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The role of agricultural systems and rangeland ecosystem services in the food security and nutrition of smallholder farmer households: A small-scale analysis from the west of Iran

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Original Research

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Abstract:

Agriculture and rangeland are the basis of livelihood of Smallholder Farmer Households (SFHs) in Sarpol-Zahab county, west of Iran. In this area, three distinct Agricultural Systems (ASs) based on agricultural and pasture ecosystem services have been formed over time including a) AS of guaranteed agri-products that are purchased by the government, b) AS of commercial agri-products that are limited to agro-ecosystem services and c) AS of agri-pasture products that are characterized by a diverse range of agricultural and pasture ecosystem services. The purpose of the present study was to evaluate the consequences of Food Security and Nutrition (FSN) of these ASs for SFHs and compare them. Collecting the required information using the USDA household food security questionnaire, the structured questionnaire for ASs, interviews and field surveys lasted from October to December 2023. The results showed a relatively high prevalence of food insecurity (57.3%) among SFHs. Food insecurity was negatively correlated with farmland size ($r = -0.17$, $p < 0.05$), household income ($r = -0.73$, $p < 0.01$), AS of commercial agri-products ($r = -0.46$, $p < 0.01$), AS of agri-pasture products ($r = -0.21$, $p < 0.05$), while, there was a weak and positive correlation between food insecurity and AS of guaranteed agri-products that was purchased by the government ($r = 0.15$, $p > 0.05$). The results of the relative risk test also confirm the occurrence of household food insecurity for the conditions of the absence of the AS of commercial agri-products, the absence of the AS of agri-pasture products, and the presence of the AS of guaranteed agri-products. The proper income and crop diversity, part of which is consumed in the households' food basket, will improve the food security status of the SFHs by the AS of agri-pasture products.

Keywords: Agricultural systems; Pasture; Agroecosystem services; Food insecurity; Rural household livelihood

Introduction

About 80% of the population in developing countries live in rural regions and the main basis of their livelihood is agricultural activities (Castañeda et al., 2018). The linkage between agricultural systems (ASs) and food security and nutrition (FSN) is known in the form of a conceptual framework. This linkage is critical for many farming households in low- and middle-income countries, especially those facing declining water availability, land degradation, and climate variability (WHO, 2018). Despite the recognition of important linkages and associated challenges, there are few studies with a clear quantitative analysis of the linkage between ASs and food security (Nicholson et al., 2021).

Out of 570 million farms worldwide, most of them are small-scale and family farms. In developing countries, small farms (less than 2 ha) and family farms occupy about 12% and 75% of the world's agricultural land, respectively (Zou and Mishra, 2024). The term "smallholder" refers to farmers who cultivate relatively small plots of farmland and often do not have adequate access to resources, including land, capital, and technology (Nwaobiala et al., 2019).

Kermanshah province in the west of Iran as one of the important agricultural zones of the country plays a vital role

in producing strategic crops. In this province, Sarpol-Zahab County has special characteristics from the viewpoint of political ecology. 45% of 80,000 population of this county live in villages, and the livelihood of rural households is through agricultural and animal husbandry activities and mainly in small-scale farms. The 8-year war between the two countries of Iran and Iraq, followed by the terrible earthquake of 2017, caused serious damage to the infrastructure of the villagers and caused them psychological consequences.

During the last three decades, the agricultural landscapes of this area changed a lot due to the evolution of the Green Revolution. Changing the use of hilly pasture land and annexing it to agricultural land, removing most of the trees along the rivers, significantly reducing agrobiodiversity and livestock breeding, increasing the homogeneity of fields, reducing or eliminating crop rotation, increasing tillage, and the excessive use of chemical inputs are quite evident in these landscapes. These changes, together with climate changes, have caused the reduction of surface water resources and overexploitation of subsurface water resources; so that the water volume of the main rivers has become much less than before and more than 95% of the springs have dried up (IMAJ, 2011).

As a result of these changes over time, today there are three distinct types of ASs for smallholder farmers households (SFHs) in agricultural landscapes; 1) the AS of guaranteed agri-products to be purchased by the government, 2) the AS with commercial agri-products, and 3) the AS with agri-pasture-products. Each of these ASs has its unique agroecological characteristics. Therefore, our goal here is to evaluate the consequences of FSN of these ASs for SFHs and compare them.

Background

Food security is achieved when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs (FAO, 1996). Food security has four interrelated components: Availability, accessibility, utilization, and stability (Okpala et al., 2024). These characteristics have caused the complexity of the issue of food security and its impact and influence on the patterns of natural resource use, climate change, and demographics (Brown and Funk, 2008; Lobell et al., 2008; Wheeler and Von Braun, 2013). For example, land use change, extreme temperatures, long dry seasons, wildfires, and increasing prevalence of pests, diseases and weeds lead to reduced access to food for SFHs (Bank, 2011).

The evaluation of the food security status of SFHs and the factors related to it has been the focus of many researchers of different sciences. In order to draw the line of thought of the readers of the article, here we will mention some cases from the research literature. Mango et al. (2014) collected data from the answers of 120 SFHs in Mudzi district, Zimbabwe, using a structured questionnaire. The results of their analysis showed that household food diversity was influenced by the variables of age and education of the household's head, the number of household members and labor force, livestock ownership, and access to market information. In their study, the results of linear regression also show the relationship between food security and the education of the household's head, the number of household members, livestock ownership, and access to market information (Mango et al., 2014).

