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The Effect of Contract Farming on the Sustainability of Wheat Production in Iran (Study Case of Golestan Province)

S.H. Hosseini Kasgari[1], M. Ahmadpour Borazjani[1]*, A. Keyka[1], M. Salarpour[1]

Abstract

The Ministry of Agriculture Jihad in Iran implemented contract farming (CF) for wheat in 2021 to address marketing issues. This study compares agricultural sustainability for farmers participating in and not participating in CF. Agricultural sustainability was assessed by applying a combined index approach that considers economic, social, and environmental dimensions. The required data came from 620 wheat farmers in Golestan province, sampled using the multi-stage randomization technique. The data were evaluated using exploratory factor analysis (EFA) and clustering methods. The findings indicated a significant difference in the performance of economic and environmental sustainability dimensions between two groups of wheat farmers. For the participants, 14.2% were deemed unsustainable, 47.7% were considered partially sustainable, and 38.1% were classified as sustainable. For non-participants, the figures were 38.7%, 47.7%, and 13.5%, respectively. Therefore, it is suggested to provide more opportunities for participation in this program and expand it to other key crops. Additionally, authorities should provide more information about the benefits of the CF plan.

Keywords: Composite index approach, Dimensions of sustainability, Exploratory factor analysis, Sustainable agriculture.

INTRODUCTION

The Sustainable Development Goals (SDGs) serve as a "blueprint for achieving a better and more sustainable future for all" by 2030. They integrate sustainability into production, distribution, and consumption. The goals aim to ensure increased agricultural productivity through sustainable and resilient practices (United Nations, 2021). Achieving the goals relies on global agricultural sustainability. This meets society's long-term needs for food and fiber while protecting ecosystems (Suresh et al., 2022). The agricultural sustainability system is a complex concept that involves agricultural production and is guided by three fundamental principles: "Healthy environment," "economic viability," and "social acceptability" (Velten,

[1] Department of Agricultural Economics, Faculty of Agriculture, University of Zabol, Zabol, Islamic Republic of Iran.
* Corresponding author; e-mail: mahmadpour@uoz.ac.ir

2015). As the primary participants in the food value chain, farmers play a crucial role in promoting agricultural sustainability development (Liu et al., 2020; Chèze et al., 2020).

Today, agricultural contracts play a crucial role in most countries as a significant tool in managing risks, instilling confidence in farmers, and ensuring stable crop prices. The application of these contracts is increasing in developing countries (Gatto et al., 2017; Ntukamazina et al., 2017; Shahnavazi., 2022). The Food and Agriculture Organization (FAO) (2017) defines CF as bilateral agreements between farmers and companies to produce and supply crops under prior agreements, often at set prices. In general, CF involves agreements between farmers and buyers regarding production. Based on this agreement, smallholders gain access to inputs, assistance, and markets (Ragasa et al., 2018; Pouliot and Wang, 2018) through integration, which helps them cope with price changes and lower transaction costs (Guo et al., 2007; Li et al., 2016; Soullier and Moustier, 2018). This enhances efficiency and boosts farmers' incomes (Gulati et al., 2007; Miyata et al., 2009; Bellemare and Bloem, 2018; Khan et al., 2019).Therefore, CF must balance the goals of ensuring food/farmer welfare with protecting nature from degradation (Jianping et al., 2014; Knickel et al., 2017; Sharma et al., 2018; Kleemann and Abdulai, 2013).

This is important because market-based developments, such as CF can fuel the expansion of arable land to increase contract crop productivity (Evans et al., 2015; Vanderhaegen et al., 2018). Heavy chemical use threatens ecosystems through landscape changes, water pollution, and reduced soil biodiversity (Foley et al., 2011; Laurance et al., 2014; Sharma et al., 2018). CF helps farmers, especially poor ones, purchase fertilizers and pesticides under quality control (Gramzow et al., 2018). CF offers economic benefits such as price stability and market access, which shield farmers from the risks associated with price drops and seasonal fluctuations (Guo et al., 2007; Soullier and Moustier, 2018). Past research shows positive impacts of CF on farmer income (Bellemare and Bloem, 2018; Dargah., 2017; Dube et al., 2017). Sustainable production is often more expensive due to the higher costs of inputs such as labor, seeds, and organic fertilizers (Maggio et al., 2008; Wang et al., 2018).

