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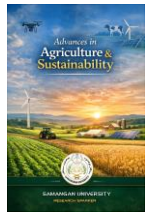

Assessment of Agricultural Sustainability Among Grape Producers in Feroz Nakhchir District

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Keywords

Agricultural Sustainability, Analytical Hierarchy Process, Feroz Nakhchir District, Grape Producers.

Research/Review Article

Abstract

The exacerbation of environmental conditions due to pollution, global warming, air pollution, and other factors has increased the focus on sustainability in all domains. In this regard, the escalating population pressure and the growing need for food, coupled with the consequent rise in the indiscriminate use of fertilizers and pesticides for production, have presented unprecedented challenges to achieving sustainability in the agricultural sector. Expert questionnaires were used to weigh criteria, and farmer questionnaires were used to estimate agricultural sustainability. A total of 20 questionnaires were distributed among experts in economics and agricultural development, while 385 questionnaires were distributed among farmers in this district, using a stratified random sampling method proportional to the size.

Subsequently, through data coverage analysis, the data were analyzed to assess and calculate agricultural sustainability.

1. Introduction

One of the most significant challenges facing human society and governments is ensuring an adequate and healthy food supply for the growing global population, which is expected to reach approximately 9 billion soon. Agricultural systems must move towards providing sufficient food for all individuals, understanding that merely ensuring an adequate food supply is insufficient (Rezaei et al., 2021). Attention must also be directed towards the discussion of food safety. The minimum requirements and primary necessities for sustaining the nutrition of this population involve cultivating an additional one billion hectares, accompanied by a proportional increase in nitrogen consumption through chemical fertilizers, a substantial rise in pesticide usage, and a heightened demand for water. This occurs while production resources are severely deteriorating and under threat due to the disruption of natural and ecosystem balances (Rahmani et al., 2022).

On the one hand, the prevailing intensive agricultural system, reliant on external inputs, despite its increased productivity due to the incorporation of new technologies, has not only failed to ensure food security but has also given rise to environmental and ecosystem risks, as well as undesirable economic and social consequences, especially in the realm of health (Pretty, 2008). The intensive agricultural system, initiated in the 1950s to enhance productivity by utilizing high-yielding varieties, modern irrigation methods, and new machinery primarily based on chemical inputs, faced significant challenges and crises only a decade later. This was primarily due to the unregulated and inappropriate use of chemical inputs and other technologies. The production process encountered new difficulties and crises, the repercussions of which have been far more severe and acute than the challenges associated with a lack of access to technology (Therond et al., 2017).

The risks and crises arising from introducing chemical inputs into the agricultural sector have not only impacted production health but have also posed challenges to the quantity and quality of production (Brodt et al., 2011). The emergence of these issues has led to a shift towards sustainable agriculture, especially organic farming, gaining attention in recent decades, particularly since the 1980s (Bendjebbar

& Fouilleux, 2022). This movement has prompted agricultural experts and researchers to recognize this process. For agricultural sustainability, three key aspects are crucial: ensuring sufficient income, especially among low-income individuals, enhancing accessibility to food and its consumption, and recent attention has been directed towards the protection and improvement of natural resources due to the effects of increased food production on these resources (Antle & Ray, 2020). The preservation of natural resources must also be considered in light of the recent focus on the impact of increased food production on these resources (Serra-Majem et al., 2020).

In traditional and prevalent agriculture practices today, standard in many parts of the world, profound and fundamental attention has yet to be given to soil and water conservation. The distinction between sustainable agriculture and contemporary intensive agriculture lies in the emphasis on long-term performance sustainability with minimal environmental impact in sustainable agriculture, whereas intensive agriculture is reliant on short-term goals and maximizing performance. In sustainable agriculture, two fundamental principles exist: reducing chemical usage, particularly pesticides, and establishing complexity and diversity. This necessitates the preservation of various plant species and habitats on the farm (Gachene et al., 2020).

