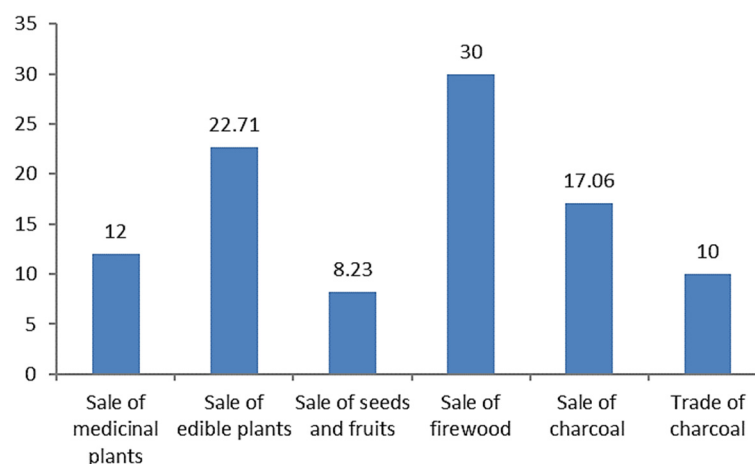


Figure 4. Forest income sources (extracted from questionnaires) averaged across the five study villages. Note that the trade of charcoal denotes a business activity that includes buying and selling of charcoal whereas the sale of charcoal does not include the sale of charcoal produced by other households.

Table 5 shows the amount that each source of forest income contributes to the household economy. The average annual household income derived from the forest was equal to IRR 27.72 million (USD 658), of which the sale of firewood accounted for the greatest share (42.3%). The average annual sale of firewood was 5.60 cubic meters per household per year.

Table 5. The role of each source of forest income in the household economy across the five study villages.

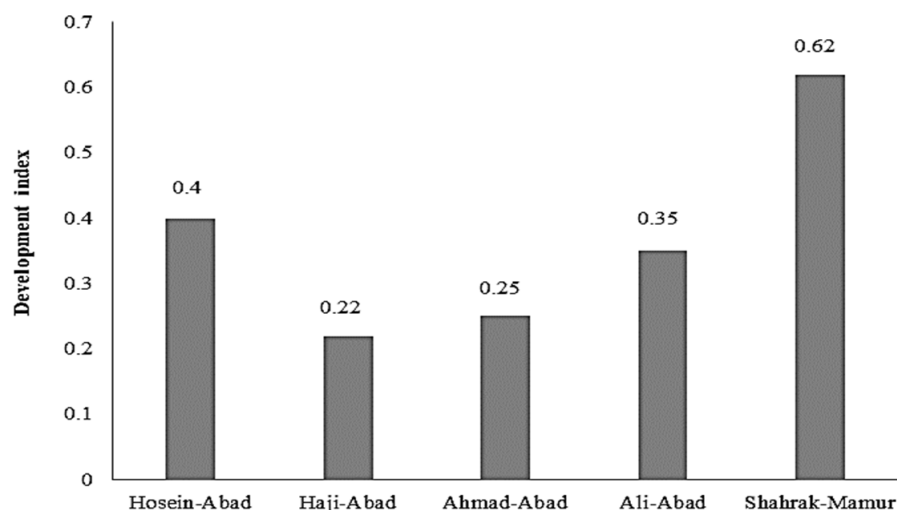
Income Resources	Average Income (IRR Million)	Maximum Income (IRR Million)	Standard Deviation (RR Million)	Total Household Income (%)
Sale of firewood	11.75	100	22.84	42.33
Sale of charcoal	6.62	80	17.27	23.95
Trade of charcoal	5.21	100	17.86	18.76
Sale of medicinal plants	2.61	50	8.04	9.42
Sale of edible plants	1.42	20	3.24	5.10
Sale of seeds and fruits	0.12	5	0.59	0.44
Total forest income	27.72	180	41.38	100