While the CF and economic and welfare effects of carbon footprint are extensively studied, sustainability impacts receive little attention. For example, Soullier and Moustier (2018) found that there was no significant difference in the use of chemical fertilizers and weeding for marketing contracts. Mishra et al. (2018) showed that farmers with access to irrigation water were more likely to participate in CF. Increasing land and water use potentially leads to biodiversity degradation and loss, as discussed by Singh (2002), Bijman (2008), and Vicol (2017). All of them have raised concerns about environmental degradation due to CF and have claimed that CF can have negative effects on sustainable land management. However, in some cases, participation in CF can have positive effects on agricultural sustainability (Minten et al., 2007; Wollni et al., 2010; Dedehouanou et al., 2013; Kathage et al., 2016). Khan et al. (2019) and Wu et al. (2020) found that participation in a CF scheme increased producers' income and CF may positively impact skilled labor. Olounlade et al. (2020) reported CF negatively impacted the rice income. Hoang (2021), Dubbert et al. (2021) and Ren et al. (2021) investigated CF's small positive effect of sustainable technology.

Iranian farmers have been struggling to source inputs, sell crops, or channel them to industries without finding any solutions in recent years. The Ministry of Agriculture Jahad believes that CF can solve these issues by preventing corruption and farmers' losses, addressing brokering and middlemen, and increasing farmers' income. In CF, the private sector takes over government purchases and support, privatizing agriculture according to Act 44. In Iran, CF is based on agreements between farmers and companies.

Agriculture's importance in Iran's economic, social, political, and other fields cannot be denied due to its role in providing basic resources and fostering sustainable development through their utilization.

Considering the importance of wheat as Iran's main food source, sustainable production and reducing the need for imports have always been agricultural goals. Despite land allocation and efforts, Iran's low wheat yield compared to other countries places it in an unfavorable position among producers. Self-sufficiency has long been an official goal, but imports have risen recently due to threats such as drought, lack of training on pests for farmers, credit issues, and poor farmer support policies. Thus, the Ministry of Agricultural Jahad emphasized, within a resilient economy framework, initiatives such as CF to attain sustainable self-sufficiency in wheat.

Wheat grows across Iran under irrigation and rain in all provinces. Golestan was chosen for ranking first in quality and third in quantity of wheat nationally. It supplies over ten provinces. Over 1600 Golestan farmers, representing leading producers, participated in the CF plan. Significant funds and time were invested in the implementation of the plan there.

Iran's wheat CF plan began in 2021. The State Trading Company was tasked with signing farmer contracts, ensuring crops, supplying inputs, and settling accounts when buying harvest.

In 2022, over 250,000 hectares of wheat land were covered by the plan, with 2 million hectares expected next year (Ministry of Jahad Agriculture, 2022). Despite Iran's CF plan, no study has examined its impact on sustainability. Additionally, there is a lack of research by PCA and EFA methodology for CF. This research utilized a composite index to examine the impact of CF on agricultural sustainability, focusing on ecological security, economic efficiency, and social equality. A survey of Golestan wheat farmers for the 2020-21 season, both those participating and not participating in CF, assessed the adoption of sustainable practices. This research addressed the following questions:

· What is the status of agricultural sustainability among wheat farmers who are participating in the CF plan and those who are not participating in the plan in Golestan province?

· What is the status of the combined index of agricultural sustainability among wheat farmers participating in the CF plan and those not participating in the plan in Golestan province?