Jumbe and Nyambose (2016) investigated the impact of conservation agriculture on household food security using data collected from SFHs in Nkhotakota, Malawi. By comparing the estimated production function between adopters and non-adopters of conservation agriculture, they found that adopters of conservation agriculture have a better situation than others in various aspects such as corn production, per capita corn needs, and number of meals. Therefore, they concluded that conservation agriculture technologies can be promoted as an effective strategy for reducing food insecurity in the FSHs.

Wekesa et al. (2018) by examining micro-level evidence using principal component analysis found that crop and farm management, farm risk reduction strategies, and soil management practices as climate-smart agricultural practices have an impact on household food security in smallholder production systems in Kenya. Adeniyi and Dinbabo (2019) collected quantitative data from 306 SFHs in northwest Nigeria using a structured questionnaire. The results of their study showed that at least 45% of households had food insecurity. Also, the results of multiple linear regression showed that the variables of household income, education, agricultural experience, land size, and livestock ownership were related to household food security.

Woleba et al. (2023) collected data from 150 SFHs in the Kedida Gamela district of Southern Ethiopia using a questionnaire, as well as group discussions and interviews with knowledgeable individuals and showed that 56.67% of them have insecurity. In their study, the results of the binary logit model showed that the level of education, gender, and age of the household's head, farmland size, livestock ownership, access to promotional, and credit services are positively and significantly related to the household food security.

Materials and methods

Study location

Sarpol-Zahab County is located in the west of Kermanshah Province, Iran, with a geographical location of 34°12′ N to 34°41′ N and 45°44′ E to 46°08′ E. This county has two administrative districts, which are the lowest administrative units after the city. The area has an altitudinal range of 438 to 2556 m above sea level. The semi-arid climate with an average annual rainfall of 476 mm and an average temperature of 44.8 °C for the hottest month of the year (July) are prominent features of this area.

The livelihood of the rural population in this area is through agricultural and pasture activities. These activities can be separated into the agricultural landscape in the form of three types of ASs for the SFHs. Two types of these systems are based on agricultural ecosystem services, and the third type is characterized by ecosystem services provided by agricultural and pasture ecosystems. The first type is the AS of guaranteed agri-products that are purchased by the government. Wheat, corn, rapeseed, and sugar beet are crops that are guaranteed by the central government of Iran. Most of

the SFHs who have surface or groundwater water supply sources do double-cropping of wheat corn and other crops with a purchase guarantee. The second type is the AS of commercial agri-products. Ruby grapes, potatoes, tomatoes and cucumbers are specific crops in this system. The third type is the AS of agri-pasture products. In this system, various types of crops such as faba bean, garden pea, eggplant, okra, pepper, and leafy vegetables are cultivated by the SFHs for the livelihood of the family. A distinctive feature of the latter agricultural system compared to the previous two systems is that the SFHs enjoy pasture ecosystem services. In this system, livestock grazing from the natural resources of rangelands is the main source of seasonal fodder supply (especially in the spring season) significantly contributes to the continuation of traditional livestock activities by SFHs. The establishment of beehives in rangeland by some households is also dependent on the ecosystem services provided by the natural vegetation of the rangeland. Collecting edible wild plants from the pasture that are used as human food, such as *Gundelia tournefortii* Sickleweed, and Salsify, as well as wild plants that are used for spice and medicine, such as Mountain thyme, Jerusalem Sage, Marshmallow, and Ziziphora help to feed and the household's livelihood.

Research method

This work was a cross-sectional study to evaluate the FSN status of the SFHs and its relationship with conventional ASs in the study area. Therefore, in order to check the general situation of the area, first, communication was established with the agricultural experts of Sarpol-Zahab County in western Iran, and then field investigations were carried out. Considering the extent and population of the central district (including six subdistricts) compared to the Qala-Shahin district (including two subdistricts), it was decided to select six villages from each subdistrict for sampling. Therefore, a total of 36 villages and 8 SFHs from each village were randomly selected.

To collect household FSN information, the USDA's household food security questionnaire was used. Through 18 items, this questionnaire evaluates the severity of the household's access to food (Bickel et al., 2000). The validity of this tool to measure the food security status of Iranian rural households has already been reported by (Rafiei et al., 2009).

In this method, the severity of household food access problems based on household experiences and self-reported behaviors was collected by an interview with one household member who had enough information. The questions cover a wide range of the severity of food access problems ranging from worrying about running out of food to children not eating for a whole day. Finally, the answers to all questions were coded, and the total score of the questionnaire determined the household food security status.

For the often/sometimes/never responses, "often" or "sometimes" were coded as affirmative (value = 1), and "never" was coded as negative (value = 0).

For yes/no responses, "yes" was coded as 1 and "no" as 0. For "how often?" responses, "almost every month" and "some months" were coded as 1 and "only 1 or 2 months" was coded as 0. The "how often?" follow-up items were coded 0 if the base item (i.e., response to the preceding question) was 0, and missing if the base item was missing.

To collect the demographic, economic, and agricultural information of the SFHs, the AS questionnaire designed by the research team was used. Through 20 items, this questionnaire collects information related to the age of the household's head, the number of household members, farmland size, household income, the type of crops planted and the area under their planting, planting pattern, crop rotation, the purpose of crop production, product marketing, and the type and level of traditional animal husbandry activity. The presence of other sources of income other than agricultural activities for the SFH was determined by an open question at the end of the questionnaire.

Data collection

After a short face-to-face interview with one of the household members who had enough information about the items of the FSN and AS questionnaires, she/he was asked to read the questionnaires carefully and complete them. This interview was conducted in the local Kurdish language in order to familiarize the audience with the purpose of the study. Questionnaires were distributed for each village in one day and completed questionnaires were collected at the end of the same day. Therefore, data collection lasted from October to December 2023.

