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Agroforestry Systems in Arasbaran Region, Obstacles and Opportunities for Farmers in Combating with Climate Change

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ABSTRACT

Aims: Climate change significantly threatens food security and environmental sustainability in semi-arid regions, such as northwestern Iran, where declining rainfall and rising temperatures challenge agricultural productivity and resource management. Agroforestry systems, integrating agriculture, forestry, and animal husbandry, have emerged as a promising solution to these challenges. This study evaluates the potential of agroforestry systems for enhancing resilience to climate change in the Arasbaran Region of northwest Iran.
Materials & Methods: The research assesses the impact of these systems on soil quality, biodiversity, and water resource optimization through a detailed survey of 78 households. Quantitative and qualitative questions were used to collect information from the sample households. The main questions addressed personal characteristics, occupation, farm details, types of species, costs, incomes, types of harvested products, selling methods, changes in species and products over time, and factors affecting production levels.
Findings: Results indicate that agroforestry practices, such as integrating drought-resistant tree species with crops and livestock, improve soil health, conserve moisture, and diversify income sources. Despite these benefits, farmers face obstacles, including inadequate technical knowledge, limited access to quality seedlings, and insufficient policy support. Socioeconomic factors such as land tenure and financial constraints further complicate widespread adoption. The study reveals that income increase is the primary motivation for adopting agroforestry, while challenges such as lack of government support and educational gaps are significant barriers. Apple (56%) and walnut (41%) are the most commonly planted species, followed by poplar (20.5%) and sour cherry (15%). The three-year mean household income is 2,185 million rials (SD= 2,382).
Conclusion: Overall, agroforestry presents a valuable opportunity for improving agricultural sustainability and resilience in arid and semi-arid regions. Addressing existing challenges through targeted interventions and leveraging traditional knowledge and international examples can enhance the effectiveness of these systems in mitigating the impacts of climate change.

Keywords: Farmers' Challenges; Resilience; Semi-arid Regions; Sustainability.

CITATION LINKS

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Introduction

Climate change is increasingly considered a severe threat to food security and environmental sustainability in semi-arid regions of the world, including northwestern Iran. These areas face many challenges, including decreasing rainfall, increasing temperature, and lack of water resources, which affect agricultural production and residents' quality of life [1]. In this regard, agroforestry systems have been introduced as a sustainable and effective solution to these challenges. Combining agriculture, forestry, and animal husbandry can improve soil quality, increase biodiversity, and optimize water resource use [2]. In the northwest of Iran, agroforestry systems can play a crucial role in increasing the resilience of farmers against climate change. Integrating trees with crops and livestock helps conserve soil moisture, reduce erosion, and improve the quality of agricultural ecosystems. In addition, due to the need to adapt to changing climatic conditions, these methods enable the optimal use of limited water and soil resources. They can effectively help deal with the adverse effects of climate change [3].

Agroforestry systems, which combine trees and shrubs with crops and livestock, are increasingly recognized as a viable strategy for enhancing agricultural productivity and environmental sustainability, particularly in arid and semi-arid regions. In arid and semi-arid areas, agroforestry offers several advantages. It can improve soil health through organic matter addition, enhance water retention in the soil, and diversify income sources for farmers [4, 5]. For example, integrating drought-resistant tree species with traditional crops can create a more resilient agricultural system better equipped to withstand climatic fluctuations [6]. This resilience is crucial in regions where conventional farming practices are increasingly unsustainable due to water scarcity and soil degradation [4]. However, adopting agroforestry systems in these regions is not without obstacles. Farmers often face challenges such as inadequate technical knowledge, limited access to quality seedlings, and insufficient support from agricultural policies [7]. Additionally, socioeconomic factors, including land tenure issues and financial constraints, can hinder the widespread implementation of agroforestry practices [8]. The successful integration of agroforestry into farming systems requires addressing these barriers through targeted interventions, including capacity building, improved access to resources, and supportive policies [1].

Opportunities for advancing agroforestry in arid and semi-arid regions include leveraging traditional knowledge and practices, enhancing farmer engagement through participatory research, and fostering partnerships between governments, NGOs, and local communities [9]. In Iran, for example, using drought-tolerant species and traditional agroforestry practices has shown promise in improving land productivity and resilience [8]. Internationally, successful examples of agroforestry implementation in similar climates, such as the Sahel region in Africa, provide valuable lessons on overcoming challenges and maximizing benefits [10].