From an ecological and economic perspective, any system intended to be sustainable in the long term must consider two fundamental criteria: 1) Minimal exploitation of non-renewable resources, especially fossil energy, and 2) Minimal environmental degradation. Unstable agricultural methods, including exposing the soil in certain seasons, lead to soil erosion and destructive floods (Compernolle et al., 2023).

The region of Feroz Nakhchir, situated in the heart of the spectacular landscapes of Samangan province, bears witness to the intricate interconnection of agriculture and the environment. In recent years, the grape cultivation sector has become a central element in the local economy, significantly contributing to the community's livelihood. However, with the increasing global awareness of sustainable practices, examining the agricultural outlook and assessing the sustainability of grape production in this region is essential.

This article delves into the intricate fabric of grape cultivation in Feroz Nakhchir, aiming to shed light on agricultural sustainability among grape producers. In the context of grape cultivation, sustainability extends beyond purely economic considerations. It encompasses ecological harmony, social responsibility, and the grape industry's ability to endure and progress.

The Feroz Nakhchir region boasts a rich agricultural history, with grape cultivation evolving into a central economic axis. This area's unique climatic and soil conditions have created an optimal environment for grape cultivation, leading to the expansion of vineyards that paint the landscape in shades of green and purple. Beyond visual appeal, the grape industry plays a vital role in creating job opportunities, supporting livelihoods, and contributing to the overall agricultural production of the province.

While the grape industry in Feroz Nakhchir has flourished, it is not immune to the challenges threatening modern agriculture. Climate change, water scarcity, market fluctuations, and shifts in consumer preferences pose significant threats to the sustainability of grape cultivation. Addressing these challenges necessitates thoroughly examining the practices employed by grape producers and exploring sustainable alternatives that can fortify the industry against external pressures (Wikipedia, 2023).

Agricultural sustainability is a multidimensional concept that extends beyond conventional parameters such as yield and profit. In the context of grape production in Feroz Nakhchir, this entails a comprehensive assessment of environmental impacts, resource utilization, social dynamics, and the industry's resilience in changing conditions. This article aims to uncover layers of sustainability in the grape sector and provide insights into current practices, innovations, and potential pathways toward a sustainable future.

The primary objectives of this research are to assess the ecological, economic, and social dimensions of grape production in Feroz Nakhchir and identify areas where sustainable practices can be implemented or strengthened. Through a comprehensive approach involving field surveys, interviews with grape producers, and data analysis, we aim to paint a nuanced picture of the current situation and provide informed recommendations for promoting agricultural sustainability.

As we embark on this exploration, our goal is to understand the challenges faced by grape producers in Feroz Nakhchir and engage in a broader discussion on sustainable agriculture. We seek to offer insights that resonate with grape-producing regions worldwide. A journey to the heart of Feroz Nakhchir's vineyards promises to reveal the intricate dance between tradition and innovation, economy and ecology, as we navigate a path toward a more sustainable future for grape producers in this region. Numerous studies in this field have been conducted, and below, we examine some of the studies conducted both domestically and internationally.

Abdollahzadeh et al. (2015) investigated the sustainability of the rice farming system in Sari County, Iran, using hierarchical analysis. The results showed that 17.77% and 66.53% of the rice production system were in unstable and potentially unstable states, respectively. Although the social component of sustainability was satisfactory, the economic and ecological aspects still needed to be in a more vital state of sustainability.

Amini et al. (2015) revealed regional variations in the context of rice agriculture sustainability in the studied county. The findings indicate that districts with rice paddies, namely Khoshabar district, demonstrate a high level of sustainability, Gildoolab district exhibits a moderately sustainable level, and Dinachal district is characterized by low sustainability. Furthermore, the analysis of the final indices within the three overarching domains—water resource sustainability, soil resource sustainability, and general agricultural sustainability principles—illustrates more significant variability and regional differences concerning rice agriculture sustainability and utilizing foundational agricultural resources at the county level.