Statistical analyses

After collecting the questionnaires, their information was entered into the Excel 2019 software in the form of code. Data were analyzed using the statistical software package SPSS-26. Mann-Whitney test was used to compare FSN status between two districts and Spearman's rho test was used to determine bivariate correlations. The chi-square test was used to recognize differences between food security and food insecurity groups among the SFHs. Relative risk estimates were done to survey the presence and absence of the ASs and food security occurrence. The significance was measured at the level of 5%.

Results

Food security and nutrition status

Out of 288 distributed questionnaires, 11 questionnaires were not completed by the household and 15 questionnaires had incomplete information on the FSN or AS, so after removing them, 262 questionnaires entered the analysis stage. Out of these 262 SFHs, 184 (70.2%) households were from the central district and 78 (29.8%) households were from the Qala-Shahin district.

In total, 57.3% of the SFHs in the study area had different degrees of food insecurity, and there was no significant difference ($p > 0.05$) between the central and Qala-Shahin districts in terms of the prevalence of food insecurity.

The FSN status of the SFHs in the study area was presented separately by grouped variables in Table 1. There was a significant difference ($p < 0.01$) in the FSN status for the age group of household heads older than 40 years. In total,

Table 1. Food security and nutrition status of the smallholder farmer households in the study area based on the surveyed variables.

Variables	Central (No.=184)					Qala-Shahin (No.=78)					Total (No.=262)				
	Food security		Food insecurity			Food security		Food insecurity			Food security		Food insecurity		
Age of household's head	No.	%	No.	%	X^2-P	No.	%	No.	%	X^2-P	No.	%	No.	%	X^2-P
≤ 40 year	23	46	27	54.0	0.32^{ns}	13	52.0	12	48.0	0.4^{ns}	36	48	39	52	0.12^{ns}
> 40 year	58	43.3	78	56.7	2.42^{ns}	18	34.0	35	66.0	5.45*	76	40.6	111	59.4	6.55**
Family size															
≤ 4 person	62	44.6	77	55.4	1.62^{ns}	24	42.1	33	57.9	1.42^{ns}	86	43.9	110	56.1	2.94^{ns}
> 4 person	19	42.2	26	57.8	1.09^{ns}	7	33.3	14	66.7	2.33^{ns}	26	39.4	40	60.6	2.97^{ns}
Farmland size															
≤ 3 hectares	29	32.2	61	67.8	11.38***	12	37.5	20	62.5	2.0^{ns}	41	33.6	81	66.4	13.11***
> 3 hectares	52	55.3	42	44.7	1.06^{ns}	19	41.3	27	58.7	1.39^{ns}	71	50.7	69	49.3	0.03^{ns}
Agricultural system of commercial agri-products															
No	22	22.7	75	77.3	28.96***	5	13.5	32	86.5	19.7***	27	20.1	107	79.9	47.76***
Yes	59	67.8	28	32.2	11.05***	26	63.4	15	36.6	2.95^{ns}	85	66.4	43	33.6	13.78***
Agricultural system of agri-pasture-products															
No	29	34.9	54	65.1	7.53**	8	22.8	27	77.2	10.3***	37	31.3	81	68.7	16.41***
Yes	52	51.5	49	48.5	0.09^{ns}	23	38.0	20	62.0	0.21^{ns}	75	52.1	69	47.9	0.62^{ns}
Agricultural system of guaranteed agri-products															
No	24	53.3	21	46.7	0.20^{ns}	12	42.8	16	57.2	0.57^{ns}	36	50.7	37	49.3	0.01^{ns}
Yes	57	41	82	59	4.5*	19	61.3	31	66.0	2.88^{ns}	76	40.2	113	59.8	7.24**
Monthly income (US $)															
≤ 1000	0.0	0.0	16	100	-	0.0	0.0	12	100	-	0.0	0.0	28	100	-
1001-2000	14	14.9	80	85.1	46.34***	3	10	27	90	19.2***	17	13.7	107	86.3	65.3***
2001-3000	41	87.2	6	12.8	26.06***	17	68	8	32	3.24^{ns}	58	80.5	14	19.5	26.9***
> 3000	26	96.3	1	3.7	23.15***	11	100	0	0	-	37	97.4	1	2.6	34.1***

X^2-P: X^2 test-P value; ns: no significant; *: significant ($p < 0.05$); **: significant ($p < 0.01$); ***: significant ($p < 0.001$).

out of 187 households belonging to this group, 59.4% (111 households) had food insecurity (Table 1).

There was a significant difference ($p < 0.01$) in the FSN status for the SFHs belonging to the group with farmland size less than or equal to 3 ha. In total, out of 122 households belonging to this group, 66.4% (81 households) had food insecurity (Table 1).

A significant difference ($p < 0.01$) in the FSN status was observed for both groups of the SFHs that had or did not have the AS of commercial agri-products. Out of 134 households that did not have the AS of commercial agri-products, 79.9% (107 households) had food insecurity, while 33.6% (43 households) of 128 households that had the AS of commercial agri-products had food insecurity. Also, there was a significant difference in the FSN status of the SFHs without the AS with agri-pasture products ($p < 0.01$), the AS of guaranteed agri-products ($p < 0.01$), and income groups above 1000 US $ ($p < 0.01$) were observed (Table 1).

Bivariate associations

There was a negative correlation between farmland size and household food insecurity ($r = -0.17$, $p < 0.05$). There was a strong negative correlation between the AS of commercial agri-products and food insecurity ($r = -0.46$, $p < 0.01$). The results of the study showed a negative correlation between the AS of agri-pasture products and food insecurity ($r = -0.21$, $p < 0.05$). Also, there was a strong negative correlation between income and food insecurity ($r = -0.73$, $p < 0.01$). In contrast, there was no correlation between the AS of guaranteed agri-products and food insecurity ($r = 0.15$, $p > 0.05$).