Agroforestry systems in Iran highlight a range of practices that enhance sustainable land use, particularly in semi-arid, arid, and mountainous regions. These systems include silvopastoral systems, where trees coexist with livestock to improve grazing and soil health, and agro-silvicultural systems, which integrate trees with crops to boost biodiversity and productivity. Agrosilvopastoral systems, combining trees, crops, and livestock, are common in rangeland areas and are recognized for their role in land restoration. Studies also emphasize forest farming for non-wood forest products like medicinal plants, which contribute to rural economies, and windbreaks to combat desertification in arid zones. Homegardens, especially in northern Iran, and riparian buffers planted along waterways aid soil and water conservation [11]. Although less widespread, alley cropping and Taungya systems are gaining attention due to their potential for reforestation and improving agricultural yields. Despite challenges like resource access and policy limitations, the research underscores these systems' potential for addressing climate change, food security, and rural development.

Different researchers have focused on services provided by different agroforestry systems [12-19]. For example, researchers conducted a meta-analysis of 52 studies comparing cocoa agroforestry systems with monocultures. Although cocoa yields in agroforestry systems were 25% lower than in monocultures, the overall productivity of these integrated systems was nearly ten times higher, contributing significantly to food security and diversified income streams [13]. Using statistical analyses, researchers examined species diversity and carbon stock across four agroforestry systems in northern Ethiopia. Data were gathered from 197 farmers practicing agroforestry. The results showed that species richness was more significant in mixed cultivation and scattered planted lands than in forest stands [14]. However, sparsely planted lands had lower carbon stocks than other agroforestry systems. The study concluded that mixed cropping and marginal planting can improve tree diversity and carbon sequestration in Ethiopia's arid ecosystems. Researchers analyzed current and future habitat suitability patterns for 38 tree species, including cocoa, using a consensus species distribution model that, for the first time, incorporates both climatic and soil variables. Their projections suggest a potential increase of up to 6% in suitable areas for cocoa cultivation by 2060 compared to its current range in West Africa [19]. However, when limiting their analysis to land-use options that avoid deforestation, the suitable area would decrease by 14.5%. Additionally, their models predict that 50% of the 37 shade tree species studied will face a reduction in geographic range by 2040, with this reduction potentially reaching 60% by 2060 in West Africa. Other researchers studied the importance of agroforestry systems in the rural household economy of the Arasbaran Region. They concluded that expanding the sumac agroforestry systems by increasing the abundance and density of fruit-providing species is essential to improving livelihood and security in rural areas [20].

The growing threats from climate change in semi-arid areas, especially in northwestern Iran, highlight the critical need for more research on agroforestry systems. Based on our knowledge, there is little research about agroforestry systems in Arasbaran, and we also did not find any research about climate change adaptation strategies in this region, which can be stated as the novelty of the research. These systems present a sustainable way to bolster food security and environmental resilience, yet challenges like insufficient technical expertise and limited resources remain. It is vital to conduct research that uncovers effective strategies for merging traditional knowledge with modern practices, optimizing species choices, and crafting supportive agricultural policies. Moreover, understanding socioeconomic obstacles will enable targeted interventions, promoting broader adoption of agroforestry. Successful international examples demonstrate that focused research can unlock the potential of agroforestry, ultimately enhancing farmers' livelihoods and the health of ecosystems in these at-risk regions. In summary, agroforestry systems represent a significant opportunity for improving agricultural sustainability and resilience in arid and semi-arid regions. By addressing existing obstacles and leveraging opportunities, farmers can better adapt to climate change and enhance their livelihoods while contributing to broader environmental goals.

Materials & Methods

Study Area

The study area was located northwest of Iran in the Arasbaran Region and focused on Kaleibar, Ahar, and Varzaghan counties. The Arasbaran Region, located in northwestern Iran, is a mountainous area known for its rich biodiversity and unique ecosystems (Figure 1). The region features a mix of forest, grassland, and alpine landscapes, making it an important conservation area. Arasbaran is also culturally significant, with a long history of human settlement and traditional practices like agroforestry. It was designated as a UNESCO Biosphere Reserve in 1976 due to its ecological importance and diverse habitats. The mean annual precipitation ranged from 310 to 450 mm, has an elevation of 1,360 meters, and a mean temperature of 21.9°C. The main economic activities in the region are farming and animal husbandry, with wheat and apple as the primary agricultural products [20].