METHODOLOGY

This survey was conducted in Golestan province. The statistical population included all wheat farmers in this province. A multi-stage random sampling method was used to select the research area and farmers. In this research, after selecting the district, villages in each district, and farmers in each village were randomly chosen. The sample size was determined using Cochran's formula (Eq. 1). The data were collected from wheat farmers who participated in the CF plan during the crop year 2020-21 using a questionnaire that was validated by agricultural experts. SPSS statistical software (V.16) was utilized to analyze the data (IBM SPSS Statistics, 2023).

$$n = \frac{\frac{Z^2pq}{d^2}}{1 + \frac{1}{N}\left(\frac{Z^2pq}{d^2} - 1\right)} \qquad [1]$$

In equation 1 (Cochran, 1977), n is the sample size, p is the estimated proportion of the statistical population that participated in the CF plan, q is equal to $(1 - p)$, that is, the proportion of the population that did not participate in the CF plan, d is the degrees of confidence (0.05), $Z = 1.96$ is the percentage error of acceptable confidence coefficient (α level of error (0.05), and N the size of the statistical population of wheat farmers in this province. Then the KMO and Bartlett's Test of Sphericity are estimated to determine if the sample size is adequate. Another method to calculate the sample size is by using Morgan's table. According to Morgan's table, an additional 310 samples should be included.

In this research, sampling has been conducted in 7 counties of Golestan Province that have a higher percentage of participation in CF. The statistical population size in the rural areas of Golestan province that participated in the CF plan was 1613 households, with 310 farmers sampled, and 310 questionnaires was collected from farmers who did not participate in CF.

Table 1 shows the counties of Golestan province, the number of farmers participating in the CF plan, and the number sampled in each county.

Table 1. The population of farmers participating in the CF plan in Golestan province.

Counties	The number of farmers participating in the CF plan (persons)	The ratio of participants to total farmers (%)
Gonbad-e Qabus	150	29
Agh Qala	300	58
Kalaleh	192	37
Aliabad	319	61
Minodasht	295	56
Galikesh	115	22
Gorgan	242	47
Total	1613	310

Source: Agricultural Jahad Organization of Golestan Province, 2020.

The location of Golestan Province is shown on the map of Iran in Fig. 1.

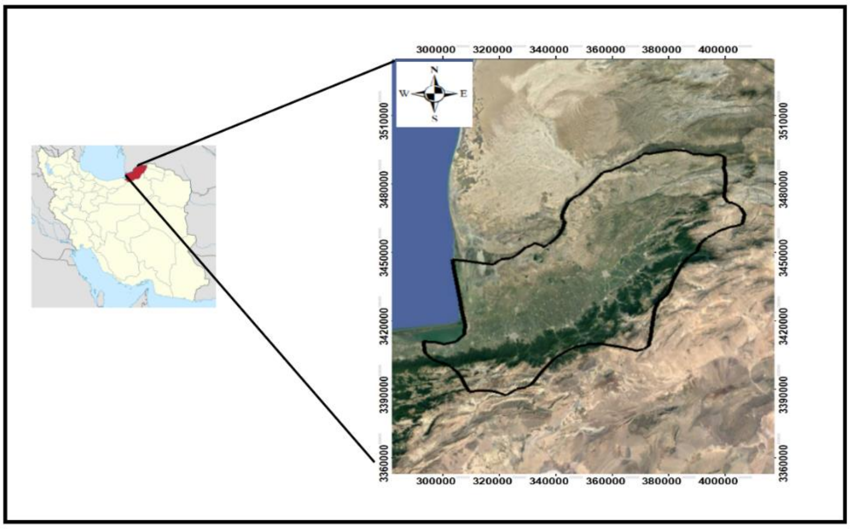

Fig. 1. Location of the studied area on the map of Iran.