Agricultural systems and food and nutrition status

The relationship between the absence or presence of each of the ASs and the probability of food security or insecurity of the SFHs estimated by the relative risk test for each of the studied districts and the entire studied area is presented in Table 2. In the entire studied area, the probability ratio of food insecurity for the SFHs in the absence of the AS of commercial agri-products is 2.377, while the probability ratio of food security for the same situation was 0.303.

Also, the probability ratio of food insecurity for the SFHs in the absence of the AS of agri-pasture products was 1.433, while the probability ratio of food security for the same situation was 0.602. In contrast, to the previous two situations, the probability ratio of occurrence of food insecurity for the SFHs in the absence of the AS of guaranteed agri-products was 0.848, while the probability ratio of occurrence of food

Table 2. The relationship between the absence or presence of each of the Agricultural systems (ASs) and the probability of food security or insecurity of the Smallholder farmer households was estimated by the relative risk test in the study area.

Risk estimate	95% Confidence interval		
	Values	Lower	Upper
Central district			
Odds ratio for AS of commercial agri-products			
(No/Yes)	0.139	0.072	0.268
Odds ratio for cohort food security	0.334	0.225	0.496
Odds ratio for cohort food insecurity	2.402	1.738	3.32
Odds ratio for AS of agri-pasture-products			
(No/Yes)	0.506	0.279	0.919
Odds ratio for cohort food security	0.679	0.479	0.962
Odds ratio for cohort food insecurity	1.341	1.039	1.731
Odds ratio for AS of guaranteed agri-products			
(No/Yes)	1.644	0.836	3.233
Odds ratio for cohort food security	1.301	0.927	1.824
Odds ratio for cohort food insecurity	0.791	0.562	1.113
Qala-Shahin district			
Odds ratio for AS of commercial agri-products			
(No/Yes)	0.09	0.029	0.281
Odds ratio for cohort food security	0.213	0.091	0.497
Odds ratio for cohort food insecurity	2.364	1.549	3.607
Odds ratio for AS with agri-pasture-products			
(No/Yes)	0.258	0.096	0.694
Odds ratio for cohort food security	0.427	0.219	0.835
Odds ratio for cohort food insecurity	1.659	1.148	2.396
Odds ratio AS of guaranteed agri-products			
(No/Yes)	1.224	0.477	3.137
Odds ratio for cohort food security	1.128	0.647	1.965
Odds ratio for cohort food insecurity	0.922	0.626	1.358
Total study area			
Odds ratio for AS of commercial agri-products			
(No/Yes)	0.128	0.73	0.223
Odds ratio for cohort food security	0.303	0.212	0.434
Odds ratio for cohort food insecurity	2.377	1.836	3.077
Odds ratio for AS of agri-pasture-products			
(No/Yes)	0.420	0.253	0.698
Odds ratio for cohort food security	0.602	0.442	0.82
Odds ratio for cohort food insecurity	1.433	1.162	1.766
Odds ratio for AS of guaranteed agri-products			
(No/Yes)	1.447	0.84	2.49
Odds ratio for cohort food security	1.226	0.917	1.64
Odds ratio for cohort food insecurity	0.848	0.657	1.094

security for the same situation was 1.226. These trends were also observed in each of the studied districts (Table 2). These results indicate the fact that the absence of the AS of commercial agri-products and the AS of agri-pasture products contributes to the food insecurity of the SFHs in the region with a higher probability ratio and highlights the important role of these systems in determining the FSN status of the SFHs.

Discussion

The prevalence of food insecurity among the SFHs in the study area was relatively high (57.3%). This issue refers to the poor livelihood conditions of most SFHs in the study area. In the study conducted by Adeniyi and Dinbabo (2019) food insecurity for SFHs in northwest Nigeria was 45%. Nkoko et al. (2024) reported the prevalence of food insecurity among SFHs in Lesotho was between 60 and. 87.2% of SFHs in rural Oyo state, Nigeria also had food insecurity in the study of (Otekunrin et al., 2021).

In this study, the variables of farmland size and household income had a negative relationship with the food insecurity of the SFHs. These results were consistent with the findings of (Adeniyi and Dinbabo, 2019; Otekunrin et al., 2021; Woleba et al., 2023). Also, the consistency of the results of our study on the positive relationship between the age of household's head and food insecurity of the SFH was observed with the study of (Otekunrin et al., 2021), while some studies reported a negative relationship between the age of household's head and food insecurity (Woleba et al., 2023).

Probably, the larger size of the farmland allows the farmer to invest more in the direction of mechanization and supply the inputs needed for agri-production, and finally, the farmer gets more income by increasing the farm productivity. An increase in income also causes less concern regarding the supply of food needed by the family and better nutritional status. Zou and Mishra (2024) showed that Chinese rural families that use better mechanization have higher corn yields, lower production costs per unit area, and higher per capita income, so they have better food security status (Zou and Mishra, 2024). The positive effect of farm characteristics and mechanization on the food security of rural households has also been reported in the studies of (Muyanga and Jayne, 2019; Zhou et al., 2020).

The support and encouragement of the government for the formation of rural cooperatives seems to be a suitable solution. By doing this, small farms can be aggregated together in the form of owner's shares. The integration of farms can help to attract better government and private investment, more control of farmers over the supply chain management, increase the bargaining power of farmers and facilitate the efficient management of farms. In such management conditions, improving agricultural mechanization, attracting young rural workers and increasing their motivation along with the application of adults' experience can improve the productivity of agricultural lands and help improve the livelihood of SFHs and reduce the migration of the rural population.