Data Collection and Analysis

This research was carried out in multiple stages, beginning with a rapid preliminary assessment to identify farms practicing different agroforestry systems. This initial step helped to map out the diversity of agroforestry systems across the study region, such as combinations of trees with crops, livestock, or mixed cropping systems. Following this, a representative sample of households was randomly selected for evaluation from each agroforestry system identified. The selection ensured that different agroforestry practices were adequately represented, allowing for a

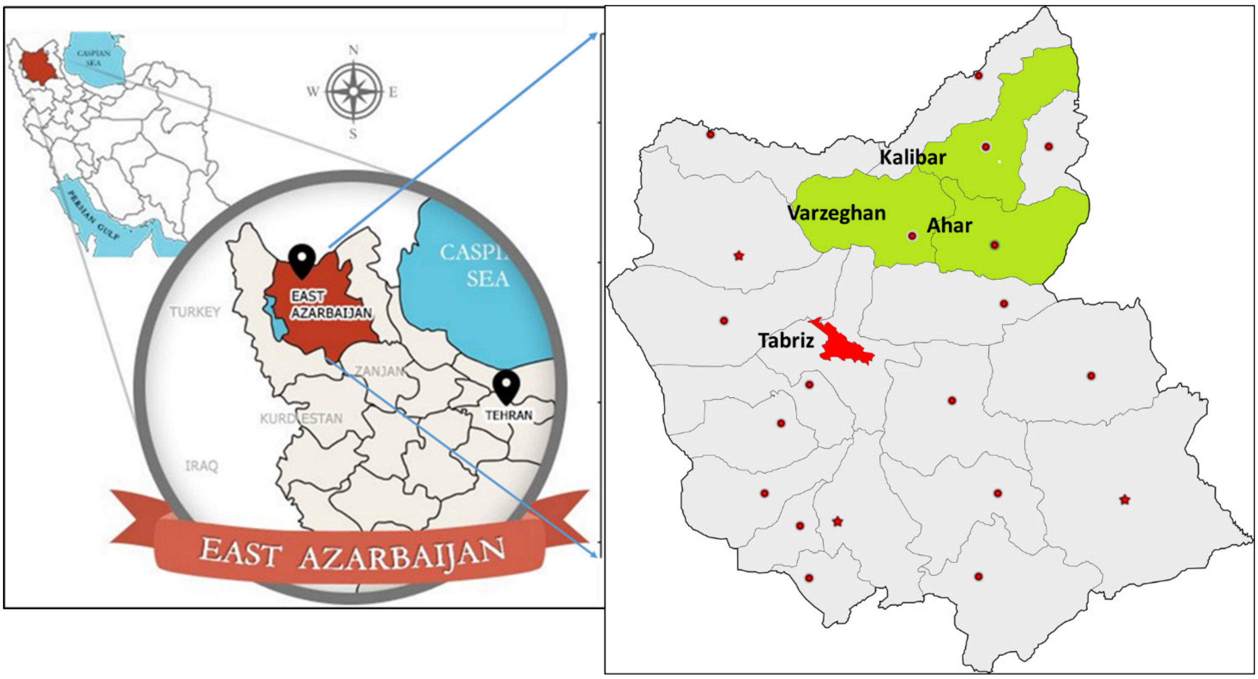

Figure 1) The location of the study area in the Iran and East Azerbaijan Province.

comprehensive analysis of the various systems. This approach ensured that the study captured various agroforestry practices and their associated benefits or challenges across households and regions [21].

The next phase of the study involved surveying local households. Before starting the interviews, farmers were briefed on the study's objectives, and their consent to participate was obtained. To ensure the clarity and neutrality of the questions, a pilot test was conducted with nine interviews, leading to adjustments of any biased questions. Despite efforts to engage all participants, four farmers declined to be interviewed after explaining the research aims. Ultimately, 78 questionnaires were completed in the semi-arid region. The interviews were designed to gather data on how households use and benefit from on-farm trees, focusing on their role in providing livelihoods through direct household use and commercialization. The survey included quantitative and qualitative questions to capture comprehensive household information [15, 22].

The main questions addressed personal characteristics, occupation, farm details, types of species, costs, incomes, types of harvested products, selling methods, changes in species and products over time, and factors affecting production levels. Each farmer was also asked to prepare a list of the most important tree species in each climatic region. Descriptive statistics were employed to analyze household data, revealing the uses and benefits of different tree species. MS Excel 2013 and SPSS Win 19 were used to analyze data. Firstly, data were checked for suitability for analysis, and the questions were coded and entered into the mentioned software. The research method has been shown in the flowchart (Figure 2).