3.2.3. Indices of Poverty and Inequality

The rural poverty line per person is equal to IRR 38 million per year (corresponding to IRR 235.6 million for an average rural household of 6.2 persons). Based on this poverty line, 76% of the households in the study area live below the poverty line. Without the amount of household income derived from forests, 88% of households would live below the poverty line. Further, without income derived from forests, the depth of poverty (PGI) would increase from 0.26 to 0.40, the FGTI would increase from 0.15 to 0.23, the GC would increase from 0.26 to 0.37, and the SPI would increase from 0.34 to 0.55. Among the studied villages, income from the forest raised household incomes the most above the poverty line in Hajiabad village. The mean total income with and without forest income differed significantly in all villages (t -test, all $p < 0.001$).

3.2.4. Rural Development Index

Figure 5 shows the development situation in each of the five study villages. The highest level of development (0.62 or moderate level of development) was observed in the village of Shahrak-Mamur. The other four villages were at a low level of development.

**Figure 5.** Development situation of each of the five study villages (extracted from questionnaires).

3.2.5. Inference Pattern of Stimulus Composition

Figure 6 shows the location of each study village in the inferential conceptual model. Only the village of Shahrak-Mamur is in the lower right quadrant, while the other four villages are in the lower left quadrant, indicating strong dependence on household income in Shahrak-Mamur and strong dependence of households on forest resources for meeting their livelihood in the villages of Hosseinabad, Hajiabad, Ahmadabad, and Aliabad.

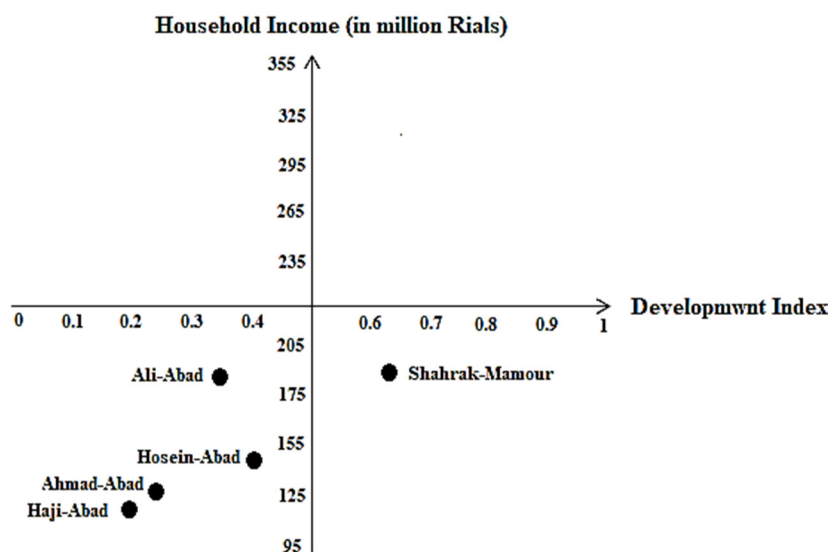


Figure 6. Location of the study villages in the inferential conceptual model.

4. Discussion

Large proportions of households deriving high levels of their relative income from forests generally point to several shortcomings in regions that limit economic development. These shortcomings typically include a limited capacity of the land or limited infrastructure that preclude engaging in more profitable agriculture or other economic activities, the lack of investment capital, and typically low levels of education in the population [47]. Indeed, in this Central Zagros study area, the education levels of most household members were generally poor and often reached only the primary level. This leaves household members with few options for any gainful employment beyond being hired out as laborers, cementing the heavy dependence of households on income derived from forests. Specifically, households in Central Zagros rely on forests for an additional average annual income of IRR 27.72 million (USD 657) or 18.1% of total household income. The benefit provided by forests to the overall economic situation of marginalized rural households in the customary region of Sardasht is not inconsequential and is larger than the 12.5% of total household income observed in North Zagros [21] and smaller than the 25–30% observed in South Zagros [20,24]. In fact, the relative contribution of forest resources to household income in Central Zagros is broadly comparable to that of the 6–15% observed in southern Cameroon [48] and 15% in southern Zimbabwe [49] and Malawi [50] but lower than the 15–50% in southern India [51], 27% in northern Ethiopia [52], 30% in Hyrcanian forests in Iran [11], 31.5% in southern China [8], 39% in northern Benin [53], and 49% in Oca, Peru [10].