All the studied SFHs had less than 10 ha of farmland and about 47% (122 households) of them had less than or equal to 3 ha of farmland. There was a significant difference between the two groups of food security and food insecurity in the SFHs who had less than or equal to 3 ha of farmland, and 66.4% of them had food insecurity. Meanwhile, for the SFHs with farmland size larger than 3 ha, there was no significant difference between the two groups of food security and food insecurity, and 49.3% of them had food insecurity. On the other hand, the positive relationship between farmland size and household income was not very strong for the food security group ($y = 12.42 + 0.61x$, $R^2 = 0.47$). Also, the R^2 value for the food insecurity group was less ($y = 6.27 + 0.51x$, $R^2 = 0.20$) showing that there was a weak positive relationship between farmland size and household income. Therefore, the interpretation of the observed results of the impact of the ASs can lead us to a clearer understanding of the factors related to the FSN statutes of the SFHs.

In this study, there was a negative correlation between food insecurity with AS of commercial agri-products and the AS of agri-pasture products, while there was a weak positive relationship between food insecurity and AS of guaranteed agri-products. The results of the relative risk test also indicate the occurrence of food security for the SFHs in the presence of the AS of commercial agri-products and the AS of agri-pasture products. Also, the results of this test showed the occurrence of food insecurity for the SFHs in the presence of the AS of guaranteed agri-products.

In the AS of commercial agri-products, agricultural activity turns into market-oriented production, which affects household income, consumption, and nutrition (Braun, 1995). In this system, the decision-making behavior of the farmer's household regarding the selection of agri-products and the amount of inputs is based on the principle of maximizing economic profitability (Pingali and Rosegrant, 1995). This type of commercialization in subsistence agriculture means supplying a high percentage of agri-products to the market, which is surplus to household consumption (Gebre-ab, 2006). This process is a function of internal factors (such as land, labor, and capital) and external factors (such as infrastructure, changes in technology, demographics, and off-farm institutions (Jaleta et al., 2009).

In the studied area, ruby grapes, potatoes, tomatoes and cucumbers are common products in the AS of commercial agri-products. These products are often exported to other areas outside the study area, the center of the province, other provinces of the country, and in some cases to the market of Iraq. Therefore, the presence of suitable conditions in external factors (market, transportation, intermediaries, and inputs) encourages the SFHs to use internal factors (experience, family labor, water, land, and capital). Favorable conditions for the supply and demand of commercial products are more profitable than other agri-products for the farmer, so a better financial situation leads to a better food security status.

What is clear from the answers of the farmers and the field survey is that the AS of commercial agri-products is often implemented by farmers who have access to suitable sources of subsurface water and are equipped with light

mechanized machines. The studied area has a semi-arid climate with low average annual rainfall. The effects of climate change and excessive water consumption in the long term have caused many villages in this area to not have favorable conditions in terms of surface water. Therefore, this AS does not have much capacity to expand to other farmers, although the water supply system of the tropical system is being implemented to transfer water from other areas of the province to this area. The sustainability of this water supply system also requires special attention to monitor the amount of water extraction by farmers, the use of clean energy in the irrigation system, the implementation of appropriate irrigation methods, the recognition of the ecological water rights of the upstream and downstream areas, and other environmental considerations. Following our results, the results of a study in China showed that mechanization services increased the agricultural productivity of rural households and improved their food security (Zou and Mishra, 2024). Also, the relationship between access to sufficient irrigation water and farm income and food security of SFHs in Zimbabwe has been reported by (Mupaso et al., 2024).

In contrast to proper profitability, the AS of commercial agri-products also causes a lot of environmental damage. Excessive consumption of agrochemicals due to the intensive production of commercial products has caused surface and underground water pollution, soil degradation, and strong dependence on fertilizing chemicals. Severe reduction of soil organic matter, lowering of subsurface water level, high investment, saturation of the target market in some years, high cost of labor, high energy use, high carbon footprint, removal of livestock, and lack of social justice in access to production resources for all the farmers are another disadvantage of this AS. Allocating government subsidies to poor farmers, providing low-interest and long-term financial facilities for farm mechanization, monitoring compliance with ecological water rights in downstream areas, and eliminating merchant middlemen can help improve social justice for SFHs.

The diversity of cultivated crops and in some cases the presence of animal husbandry and beekeeping activities in the AS of agri-pasture products causes the diversity of the income portfolio of the SFH. On the other hand, the income from this AS is distributed throughout the seasons, which causes the reduction of seasonal income tensions in agriculture. This AS reduces the risk of natural factors in agriculture through diverse and alternative activities. The distribution of family labor throughout the year reduces the costs of agri-production. Women in this AS have better employment in agricultural activities.

Considering that the amount of investment for the production of agri-products in this system is less than other ASs and the produced crops are mainly for the consumption of the population of the study area and the province itself, this system, along with proper productivity and reasonable income, has lower environmental damage and higher social justice than other ASs in the area. Appropriate income and diversity of crop products, part of which is consumed in the household's food basket, improve the food security status of the SFHs by the AS of agri-pasture products.

Mburu et al. (2016) showed that agro-biodiversity affects household food security in subsistence ASs in eastern Kenya, and SFHs in the Upper Midland zones, which have more crop diversity and richness than the Lower Midland zones, are more food security. Adjimoti and Kwadzo (2018) showed the positive effect of agri-product diversity on food security by examining preliminary data from 420 rural households in Benin. By controlling farm size and income variables, Bacon et al. (2023) showed that there was a positive and significant correlation between agri-product diversity and household dietary diversity. Kaminski et al. (2024) by examining evidence from northern Zambia showed that the joint activities of agri-production and animal husbandry can double the probability of improving smallholder food security.