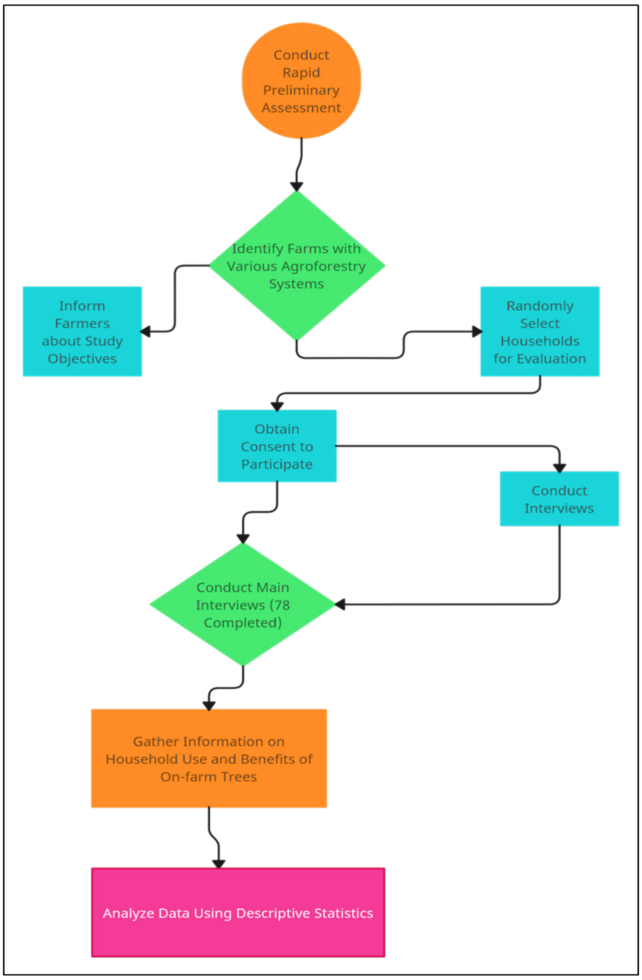

Figure 2) Flowchart for the research steps.

Findings

This research focused on agroforestry systems and species composition, changes in species composition, and farmers' obstacles and problems in implementing agroforestry systems in the Arasbaran Region.

Table 1 provides descriptive statistics of respondents across the Arasbaran Region. It includes data on age, household size, and farming experience. The mean age of the 78 respondents is 51.6 years, ranging from 32 to 81 years (SD= 12.9). Based on 76 respondents, household sizes range from 1 to 11 members, with a mean of 4.2 (SD= 1.9). The respondents' farming experience spans 7 to 65 years, averaging 33.3 years (SD=15.7).

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Table 1) Descriptive statistics of respondents in the Arasbaran Region.

Factor	N	Min.	Max.	Mean	SD
Age (year)	78	32	81	51.6	12.9
Household size (individual)	76	1	11	4.2	1.9
Farming experience (year)	78	7	65	33.3	15.7

SD: standard deviation

Table 2 outlines the socioeconomic characteristics of the respondents. Of the 78 individuals, 90% are married, and all are male. Farming is the main occupation for 72% of respondents, while 28% are in non-farming activities. Additionally, 56% have other sources of income, and 44% rely solely on farming. Regarding residence status, 74% live permanently in the region, while 26% are seasonal residents. These characteristics provide insights into the demographic and occupational landscape of the respondents.

Table 2) Socioeconomic characteristics of respondents in the Arasbaran Region.

Factor	Frequency mean (percent)		
Marital Status	Single	Married	Total
	8 (10)	70 (90)	78
Gender	Male	Female	Total
	78 (100)	0 (0)	78
Main job	Farming	Non-farming	Total
	56 (72)	22 (28)	78
Other income sources	Yes	No	Total
	44 (56)	34 (44)	78
Residence status	Permanent	Seasonal	Total
	56 (74)	20 (26)	76

Table 3 provides an overview of farmland access among farmers in the Arasbaran Region. The data shows that irrigation farming land ranges from 0 to 15 hectares, with a mean of 2.5 hectares (SD= 3.1). Rainfed farming land spans from 0.5 to 16 hectares, averaging 4.6 hectares (SD= 3.8). Garden lands vary from 0.1 to 10 hectares, with a mean of 1.3 hectares (SD 1.9). Farmers typically manage 10.7 pieces of land on average, with a wide range of 1 to 30 parcels (SD 7.3). Barren land ownership averages 3.1 hectares (SD 2.3), and the mean distance between farms and the village is 2.3 kilometers.

Table 3) Access to farmland among farmers in the Arasbaran Region.