The overall importance of forest-derived income for the rural economy in this study area is further underscored by the fact that this income lifted 12% of households above the poverty line. Although this estimate is much smaller than the 32% [11] and 50% [24] of households that were lifted above the poverty line through forest-derived income in South Zagros, this lower estimate for Central Zagros is, in fact, attributable to the prevailing poverty in the customary area of Sardasht. Not only is the rate of villagers who live below the poverty line (76%) in Sardasht much larger than the 13% observed in South Zagros [24] and 41% observed in North Zagros [21], but the depth of poverty of households is also large. The poverty gap index of 0.26 in the study area indicates that the households would need to increase their income by 26% of the current poverty line for the average household income to reach the poverty line. The elimination of forest income would increase the poverty gap index to 0.40 and the depth of poverty 1.54-fold. Similarly, eliminating income from forests would increase the severity of poverty measured by the Foster, Greer, and Torbek index from 0.15 to 0.23 and income equality measured by the Gini coefficient from

0.26 to 0.37, resulting in more extreme poverty expressed by the increase in the Sen Poverty Index from 0.34 to 0.55.

Although it is currently unclear whether, and if so, to what extent the harvest and sale of medicinal and edible plants may have led to a decline of these plant species, it is clear that the large share (85%) to which forest wood in the form of firewood sale and charcoal sale and trade contributes to the total forest-derived income of these marginalized rural households of Central Zagros has resulted in increased deforestation of public forests in the region. This is a consequence of unregulated logging activities that occur without regard to the sustainable renewal of forests. This large share of wood-related earnings to total forest income, which translates into ~15% of the total household income of marginalized rural villagers in the customary region of Sardasht, is comparable to estimates from other parts of the world. For example, income from forest timber accounted for 13–18% of total household income in Benin [50], 12% in northern Ethiopia [52], and 23% in southern Ethiopia, where the high use of firewood accounts for a larger share of income related to wood [54]. It is noteworthy that the timber-related share of total household income was only 1.4% in North Zagros, where non-timber forest products contribute nearly 90% to income derived from forests and the rate of tree felling is low [21].

Rural development indices in this study were categorized as low to moderate levels of development and were comparable to values obtained for villages in North and South Zagros [55] as well as in Ethiopia [56]. Improving the rural development index relies on policies, macroeconomic strategies, and rural planning, which requires that managers and decision makers acquire a nuanced understanding of the complexity of the dependence of the livelihood of local forest communities on forests and its linkage to development indicators at the local, regional, and national levels. This is a topic that has also been investigated in previous studies [2,26,27].

In this study, we developed a conceptual inferential model based on the empirically determined relationship between the role of forests in livelihood strategies (income) of households and the level of rural community development (rural development index). Placing each study village within the two-dimensional conceptual model space provides rural development policy makers and planners with a more tailored perspective to meet the needs of each village. It can be safely assumed that a continued laissez-faire approach and the absence of guiding forest policies will aggravate the economic situation of villagers. With this approach, demands on local public forests will only increase over time and lead to a deeper dependence on forests for income generation and greater deforestation, damage, and instability of regional forests. It is clear that the long-term policy objective is to move the position of each village to the upper right quadrant of the conceptual model that denotes forest sustainability, where levels of average household incomes well above the poverty line and above-average rural development reduce dependence on forest resources. Consequently, different strategies need to be developed that consider the placement of each village within the conceptual model and not lose sight of the nine livelihood strategies, particularly the forest income strategies that benefit nearly 62% of all rural households.