The wild edible plants harvested from the pasture play a significant nutritional role for SFHs seasonally. The ability of wild vegetables to provide nutrients needed in human physiology has been widely reported. They have higher nutritional characteristics than vegetables such as spinach and cabbage (Afolayan and Jimoh, 2009; Aletor et al., 2002; Lewu and Mavengahama, 2010; Oduse et al., 2012). Some authors hypothesized that the inclusion of wild vegetables in the diet is likely to improve micronutrient deficiency status (Berti et al., 2014; Uusiku et al., 2010), and edible wild plants potentially play an important role in food security (Bvenura and Afolayan, 2015). Edible wild plants, if included in the diet, can reduce some FSN concerns such as micronutrient deficiencies. However, these valuable natural resources must be protected and restored so that they can play their role in food security. If these species continue to be ignored, over time knowledge about them may be lost and never recovered. The sustainable exploitation of edible wild plants requires attention to the policy framework of the pasture technical office and exploitation plans of pasture and forest by-products.

In the AS of guaranteed agri-products, according to the availability of water resources, farmers cultivate one of the crops wheat, corn, rapeseed, and sugar beet, or double-cropping of wheat corn. The pricing of these products is done by the central government of Iran, and farmers are forced to sell their products to the government. The crops produced in this system are mainly sold to supply primary raw materials for industries, so despite the low diversity, they are not directly applicable to the food basket of the SFH. These features, together with the absence of a competitive market, high production costs due to the mechanization of all operations, high costs of combating pests, diseases and weeds due to genetic homogeneity and single-crop cultivation, and the high risk of production caused by environmental factors reduce the food security of the SFHs. Environmental damage is high in the AS of guaranteed agri-products. These destructions are caused by the heavy mechanization of agricultural operations, excessive water use, excessive use of agrochemicals, and a significant decrease in agri-biodiversity. The high risk of crop production in this system can impose a lot of costs on the agricultural products insurance fund.

Conclusion

Nowadays, there are more small farms than ever before, and they will become even smaller in the future. This issue is caused by the division of agricultural lands along the development of human generations and the lack of strict rules in the division of agricultural lands. Many empirical studies have argued that smallholder systems are still key to achieving global FSN. SFHs in Sarpol-Zahab County, west of Iran have three specific types of ASs for their livelihood: a) the AS of guaranteed agri-products, b) the AS of commercial agri-products, and c) the AS of agri-pasture products.

Each of these ASs has its unique agroecological characteristics. This study was designed to evaluate the consequences of the FSN of these ASs for the SFHs. 57% of the SFHs had food insecurity. The variables of farmland size, household income, the AS of commercial agri-products, and the AS of agri-pasture products had a significant negative relationship with food insecurity, while the AS of guaranteed agri-products had a weak positive relationship with food insecurity. The results of the relative risk test also confirm the occurrence of household food insecurity for the conditions of the absence of the AS of commercial agri-products, the absence of the AS of agri-pasture products, and the presence of the AS of guaranteed agri-products. The proper income and crop diversity, part of which is consumed in the households' food basket, will improve the food security status of the SFHs by the AS of agri-pasture products. This system includes various activities from growing crops to raising animals that depend on the pasture and also the use of edible wild plants. Various methods of intercropping (row, strip, and mix), alley cropping, and a combination of livestock and crops are common in this system. Therefore, one of the limitations of the present study is the separation of the impact of each of these activities and the development of a management plan to improve the food security of the SFHs, taking into account environmental considerations.

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Authors Contributions
All authors have contributed equally to prepare the paper.

Availability of Data and Materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Adeniyi D. A., Dinbabo M. F. (2019) Factors influencing household food security among irrigation smallholders in North West Nigeria. *J Rev Glob Econ* 8:291–304.

Adjimoti G. O., Kwadzo G. T.-M. (2018) Crop diversification and household food security status: evidence from rural Benin. *Agriculture & Food Security* 7 (1): 82.

Afolayan A. J., Jimoh F. O. (2009) Nutritional quality of some wild leafy vegetables in South Africa. *International Journal of Food Sciences and Nutrition* 60 (5): 424–431.

Aletor O., Oshodi A. A., Ipinmoroti K. (2002) Chemical composition of common leafy vegetables and functional properties of their leaf protein concentrates. *Food Chemistry* 78 (1): 63–68.

Bacon C. M., Flores Gomez M. E., Shin V., Ballardo G., Kriese S., McCurry E., Martinez E., Rivas M. (2023) Beyond the bean: Analyzing diversified farming, food security, dietary diversity, and gender in Nicaragua's smallholders coffee cooperatives. *Agroecology and Sustainable Food Systems* 47 (4): 579–620.

Bank W. (2011) Climate risk and adaptation country profile: vulnerability, risk reduction, and adaptation to climate change, Senegal. *Global Facility for Disaster Reduction and Recovery/GFDRR*

Berti C., Faber M., Smuts C. M. (2014) Prevention and control of micronutrient deficiencies in developing countries: current perspectives. *Nutrition and Dietary Supplements* 6:41–57.

Bickel G., Nord M., Price C., Hamilton W., Cook J. (2000) Guide to measuring household food security. *U.S. Department of Agriculture, Food and Nutrition Service*

Braun J. von (1995) Agricultural commercialization: impacts on income and nutrition and implications for policy. *Food Policy* 20 (3): 187–202.

Brown M. E., Funk C. C. (2008) Food security under climate change. *Science* 319 (5863): 580–581.