Capital	N	Min.	Max.	Mean	SD
Irrigation farming land (ha)	78	0	15	2.5	3.1
Rainfed farming land (ha)	78	0.5	16	4.6	3.8
Garden lands (ha)	74	0.1	10	1.3	1.9
Number of pieces of land	76	1	30	10.7	7.3
Barren land (ha)	58	0	10	3.1	2.3
Distance farming with village (km)	76	0.5	5	2.3	1.0

Table 4 highlights the types of species planted in agroforestry systems in the region, showing a diverse range of trees and fruit-bearing plants. Apple (56%) and walnut (41%) are the most commonly planted species, followed by poplar (20.5%) and sour cherry (15%). Other notable species include peach, almond, apricot, cherry, and plum, each representing 5% or less of the total planted species.

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Table 4) Type of planted species at the agroforestry systems.

Row	Species	Mean (percent)
1	Sour Cherry (*Prunus cerasus*)	12 (15)
2	Peach (*Prunus persica*)	4 (5)
3	Almond (*Prunus amygdalus*)	4 (5)
4	Apple (*Malus domestica*)	44 (56)
5	Cherry (*Prunus avium*)	10 (13)
6	Plum (*Prunus domestica*)	4 (5)
7	Mulberry (*Morus alba*)	2 (2.5)
8	Nectarine (*Prunus persica var. nucipersica*)	2 (2.5)
9	Walnut (*Juglans regia*)	32 (41)
10	Pear (*Pyrus communis*)	4 (5)
11	Apricot (*Prunus armeniaca*)	12 (15)
12	Poplar (*Populus* sp.)	16 (20.5)
13	Ash (*Fraxinus excelsior*)	4 (5)
14	Elm (*Ulmus glabra*)	2 (2.5)
15	Willow (*Salix alba*)	8 (10)
16	Rose (*Rosa* sp.)	2 (2.5)
17	Quince (*Cydonia oblonga*)	2 (2.5)
-	Total	164 (210)

Table 5 highlights farmers' motivations for engaging in agroforestry systems, with various factors ranked from 1 (very low) to 5 (very high). The highest motivation is income increase, with a mean score of 3.8 (SD= 1.0), indicating it is a crucial driver for farmers. Employment and other purposes, such as additional benefits from agroforestry, also score relatively high, with means of 3.4 and 3.2, respectively. Other motivations, such as biodiversity conservation, shading, water storage, soil quality, and medicinal uses, have mean scores around 3, reflecting intermediate importance. Lower motivations include manure production (mean 2.2) and ecosystem fixation (mean 2.4), which rank lower on the list.

Table 5) Farmers' motivation from activity in agroforestry systems.

Reason	N	Mean	SD
Water storage	78	2.9	1.2
Soil quality	78	2.9	1.2
Biodiversity conservation	78	3.0	1.3
Employment	78	3.4	0.9
Manure production	74	2.2	1.0
Ecosystem fixation	74	2.4	1.2
Shading	76	3.0	1.1
Increase income	78	3.8	1.0
Medicinal uses	72	2.9	1.2
Wood production	78	2.7	1.0
Windbreak	78	2.7	1.5
Other uses	74	3.2	1.2

Answer scale: 1: very low, 2: low, 3: intermediate, 4: high, 5: very high

The annual income of households over three consecutive years is represented in Table 6. In 1402, the mean income was 2,112 million rials (SD= 2,371), while in 1401, it was higher at 2,316 million rials (SD 2,718). In 1400, the mean income was 2,126 million rials (SD 2,341). The three-year mean household income is 2,185 million rials (SD= 2,382), showing moderate income variability. This indicates that household income levels have been relatively stable over the period, although there is significant income disparity within the population.

Table 6) Annual income of households in different climatic regions from different sources of income (million rials).

Income (year)	N	Mean	SD
1402	78	2112	2371
1401	78	2316	2718
1400	78	2126	2341
The mean income of three years	78	2185	2382

Table 7 highlights farmers' critical problems and obstacles in agroforestry systems. The most significant challenge is the lack of government support (mean ± SD= 3.8± 1.2), indicating it is a significant concern. Other prominent issues include the lack of education for farmers (mean± SD= 3.71.1±), inefficient information (mean± SD= 3.7±1.0), and not using updated research (mean± SD= 3.71.1±), reflecting gaps in knowledge and support. The lack of efficient land and budget constraints also pose moderate challenges, with a mean of 3.1 and 3.4, respectively. Additionally, the lack of information on tree-crop compositions (mean 3.6) suggests a need for better guidance on integrating agroforestry components. These obstacles highlight areas where improvements in education, research, and government support could enhance the success of agroforestry systems.

Table 7) Problems and obstacles in agroforestry systems.