Cahya (2016) studied agricultural sustainability within Metropolitan Jakarta, and Multidimensional Scaling was employed. The findings indicated that, under prevailing circumstances, urban agriculture in West Jakarta is predominantly categorized as less sustainable across various dimensions, with only the institutional and technological aspects being deemed relatively sustainable.

Ghabru et al. (2017) studied the Estimation of Agricultural Sustainability in Gujarat through the Sustainable Livelihood Security Index (SLSI). The research revealed that in 2001, Surat district held the top position in SLSI with a score of 0.584, whereas Narmada district had the lowest ranking with a score of 0.265. In 2011, Rajkot district emerged as the leader in SLSI with a score of 0.589, while Porbandar district recorded the lowest SLSI score at 0.257.

Tzouramani et al. (2020) examined agricultural sustainability in Greece by applying the Multiple Criteria Decision Analysis (MCDA) technique. The results of their study indicated that agricultural practices involving crops like olives and extensive livestock systems exhibited greater sustainability compared to intensive cultivation and arable crop farms.

Rahmani et al. (2022) employed the analytical hierarchy process (AHP) method to assess the agricultural sustainability of the Sholgara district. Their results indicated that Qurbaqqa Khana ranked as the district's least sustainable community, while Khowja Iskandar stood out as the most sustainable village.

Kumar & Pant (2023) explored the utilization of the Analytic Hierarchy Process (AHP) in the agricultural context. The article comprehensively covered nearly all research employing the AHP methodology, highlighting the necessity for increased focus from researchers, scientists, and policymakers to attain Sustainable Development Goals (SDGs).

Numerous research investigations have delved into assessing agricultural sustainability, encompassing various aspects. However, a primary challenge in evaluating agricultural sustainability revolves around selecting appropriate criteria. The criteria employed to assess agricultural sustainability need to exhibit two essential attributes: firstly, these indicators should demonstrate advancements in attaining sustainability objectives, and secondly, they should be quantifiable within the particular research context (Roy & Chan, 2012). The criteria for this study were established through a comprehensive review of prior research.

2. Materials and Methods

2.1 Research Area

Feroz Nakhchir District is one of the seven districts in Samangan Province, situated in northern Afghanistan. Classified as a third-grade district in Samangan Province, it covers an area of 1,211 square kilometers and, with a population of 15,000 in 1399, ranks as the seventh most populous district in the province. Feroz Nakhchir District is located in northern Afghanistan, bordering Khahan and Darah Sof districts to the north, Darah Sof and Darah Sof Bala districts to the east, Darah Sof Bala and Darah Sof Payin districts to the south, and Balkh Province to the west.

The district enjoys a moderate and mountainous climate characterized by high mountains, deep valleys, and flowing rivers. Key mountains in the district include Feroz Nakhchir Mountain, Yakhchal Mountain, Aq Cheshme Mountain, and Abgarm Mountain. Prominent rivers include the Feroz

Nakhchir, Yakhchal, and Aq-Cheshme. Feroz Nakhchir District's economy relies on agriculture, animal husbandry, and handicrafts. The primary agricultural products include wheat, barley, rice, vegetables, and fruits. The most significant horticultural product in the district is grapes, holding the foremost position in production within the province (Wikipedia, 2023).