Bvenura C., Afolayan A. J. (2015) The role of wild vegetables in household food security in South Africa: A review. *Food Research International* 76:1001–1011.

Castañeda A., Doan D., Newhouse D., Nguyen M. C., Uematsu H., Azevedo J. P. (2018) A New Profile of the Global Poor. *World Development* 101:250–267.

FAO (1996) Rome Declaration on World Food Security and World Food Summit Plan of Action. *Food and Agriculture Organization*

Gebre-ab N. (2006) Commercialization of smallholder agriculture in Ethiopia. *Note and Papers Series* 3:1–31.

IMAJ (2011) Studies on Compilation of Executive Document of Kermanshah Agricultural Hub, Sarpolzahab County Report. *Iran's Ministry of Agricultural Jihad, Kermanshah Agricultural Jihad Organization* 1:89–159.

Jaleta M., Gebremedhin B., Hoekstra D. (2009) Smallholder commercialization: Processes, determinants and impact. *International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia Discussion Paper*

Jumbe C. B. L., Nyambose W. H. (2016) Does conservation agriculture enhance household food security? Evidence from smallholder farmers in Nkhotakota in Malawi. *Sustainable Agriculture Research* 5 (1): 118–128.

Kaminski A. M., Cole S. M., Johnson J., Thilsted S. H., Lundeba M., Genschick S., Little D. C. (2024) Smallholder aquaculture diversifies livelihoods and diets thus improving food security status: evidence from northern Zambia. *Agriculture & Food Security* 13 (1): 1.

Lewu F., Mavengahama S. (2010) Wild vegetables in Northern KwaZulu Natal, South Africa: Current status of production and research needs. *Scientific Research and Essays* 5 (20): 3044–3048.

Lobell D. B., Burke M. B., Tebaldi C., Mastrandrea M. D., Falcon W. P., Naylor R. L. (2008) Prioritizing climate change adaptation needs for food security in 2030. *Science* 319 (5863): 607–610.

Mango N., Zamasiya B., Makate C., Nyikahadzoi K., Siziba S. (2014) Factors influencing household food security among smallholder farmers in the Mudzi district of Zimbabwe. *Development Southern Africa* 31 (4): 625–640.

Mburu S. W., Koskey G., Kimiti J. M., Ombori O., Maingi J. M., Njeru E. M. (2016) Agrobiodiversity conservation enhances food security in subsistence-based farming systems of Eastern Kenya. *Agriculture & Food Security* 5 (1): 19.

Mupaso N., Makombe G., Mugandani R., Mafongoya P. L. (2024) Assessing the Contribution of Smallholder Irrigation to Household Food Security in Zimbabwe. *Agriculture* 14 (4): 1–16.

Muyanga M., Jayne T. S. (2019) Revisiting the farm size-productivity relationship based on a relatively wide range of farm sizes: Evidence from Kenya. *American Journal of Agricultural Economics* 101 (4): 1140–1163.

Nicholson C. F., Stephens E. C., Kopainsky B., Jones A. D., Parsons D., Garrett J. (2021) Food security outcomes in agricultural systems models: Current status and recommended improvements. *Agricultural Systems* 188:103–128.

Nkoko N., Cronje N., Swanepoel J. W. (2024) Factors associated with food security among small-holder farming households in Lesotho. *Agriculture & Food Security* 13 (1): 3.

Nwaobiala C., Alozie E., Anusiem C. (2019) Gender differentials in farmers' involvement in cassava production activities in Abia State, Nigeria. *Agrosearch* 19 (1): 72–86.

Oduse K., Idowu M., Adegbite A. (2012) Chemical and phytochemical profile of some uncommon green leafy vegetables consumed in South West Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology* 1 (3): 22–26.

Okpala E. F., Korir L., Manning L. (2024) Food Acquirability: An Unexplored Component of Food Security?. *Foods* 13 (13): 1–18.

Otekunrin O. A., Otekunrin O. A., Sawicka B., Pszczółkowski P. (2021) Assessing Food Insecurity and Its Drivers among Smallholder Farming Households in Rural Oyo State, Nigeria: The HFIAS Approach. *Agriculture* 11 (12): 1–20.

Pingali P. L., Rosegrant M. W. (1995) Agricultural commercialization and diversification: processes and policies. *Food Policy* 20 (3): 171–185.

Rafiei M., Nord M., Sadeghizadeh A., Entezari M. H. (2009) Assessing the internal validity of a household survey-based food security measure adapted for use in Iran. *Nutrition journal* 8 (1): 1–11.

Uusiku N. P., Oelofse A., Duodu K. G., Bester M. J., Faber M. (2010) Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review. *Journal of Food Composition and Analysis* 23 (6): 499–509.

Wekesa B. M., Ayuya O. I., Lagat J. K. (2018) Effect of climate-smart agricultural practices on household food security in smallholder production systems: micro-level evidence from Kenya. *Agriculture & Food Security* 7 (1): 80.

Wheeler T., Von Braun J. (2013) Climate change impacts on global food security. *Science* 341 (6145): 508–513.

WHO (2018) The state of food security and nutrition in the world 2018: building climate resilience for food security and nutrition. *Food & Agriculture Org, World Health Organization*

Woleba G., Tadiwos T., Bojago E., Senapathy M. (2023) Household food security, determinants and coping strategies among small-scale farmers in Kedida Gamela district, Southern Ethiopia. *Journal of Agriculture and Food Research* 12:100597.

Zhou X., Ma W., Li G., Qiu H. (2020) Farm machinery use and maize yields in China: an analysis accounting for selection bias and heterogeneity. *Australian Journal of Agricultural and Resource Economics* 64 (4): 1282–1307.