Problem	N	Mean	SD
Lack of support from the government	78	3.8	1.2
Lack of needed education for farmers	78	3.7	1.1
Lack of efficient information	76	3.7	1.0
Lack of efficient land	74	3.1	1.3
Lack of efficient budget	78	3.4	1.1
Lack of information from the composition of tree plus crops	78	3.6	1.1
Not using updated research	74	3.7	1.1

Answer scale: 1: very low, 2: low, 3: intermediate, 4: high, 5: very high

Table 8 provides an overview of species composition across different agroforestry systems in various climatic regions. It outlines the diversity of crops, trees, livestock, and other species integrated into four agroforestry practices: agrisilviculture, alley cropping, apiculture farming, and silvopastoral. The agrisilviculture system includes wheat, barley, lentil, apple, walnut, fruit trees, and livestock such as cow, sheep, goat, and honeybee. The alley cropping system features similar species but introduces crops like alfalfa, beans, and fruit varieties such as peaches, plums, and cherries. Apiculture farming emphasizes a mix of beans, forage crops, walnut, apple, honeybee, and livestock. Silvopastoral systems typically combine crops like wheat and barley, fruit trees (apple, walnut), and livestock, focusing on sustainable agriculture and animal husbandry integration. These systems reflect agroforestry's complex, multifunctional nature, supporting biodiversity, food production, and livestock management.

Tables 9 and 10 illustrate farmers' strategies to combat climate change by changing crop and tree species. In Table 9, various crops have been replaced in recent years, primarily due to the need for increased water efficiency and adaptation to new climate conditions. For example, alfalfa has replaced water-demanding crops such as barley and wheat due to their better adaptation to drier conditions and improved efficiency. Farmers also switch to modified barley and wheat varieties or medicinal plants requiring less water. The common reasons for these changes include the desire for higher efficiency in crop production and better adaptation to changing climate dynamics.

Table 10 highlights similar trends in tree species changes. Farmers are increasingly replacing traditional species like plum, apple, and walnut with more climate-resilient options such as walnut, mulberry, and poplar or modified varieties of the same species. The reasons for these changes are driven by the need for trees that are better adapted to the local climate, require less water, and offer improved efficiency. For example, walnut trees have been replaced by mulberry and pomegranate in some

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cases, which are more resilient to drought. These adaptations illustrate the ongoing adjustments in farming practices to maintain productivity while addressing the challenges of climate change.

Discussion

The mean age of 51.6 years reflects a relatively older farming population, which can impact adopting new agricultural practices and innovations [23]. Household sizes, averaging 4.2 members, suggest a moderate family structure that may influence farm labor availability. With a mean of 33.3 years of farming experience, the respondents possess substantial agricultural knowledge, though the broad range and high standard deviation indicate significant variability in expertise. The predominance of farming as the main occupation for 72% of respondents and the reliance on farming as the sole income source for 44% of them highlight a high degree of economic dependence on agriculture, making this group vulnerable to climatic and market changes. Diversification of income streams by 56% of respondents reflects adaptive strategies to cope with economic uncertainties. In comparison, the fact that 74% of residents are permanent underscores their strong ties to the land, which could influence their engagement in sustainable land management practices [24].

The farmland access highlights the complexities of land use among farmers in the Arasbaran Region, where land fragmentation and variability in farm sizes pose challenges to agricultural productivity. With irrigated land averaging only 2.5 hectares, many farmers are constrained in expanding irrigation-based agriculture, which is essential for coping with the region's semi-arid conditions [25]. Rainfed farming, which averages 4.6 hectares, is more widespread but remains vulnerable to fluctuations in rainfall, which can impact crop yields and food security. The smaller garden plots, averaging 1.3 hectares, may be focused on high-value crops but contribute less to overall land productivity. Notably, the mean of 10.7 parcels per farmer reflects significant land fragmentation, often linked to inefficient farming practices, higher labor costs, and reduced mechanization opportunities [26]. The ownership of barren lands (3.1 hectares on average) indicates underutilized agricultural potential. In contrast, the mean 2.3-kilometer distance between farms and villages suggests logistical challenges in transporting goods to market, further influencing agricultural sustainability.

The motivations for engaging in agroforestry systems reveal that income generation is the primary driver, suggesting that financial benefits are a significant factor in farmers' decision-making [27]. This aligns with studies showing that economic incentives are often the most potent motivators for adopting agroforestry, particularly in rural areas where income diversification is crucial [1]. Employment opportunities and additional benefits from agroforestry, such as fuelwood or food production, also score relatively high, further underscoring the importance of economic stability in these systems. However, while recognized, environmental benefits like biodiversity conservation, water storage, and soil quality improvements appear to be secondary motivations, likely reflecting the farmers' prioritization of immediate economic gains over long-term ecological benefits. Lower-ranked motivations, such as manure production and ecosystem fixation, suggest that certain agroecological functions of agroforestry are perceived as less critical by farmers, possibly due to a lack of awareness or immediate need for these services [28].