The research examined the agricultural sustainability of two groups of farmers: those who participated in the CF plan and those who did not, using survey data. The study recorded the characteristics of each group for analysis. To accurately measure the sustainability of agriculture, the study identified important indicators of agricultural sustainability from the perspective of agricultural experts. The criteria included 32 indicators, which were measured on a five-point Likert scale ranging from very low sustainability to very high sustainability. Table 2 presents the agricultural sustainability indicators among farmers who participated in the CF plan and those who did not, separated by dimensions. The comprehensive calculation of sustainability enabled the determination of the overall level of agricultural sustainability in Golestan province. This was based on available information and a review of studies conducted in Iran and other countries (Durán Gabela et al., 2022; Ataei et al., 2022; Benitez- Altuna et al., 2023).

Table 2. Agricultural sustainability indicators and their dimensions.

Sustainability dimensions	Indicators
Economic	Access to various chemical fertilizers
	Access to agricultural machinery
	Access to crop markets
	Access to warehouses, cold storage, and silos
	Access to a variety of seeds
	Investment in agriculture
	Easy access to loans and bank credits
	The quality of chemical fertilizers used
	The existence of sufficient agricultural infrastructure in terms of irrigation facilities
Environmental	The application of the integrated method of livestock and plants
	The extent of using fallow (land fallow)
	Cultivation of other crops to implement crop rotation
	Using the forest-agriculture method
	Not burning the straw and stubble left over from harvesting the crop
	Adjusting planting and harvesting time to fight pests
	The use of integrated pest management
	The use of animal manure to strengthen the soil
	Consumption of micronutrient fertilizers
	Planting green manure to strengthen and increase soil fertility
	Correct and accurate use of fertilizers recommended by agricultural experts
	Minimal use of chemical fertilizers and pesticides
	Better water quality and quantity protection (consumption savings)
Social	Satisfaction with farming job
	Satisfaction with future career
	No feeling of deprivation
	The amount of social participation in village activities
	The extent of using communication networks
	The degree of willingness to insure land
	The level of satisfaction with agricultural officials and workers
	The amount of participation in educational and promotional classes
	Access to the nearest primary health care centers
	Access to safe drinking water in the household

Source: Dubbert et al. (2021); Ren et al. (2021); Khan et al. (2019); Liu et al. (2020); Guo et al., (2019); Dubbert, 2019; Dubbert and Abdulai, (2021); Peng and Pang (2019); Nguyen et al. (2015); Minot and Sawyer (2016).

The research questionnaire included questions on household characteristics, environment, economy, and society. Questions on household profiles covered demographics such as age, gender, marital status, education, family size, residence, land size, income, livestock ownership, and farm tools. To assess agricultural sustainability and its environmental, economic, and social dimensions, indicators from selected regions and farmer data were collected. Questions on CF and its effects arose from ministry instructions and expert opinions on wheat contract farming. To measure sustainability using composite indexes, factor analysis summarized the indicators in each dimension into factors. The factors were then combined in cluster analysis to determine farmers' status regarding adherence to sustainable agriculture principles in three categories: sustainable, partially sustainable, and unsustainable.

Normally, there are two problems in determining and measuring sustainability through a set of variables: a) the interdependence of the selected indicators, and b) the lack of consideration for the importance coefficient (weight) of each indicator. We used Exploratory Factor Analysis (EFA) to address these two problems. EFA is the most common method in factor analysis. The factor is a new variable estimated through the linear combination of the main variables as per Eq. 2 (Wold et al, 1987).

$$F_j = \sum_{i=1}^{p} A_{ji}\, X_i = A_{ji}X_1 + A_{ji}X_2 + \cdots + A_{jp}X_p \qquad [2]$$

The objective of this method is to find combinations of variable P $\left(X_1 + X_2 + \cdots + X_p\right)$ to create independent and uncorrelated variables$\left(F_1 + F_2 + \cdots + F_j\right)$. These new variables contain different variables, and the duplicate information is removed. In Eq. (2), A represents factor score coefficients and P represents the number of variables. In EFA-based research, determining the sample size and correlations between variables is essential. The sample size determines the correct clustering in EFA. The Kaiser-Meyer-Olkin (KMO) and Bartlett's tests ensure an adequate sample size and variable sphericity before conducting EFA. According to these interpretations, to measure agricultural sustainability, the factor analysis method was first used through the following steps: (1) preparing the standard matrix, (2) calculating the matrix of correlation coefficients, (3) extracting the factors, (4) rotating the factors, and (5) calculating factor scores. Other studies utilised instrumental variables and regressions to estimate the impact of CF on agricultural production and sustainability. (Soullier & Moustier, 2018; Mishra et al, 2018; Ren et al, 2021).