We propose a two-pronged strategy to move the four villages from the lower left quadrant of the conceptual model (i.e., subsistence dependence) to the upper left (i.e., greater household income) or lower right quadrants (i.e., greater rural development). The first strategy takes advantage of the fact that nearly 60% of rural households engage in some form of agriculture for their livelihood. Current agricultural practices are not very efficient and often carried out in forests, resulting in damaged trees, impoverished soils, and eroded soils. Helping rural villagers develop more efficient agriculture and agroforestry techniques and cultivation practices to sustainably grow non-timber products such as medicinal plants, food, fruits and seeds of trees and forest shrubs that currently contribute only 15% to overall household income from forests may be effective in conserving soil quality and slowing or halting the further degradation of forests. While a shift from wood harvesting and timber extraction toward the sustainable production of non-timber forest products may not fully alleviate the subsistence dependence of villagers on forests, the

second strategy would seek to direct the use of forests away from exploitation of timber and/or plants toward softer approaches such as ecotourism. Ecotourism would require investments in infrastructure projects and power transmission lines and may not only directly increase the income levels of rural households but would also lead to improved rural development (i.e., a shift of the position of rural villages to the lower right quadrant).

In this study, an attempt was made to propose new livelihood strategies based on the location of the villages in the inferential model to improve the livelihood of forest households and thus keep the forest sustainable. For this reason, the modification of agricultural practices, the cultivation of edible–medicinal plants, the cultivation of forest fruit trees, and ecotourism were suggested. By implementing the introduced strategies, rural development criteria (Table 2), including social growth, education, health and medical services, political–administrative system attributes, and finally, infrastructure, will be improved. The diversification of rural livelihoods is a basic strategy for reducing poverty and, as a result, improving rural development indicators and mitigating the effects of environmental hazards on the forest [57,58].

The inferential model introduced in this study enabled the investigation of our central research hypothesis that the contrast between household income and the rural development index in the forest villages of the central Zagros can play a key role in the sustainability or non-sustainability of the forest. In fact, in villages where both the household income is low and the rural development index is not favorable due to the severe livelihood dependence of forest dwellers, the forest is destroyed and ever more pushed towards instability and loss.

5. Conclusions

Following a description of the livelihood characteristics of Central Zagros forest dwellers and a determination of the extent of forest involvement in household livelihood, we analyzed the relationship between household income levels and the rural development index in terms of the rate of destruction or preservation of forest structure. We further developed a conceptual model based on the assumption that higher household incomes and lower poverty indices reflect higher rural development indices whereby deforestation is reduced to meet livelihood needs, increase income, and lead to forest sustainability. This conceptual model can be used as a guide to understanding the complexity of the relationship between rural development, poverty, and forest protection.

Combining the economic situation of individual households with the development status of their home village within the inferential conceptual model enables us to propose different strategies that could be pursued to gradually move households and villages from a position of livelihood dependence or income dependence toward forest sustainability. Undoubtedly, with more research in other forest areas of developing countries, different dimensions of livelihood dependence on forest, rural development, poverty, and forest dynamics can be achieved.

While the living conditions of local forest communities in Central Zagros and their relationship with the rural development index were investigated in only five villages in this study, adding more villages in future livelihood analyses will achieve a more comprehensive picture of the living conditions of forest communities throughout the region. Future studies can also help improve the inferential model by adding the conditions and development over time of other Central Zagros villages. Considering more diverse dimensions of effective indicators of poverty and rural development may also facilitate the development of a more comprehensive multidimensional model to improve our understanding of the protection and sustainability of forests in other forest ecosystems of the world.

Author Contributions: Conceptualization, B.M. and E.Z.; methodology, B.M., E.Z., D.M.-G. and F.E.; software, B.M. and E.Z.; data curation, B.M., E.Z., D.M.-G. and F.E.; writing—original draft preparation, B.M. and E.Z.; writing—review and editing, B.M., E.Z., D.M.-G. and F.E.; visualization, B.M. and E.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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