The analysis of household income over three consecutive years indicates relative

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Table 8) Species composition at different agroforestry systems in different climatic regions.

Type of agroforestry	Species composition
Agrisilviculture	Wheat, barley, lentil, alfalfa, apple, cow, hen,
	Wheat, barley, lentil, pea, apple, walnut, apricot, cow, sheep, goat, hen, honeybee
	Wheat, barley, lentil, pea, apple, walnut, cow, sheep, goat,
	Wheat, caraway, red cotton, apple,
	Alfalfa, apple, sour cherry,
	Bean, alfalfa, wheat, barley, apple, walnut, cow,
	Pea, lentil, wheat, barley, apple, walnut, cherry, cow,
	Walnut, apple, honeybee,
	Walnut, honeybee,
	Wheat, alfalfa, apple, apricot, cherry, pear, honeybee,
	Wheat, apple,
	Wheat, apple, peach, sour cherry, plum,
	Wheat, barley, alfalfa, apple, cow,
	Wheat, barley, apple, cow, sheep,
Alley cropping	Wheat, barley, apple, peach, no,
	Wheat, barley, apple, sour cherry,
	Wheat, barley, apple, sour cherry, cow, sheep, hen
	Wheat, barley, bean, apple, walnut, cow,
	Wheat, barley, evil, apple, cow, sheep, hen
	Wheat, barley, lentil, apple, pear, cow, sheep, hen
	Wheat, barley, lentil, mulberry, walnut, apricot, cow, sheep, goat, honeybee
	Wheat, barley, lentil, pea, apple, walnut, apricot, cow, sheep, goat, honeybee
	Wheat, barley, lentil, poplar,
	Wheat, barley, lentil, saffron, apple, walnut, peach, almond, sour cherry, plum
	Wheat, lentil, rosa, honeybee,
	Bean, wheat, lentil, barley, walnut, cow,
	Forage, walnut, apple, honeybee,
Apiculture farming	Wheat, barley, apple, peach, apricot, sour cherry,
	Wheat, barley, bean, apple, cow,
	Bean, barley, wheat, apple, walnut,
	Wheat, alfalfa, apple, peach,
	Wheat, apple, cow, sheep, hen
	Wheat, barley, apple, walnut, cow, sheep, hen
Silvipastoral	Wheat, barley, bean, lentil, apple, cherry, sour cherry, cow, sheep,
	Wheat, barley, lentil, alfalfa, apple,
	Wheat, barley, lentil, pea, apple, walnut, apricot, cow, sheep, goat, honeybee
	Wheat, lentil, alfalfa, apple,

Table 9) Changing crop species and strategies to combat climate change.

Crop cultivated past	How many years ago?	Crop cultivated recently	Reason of change
Alfalfa	7	Clover	Low demanded water, adaptation, change in efficiency
Barley	5	Alfalfa	Change in efficiency
Barley	10	Wheat	Change in efficiency and adaptation
Barley	2	Pea	Change in efficiency
Barley	5	Modified barley	Adaptation and change in efficiency
Barley	9	Medicinal plants	Low demanded water, change in efficiency
Barley	10	Modified wheat	Low demanded water and change in efficiency
Tomato	8	Barley	Low demanded water, adaptation
Tomato	5	Alfalfa	Change in efficiency
Wheat	3	Modified barley	Change in efficiency
Wheat	3	Alfalfa	Low demanded water and change in efficiency
Wheat	5	Barley	Change in efficiency, low demand water
Wheat	10	Alfalfa	Change in efficiency, low demand water
Wheat	9	Medicinal plants	Low demanded water, change in efficiency
Wheat	10	Modified wheat	Change in efficiency
Wheat	2	Modified wheat	Low demanded water and change in efficiency
Wheat	9	Medicinal plants	Low demanded water, change in efficiency

Table 10) Changing tree species and strategies to combat climate change.