Factor analysis summarizes the collinearity among indicators and groups them into factors, each assigned an appropriate weight. The factor score sum thus represents indicators well. The sum of average factor scores can indicate compliance with agricultural sustainability principles and levels of enjoyment. Cluster analysis classified sustainability levels, enabling researchers to group studied cases based on their existing homogeneity, and subsequently interpret and explain them. Researchers first calculated a composite index using principal component analysis and indicator weighting. The composite index obtained then served as the basis for cluster analysis, which was analyzed hierarchically. This research utilized factor analysis to streamline the indicators of sustainability dimensions, building on the studies by Dovbischuk (2023), Saygili et al. (2023), Das et al. (2023), and Blay Jnr et al. (2022).

RESULTS AND DISCUSSION

To assess wheat farmers' compliance with sustainability principles in Golestan, the questionnaire's reliability was tested through a pre-test involving 30 individuals from the population. Cronbach's alpha was 0.77 for economic, 0.65 for social, and 0.64 for environmental dimensions, indicating reliable measurement. Agricultural sustainability dimensions were evaluated by the EFA. KMO (It should be more than 0.6) and Bartlett tests (The significant level should be less than 0.05) were conducted to assess the suitability of the data for factor analysis. The results in Table 3 confirmed that the variable correlations were suitable for factor analysis.

Table 3. The results of KMO's and Bartlett's tests.

Sustainability dimensions	KMO stat value	Bartlett's value	DF	Significance level
Economic	0.726	2162	36	0.000
Social	0.722	1885	28	0.000
Environmental	0.716	2201	45	0.000

Source: Research Findings.

Table 4 presents the extracted factors, along with their eigenvalues and the variance they account for after Varimax rotation. The results show that when the eigenvalue was greater than one, two factors were extracted for the economic dimension. The first factor was the most significant, with an eigenvalue of 3.218, accounting for 35.760% of the variance in the factors that determine the economic dimension of agricultural sustainability. It was named Access to Agricultural Inputs and Equipment, according to the five indicators included in this factor (access to various chemical fertilizers, agricultural machinery, crop markets, warehouses, cold storage, silos, and a variety of seeds). The second factor with an eigenvalue of 2.020 is loaded by investment in agriculture, facilitating access to loans and bank credits, the quality of chemical fertilizers used, and the existence of sufficient agricultural infrastructure for irrigation. This factor could capture 22.440% of the total variance. It was named Investment Possibilities, Infrastructure, and Quality of Inputs.

In the social dimension of sustainability, three factors were identified. In this study, two indicators (the willingness to invest in land and the satisfaction level with agricultural officials and workers) were excluded from the analysis because they did not show significant correlations with other indicators in the factor analysis. The first factor with an eigenvalue of 2.466 accounted for 30.820% of the variance in the factors determining this dimension. It was named "Job Satisfaction" based on the three indicators included in this factor: satisfaction with the farming job, satisfaction with the future career, and absence of feelings of deprivation. The second factor, with an eigenvalue of 2.110, included three indicators: the level of social participation in village activities, the extent of using communication networks, and the degree of participation in educational and promotional classes. The study was titled "The Extent of Social, Communicational, and Educational Participation." The third factor from the social dimension was loaded with two indicators: access to the nearest primary health care centers and access to safe drinking water in the household. It was named "Access to Safe Drinking Water and Sanitary Facilities."