Zou B., Mishra A. K. (2024) Modernizing smallholder agriculture and achieving food security: An exploration in machinery services and labor reallocation in China. *Applied Economic Perspectives and Policy* 17008:1–47.

Appendix 1. The original english version of USDA household food security questionnaire (18 items).

I'm going to read you several statements that people have made about their food situation. For these statements, please tell me whether the statement was often true, sometimes true, or never true for (you/your household) in the last 12 months – that is, since last (name of current month).	
Ten adult items	
Q1	"(I/We) worried whether (my/our) food would run out before (I/we) got money to buy more." Was that often true, sometimes true, or never true for (you/your household) in the last 12 months?
Q2	"The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
Q3	"(I/we) couldn't afford to eat balanced meals." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
Q4a	In the last 12 months, since last (name of current month), did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food? (Yes/No)
Q4b	[IF YES ABOVE, ASK] How often did this happen – almost every month, some months but not every month, or in only 1 or 2 months?
Q5	In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food? (Yes/No)
Q6	In the last 12 months, were you every hungry but didn't eat because there wasn't enough money for food? (Yes/No)
Q7	In the last 12 months, did you lose weight because there wasn't enough money for food? (Yes/No)
Q8a	In the last 12 months, did (you/you or other adults in your household) ever not eat for a whole day because there wasn't enough money for food? (Yes/No)
Q8b	[IF YES ABOVE, ASK] How often did this happen – almost every month, some months but not every month, or in only 1 or 2 months?
Eight child items	
Q1	"(I/we) relied on only a few kinds of low-cost food to feed (my/our) child/the children) because (I was/we were) running out of money to buy food." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
Q2	"(I/We) couldn't feed (my/our) child/the children) a balanced meal, because (I/we) couldn't afford that." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
Q3	"(My/Our child was/The children were) not eating enough because (I/we) just couldn't afford enough food." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
Q4	In the last 12 months, since (current month) of last year, did you ever cut the size of (your child's/any of the children's) meals because there wasn't enough money for food? (Yes/No)
Q5a	In the last 12 months, did (CHILD'S NAME/any of the children) ever skip meals because there wasn't enough money for food? (Yes/No)
Q5b	[IF YES ABOVE ASK] How often did this happen – almost every month, some months but not every month, or in only 1 or 2 months?
Q6	In the last 12 months, (was your child/were the children) ever hungry but you just couldn't afford more food? (Yes/No)
Q7	In the last 12 months, did (your child/any of the children) ever not eat for a whole day because there wasn't enough money for food? (Yes/No)

Appendix 2. Questionnaire of information on the agricultural systems of the smallholder farmer's household.

Below are a number of questions that tell information about the agricultural systems of the smallholder farmer's household. Specify the status of your family in each case by answering the questions.	
Q1	How old is the head of your family?
Q2	How many members are there in your family?
Q3	What is the average monthly income of your family? If the income is annual, enter the word annual.
Q4	How many hectares of farmland is owned by your family?
Q5	Which crop/crops do you usually grow that have a guarantee of purchase by the government? a) Wheat, b) Corn, c) Rapeseed, d) Sugar beet, and e) None
Q6	What is the amount of arable land area that you usually dedicate to the cultivation of the crop/crops with purchase guarantee by the government? a) None, b) Very little, c) Little, d) Moderate, and e) High
Q7	In case of cultivation of the crop/crops with purchase guarantee by the government, how is the marketing of the product/products done? a) Delivery to government shopping centers, b) Supply in the local market, and c) Selling to intermediaries for supply in other markets
Q8	Which crop/crops do you usually grow for commercial production (high profit)? a) Potatoes, b) Tomatoes, c) Cucumbers, d) Ruby grapes, and e) None
Q9	What is the amount of arable land area that you usually dedicate to the cultivation of the commercial crop/crops? a) None, b) Very little, c) Little, d) Moderate, and e) High
Q10	In case of cultivation of the commercial crop/crops, how is the marketing of the product/products done? a) Delivery to government shopping centers, b) Supply in the local market, and c) Selling to intermediaries for supply in other markets
Q11	Which crop/crops do you usually grow with the aim of your family's livelihood? a) Faba bean and/or garden pea, b) Eggplant and/or okra, c) Pepper, d) Leafy vegetables, and e) None
Q12	What is the amount of arable land area that you usually dedicate to the cultivation of the subsistence crop/crops? a) None, b) Very little, c) Little, d) Moderate, and e) High
Q13	In case of cultivation of the subsistence crop/crops, how is the marketing of the product/products done? a) Delivery to government shopping centers, b) Supply in the local market, and c) Selling to intermediaries for supply in other markets
Q14	Which animal husbandry activity/activities do you usually with the aim of your family's livelihood? a) Cattle breeding, b) Sheep breeding c) Bee breeding d) Chicken and rooster breeding, and c) None
Q15	What is the share of the animal husbandry activity/activities in your family's livelihood? a) None, b) Very little, c) Little, d) Moderate, and e) High
Q16	In case of the animal husbandry activity/activities, how is the marketing of the product/products done? a) Delivery to government shopping centers, b) Supply in the local market, and c) Selling to intermediaries for supply in other markets
Q17	How much does your family feed from wild edible plants that you collect from the pasture? a) None, b) Very little, c) Little, d) Moderate, and e) High
Q18	What is the contribution of edible wild plants that you collect from the pasture to your family's livelihood? a) None, b) Very little, c) Little, d) Moderate, and e) High
Q19	Specify the source/sources of water supply used in your agricultural activities? a) River b) Well c) Tropical system and, d) None
Q20	Briefly describe any other sources of income for the family other than agriculture and animal husbandry activities?