Tree planted past	How many years ago?	Tree planted recently	Reason of change
Plum	4	Cherry	Adaptation, low demanded water
Apple	3	Walnut	Low demanded water, adaptation, and change in efficiency
Grape	5	Pear	Adaptation, low demanded water
Poplar	17	Modified poplar	Change in efficiency
Native walnut	10	Modified walnut	Adaptation and change in efficiency
Plum	5	Poplar	Change in efficiency
Plum	15	Poplar	Adaptation and change in efficiency
Poplar	11	fruit trees	Change in efficiency
Poplar	15	Walnut	Adaptation and change in efficiency
Walnut	4	Mulberry	Adaptation, change in efficiency
Walnut	14	Mulberry	Change in efficiency, low demand water
Walnut	15	Pomegranate	Adaptation, change in efficiency
Walnut	15	Mulberry	Adaptation
Walnut	15	Mulberry	Change in efficiency
Walnut	15	Pomegranate	Adaptation, change in efficiency
Willow	5	Poplar	Change in efficiency

stability, with a three-year mean of 2,185 million rials and moderate variability, though income disparity remains significant. This income consistency is crucial for the economic resilience of farming households. However, the disparity suggests uneven access to resources and opportunities, potentially influenced by farm size, market access, and farming practices [26, 29]. Table 8 highlights key obstacles that hinder agroforestry adoption and success, with the lack of government support being the most pressing issue, followed by the absence of education, inefficient information dissemination, and outdated research. These challenges are consistent with broader trends in rural areas, where insufficient policy frameworks and limited access to knowledge impede the adoption of sustainable agricultural practices [30]. The moderate challenges related to land and budget constraints further underline the need for financial and infrastructural support to empower farmers in integrating agroforestry effectively. Improving access to updated research, tree-crop composition guidance, and education could significantly enhance the viability of agroforestry systems in the region [31].

The diverse species composition across agroforestry systems underscores the multifunctional nature of these practices, which integrate various crops, trees, and livestock to enhance agricultural sustainability and productivity. Agrisilviculture, combining staple crops like wheat and barley with fruit trees such as apple, walnut, and livestock, supports food production and ecological benefits [32]. Alley cropping extends this diversity by incorporating alfalfa, beans, and additional fruit varieties, which can improve soil fertility and provide multiple harvests. Apiculture farming's focus on honeybee alongside forage crops and fruits emphasizes the crucial role of pollinators in boosting yields and ecosystem health [33, 34]. Silvopastoral systems, which blend crops and livestock with fruit trees, highlight a holistic approach to land use that balances agricultural productivity with environmental conservation [2, 35]. These systems collectively reflect a robust strategy for enhancing biodiversity, optimizing land use, and integrating multiple functions within agroforestry [33].

Results illustrate how farmers adapt their practices to climate change, demonstrating a shift towards more water-efficient and climate-resilient species. Replacing water-intensive crops like barley and wheat with drought-tolerant species such as alfalfa and using modified crop varieties aligns with global trends in sustainable agriculture [1]. Similarly, transitioning from traditional tree species like plum and apple to more resilient varieties such as mulberry and pomegranate reflects the need to adapt to increasingly arid conditions and ensure long-term viability [3, 36]. These changes indicate a proactive approach to climate adaptation, aiming to maintain agricultural productivity and resilience amid shifting environmental conditions. By integrating more resilient species and modifying existing varieties, farmers are better equipped to handle the challenges of climate variability and secure their livelihoods.

Conclusion

The comprehensive analysis of demographic, socioeconomic, and environmental data presented in this study highlights key insights into the farming practices and challenges households face in the Arasbaran Region. The data reveal an older farming population with substantial experience, which influences their adoption of new practices and highlights a reliance on agriculture as the primary source of income. Despite significant variability, the moderate household income stability underscores these farming communities' economic vulnerabilities. Additionally, the complex land use patterns, including issues with land fragmentation and underutilized barren lands, further stress the need for improved agricultural practices and infrastructure to enhance productivity and market access. The research highlights the multifunctional aspects of agroforestry systems and how farmers adapt their species' choices to meet environmental challenges posed by climate change. While economic gain remains the primary motivation for adopting agroforestry, there is a clear trend toward selecting more resilient and water-efficient crops and tree species to cope with increasingly arid conditions. This proactive adjustment reflects the farmers' resilience and adaptability to climate variability, underscoring the need for ongoing education, research, and policy support to improve these systems' effectiveness. Ultimately, addressing the identified challenges and capitalizing on the benefits of agroforestry will be essential for maintaining agricultural productivity and environmental health in the region.

Based on the research findings on agroforestry systems in the Arasbaran Region, we suggest that farmers and decision-makers focus on enhancing government support and education for farmers to overcome existing obstacles. Key recommendations include providing access to updated agricultural research, improving information dissemination regarding tree-crop compositions, and addressing budget constraints to facilitate investment in agroforestry. Encouraging the adoption of climate-resilient species and promoting diversification in species composition can help farmers adapt to changing climate conditions while maximizing productivity and income. Fostering cooperative initiatives among farmers can enhance resource sharing and strengthen community resilience. Like other research, we found limitations, such as a lack of previous studies and not easy access for the farmers.

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