In the environmental dimension, three indicators (adjusting planting and harvesting time to combat pests, implementing integrated pest management, and utilizing micronutrient fertilizers) were excluded because they did not correlate with other indicators in the factor analysis. The first factor from the environmental dimension of sustainability included five indicators: utilizing the integrated method of livestock and plants, the amount of fallow application, cultivation of other crops to implement crop rotation, using the forest-agriculture method, and not burning the straw and stubble left over from harvesting the crop. It had an eigenvalue of 3.631 and accounted for 36.315% of the variance in the determining factors of this dimension. Adherence to Cultivation Principles The second factor included two indicators: the use of animal manure to enhance the soil and planting green manure to improve soil fertility. This factor was named "The Application of Organic Fertilizers." Finally, the third factor from the environmental dimension was loaded with three indicators: correct and accurate use of fertilizers recommended by agricultural experts, minimal use of chemical fertilizers and pesticides, and better protection of water quality and quantity. This factor was named "The Correct Use of Agricultural Inputs."

Table 4. The factor matrix rotated by the Varimax method.

Sustainability dimensions	Factor loading	Variables	Factor name
Economic	0.848	Access to various chemical fertilizers	Access to agricultural inputs and equipment (eigenvalue:3.218) (variance percentage:35.760)
	0.815	Access to agricultural machinery	
	0.814	Access to crop markets	
	0.827	Access to the warehouses, cold storage, and silos	
	0.554	Access to a variety of seeds	
	0.599	Investment in agriculture	Investment possibilities, infrastructure, and quality of inputs (eigenvalue:2.020) (variance percentage:22.440)
	0.789	Facilitating access to loans and bank credits	
	0.548	The quality of chemical fertilizers used	
	0.820	The existence of sufficient agricultural infrastructure for irrigation	
Social	0.815	Satisfaction with farming job	Job satisfaction (eigenvalue:2.466) (variance percentage:30.820)
	0.872	Satisfaction with future career	
	-0.610	No feeling of deprivation	
	0.728	The extent of social participation in village activities	The extent of social, communicational, and educational participation (eigenvalue:2.110) (variance percentage:26.374)
	0.890	The extent of using communication networks	
	0.794	The extent of participating in educational and promotional classes	
	0.861	Access to the nearest primary healthcare centers	Access to safe drinking water and sanitary facilities (eigenvalue:1.366) (variance percentage:17.075)
	0.610	Access to safe drinking water in the household	
Environmental	0.864	Utilizing the integrated method of livestock and plants	Adherence to cultivation principles (eigenvalue:3.631) (variance percentage:36.315)
	0.930	The amount of the application of fallow (land fallow)	
	0.529	Cultivation of other crops to implement crop rotation	
	0.864	using the forest-agriculture method	
	0.930	Not burning the straw and stubble left over from harvesting the crop	
	0.764	The use of animal manure to strengthen the soil	The application of organic fertilizers (eigenvalue:1.960) (variance percentage:19.604)
	0.857	Planting green manure to strengthen and increase soil fertility	
	0.774	Correct and accurate use of fertilizers recommended by agricultural experts	The correct use of agricultural inputs (eigenvalue:1.587) (variance percentage:15.866)
	0.796	Minimal use of chemical fertilizers and pesticides	
	0.782	Better water quality and quantity protection	

Source: research findings

In this section, Friedman's variance analysis was utilized to determine the relative importance of each factor based on their factor scores. As evident in Table 5, there were significant differences in the relative importance of sustainability components. The components of social, communicational, and educational participation, as well as the consumption of organic fertilizers, had ranks higher than the average.

Table 5. Friedman analysis test results.

Sustainability dimensions	Factors	Rank average	Factors rank
Economic	Access to agricultural inputs and equipment	4.29	8
	Investment possibilities, infrastructure, and quality of inputs	4.52	4
Social	Job satisfaction	4.31	7
	The extent of social, communicational, and educational participation	4.93	1
	Access to safe drinking water and sanitary facilities	4.33	6
Environmental	Adherence to cultivation principles	4.54	3
	Consumption of organic fertilizers	4.73	2
	Correct use of agricultural inputs	4.35	5
Friedman's test statistic value=38.002		DF=7	Significance level= 0.000

Source: research findings

The results of the differences in sustainability dimensions between the group of wheat farmers participating in the CF plan and those not participating in this plan are presented in Table 6.

Table 6. The difference in sustainability dimensions between the group of wheat farmers participating in the CF plan and those not participating in this plan.

Sustainability dimensions	Mann-Whitney test statistic	Wilcoxon test statistic	Z test statistic	Significance level
Economic	2.982E4	7.803E4	-8.179	0.000
Social	4.565E4	9.385E4	-1.078	0.281
Environmental	3.791E4	8.611E4	-4.549	0.000
Total sustainability index	2.948E4	7.768E4	-8.325	0.000

Source: research findings

The distribution of the three dimensions of stability and the total sustainability index is non-normal, so the Mann-Whitney test can be used.

As seen in Table 6, the wheat farmers in two groups of participants and non-participants in the CF project differed significantly ($P < 0.01$) in terms of economic and environmental sustainability, as indicated by the reported statistics. Also, based on the total sustainability index, there was a significant difference between the two groups. The wheat farmers were separated into three groups based on the composite index of sustainability through cluster analysis. The results of the classification of the composite sustainability index are presented in Fig. 2. These results indicate that the number of farmers in the sustainable group exceeded the number in the other groups. Based on the total sustainability index, 25.8% of the farmers were at the sustainable level.

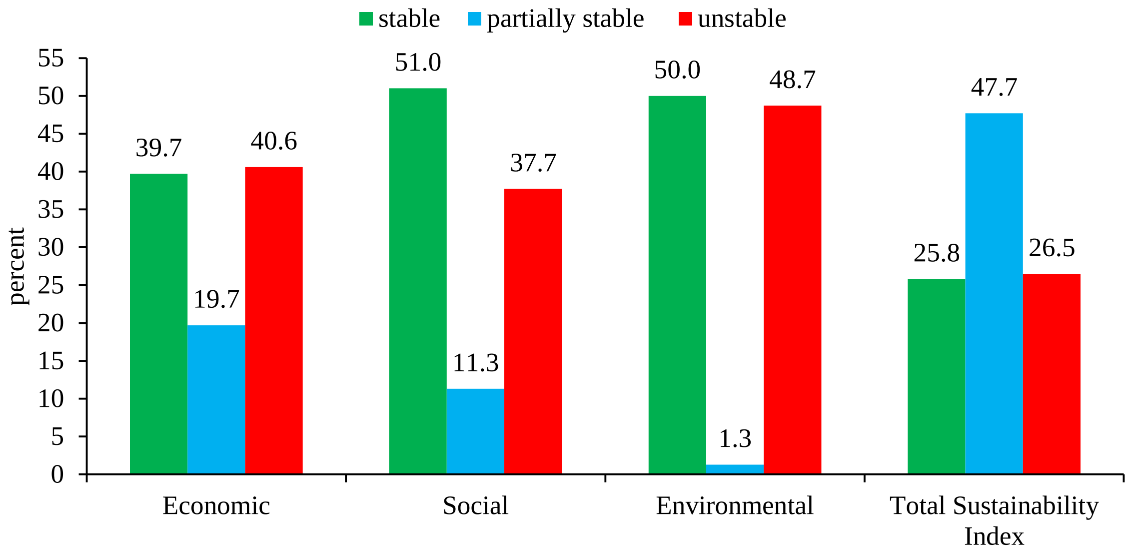

Fig. 2. Agricultural sustainability status of all wheat farmers investigated in Golestan province (Source: research findings).

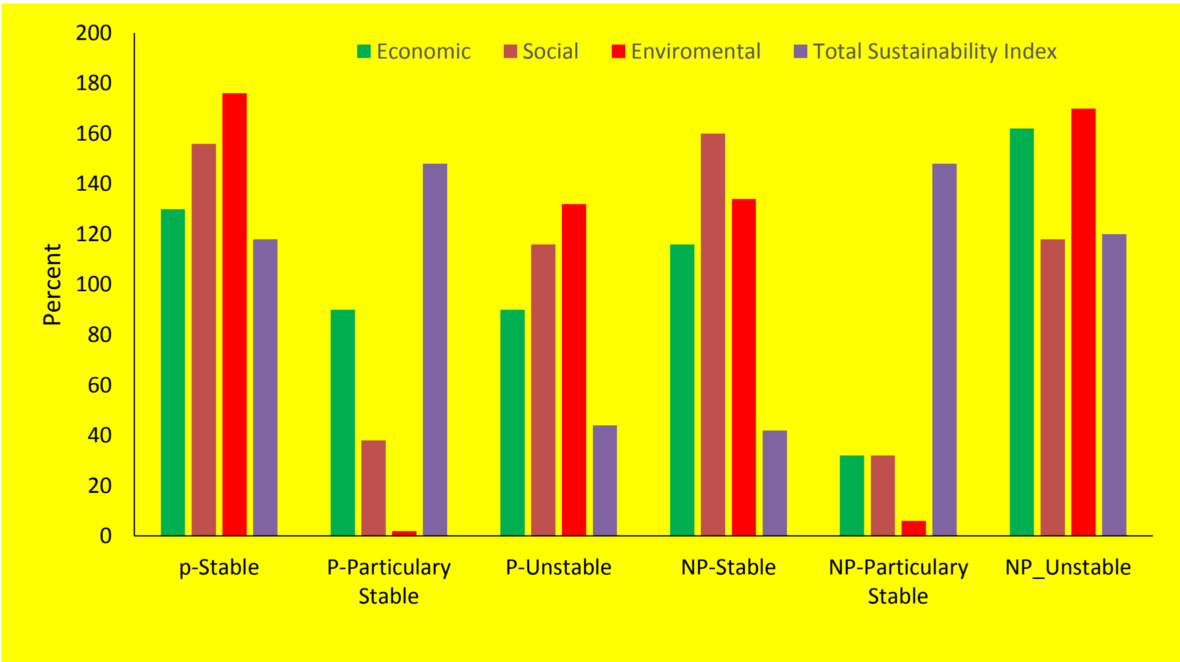

Fig. 3. Agricultural sustainability status among wheat farmers participating(P) and non-participating(NP) in the CF plan in Golestan province (Source: research findings).

The analysis of sustainability levels between wheat farmers participating or not in CF showed that participation increased production sustainability in economic, social, and environmental dimensions (Figs. 2). Based on the total sustainability index, more participating wheat growers (38.1%) were in the sustainable cluster, indicating that CF successfully enhanced wheat grower sustainability across three dimensions.

As a result, the economic sustainability of CF farmers is higher than that of non-CF farmers because they sell wheat at a higher price, assure the markets, and experience no fluctuations in their wheat selling prices. Additionally, CF farmers are required to use a specified amount of fertilizer and pesticide through contracting, making them more environmentally sustainable than other farmers.

CONCLUSIONS

To measure CF's effect on agricultural sustainability, this study analyzed 32 rural social, economic, and environmental indicators in Golestan province located in the northeast of Iran. To address the question of sustainability status, three dimensions were evaluated. Economic and environmental dimensions were more sustainable for wheat farmers participating in CF, with no difference in the social dimension between groups. Results also showed an imbalance between the sustainability levels of farmers participating or not in CF. Non-participants had less favorable conditions. CF implementation has contributed to greater farmer sustainability through support, contracts, advice, and monitoring. Authorities should inform farmers about the benefits of CF, and facilitate broader participation to enhance production sustainability. Additionally, they should consider extending the plan to other important crops. In this study, like many studies in Iran, obtaining data from Agricultural Jahad of CF farmers posed challenges for researchers. Researchers suggest conducting further research in other cities and on different products to compare and understand the benefits of CF farming, in order to develop it further and achieve more sustainability.

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