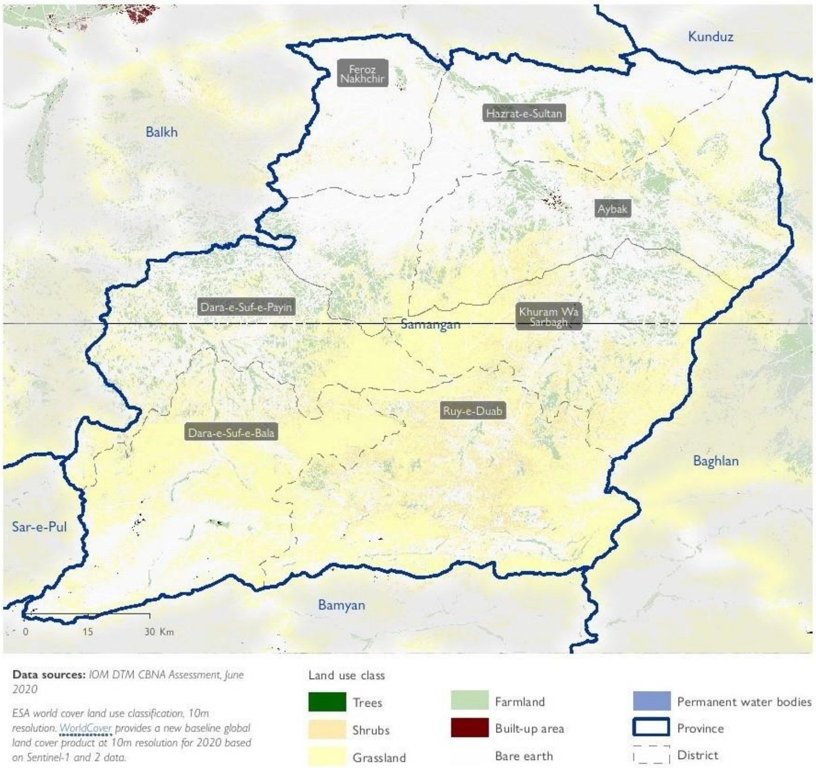

Figure 1. The Location of Feroz Nakhchir District in Afghanistan

2.2 Analytical Hierarchy Process.

The Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method used for weighting criteria and selecting the optimal option based on pairwise comparisons. In this approach, experts contribute to determining criteria weights and prioritizing options. The term "Analytical Hierarchy Process" is abbreviated as AHP. This method was introduced by Thomas Saaty in 1983 (Yadav, 2021). The primary goal of this approach is to prioritize a set of criteria or options. Once the objective is defined, criteria for decision-making are identified. These criteria are pairwise compared based on the objective, and their weights are determined. Finally, the options are pairwise compared for each criterion, and the final priority of options is established (Sharma et al., 2020).

The main objective of the Analytical Hierarchy Process is to choose the best option based on various criteria through pairwise comparisons. This technique is also used for weighting criteria. Since increasing the elements in each comparison set complicates the pairwise comparison, decision criteria are usually divided into sub-criteria. This article illustrates the Analytical Hierarchy Process with a practical example. Agricultural sustainability is a complex concept that encompasses various economic, social, and environmental aspects. Assessing agricultural sustainability is a crucial challenge that requires multi-criteria methods. Analytic Hierarchy Process (AHP) is a powerful method for assessing agricultural sustainability. This method can determine the relative importance of agricultural sustainability criteria, evaluate different options for improving agricultural sustainability, and rank various agricultural systems in terms of sustainability (Nydick & Hill, 1992).

In the first step of assessing agricultural sustainability, criteria for agricultural sustainability must be defined. These criteria may include economic, social, and environmental aspects of agricultural sustainability. AHP can assist decision-makers in determining the relative importance of these criteria. After defining the criteria, AHP can be utilized to evaluate various options for improving agricultural sustainability. These options may involve different agricultural management practices, policy reforms, and infrastructure investments. AHP provides a systematic approach to assess the impact of these options on agricultural sustainability (Vaidya & Kumar, 2006).

Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method used to assist decision-makers in choosing between different options. It relies on the intuitive judgments of decision-makers regarding the relative importance of criteria and options. AHP finds applications in various fields, including industry, agriculture, education, healthcare, and government management. Some of the applications of AHP include:

- Choosing between different options.
- Setting priorities.
- Solving complex decision-making problems.
- Resource management.
- Strategic planning.

Analytical Hierarchy Process involves five main steps:

Step 1: Calculate the weighted sum vector by multiplying the pairwise comparison matrix with the column vector "Relative Weight." The resulting vector obtained this way is called the weighted sum vector.

Step 2: Calculate the compatibility vector by dividing the elements of the weighted sum vector by the relative priority vector. The vector obtained is called the compatibility vector.

Step 3: Obtain Lmax, which gives the average of the elements of the compatibility vector.

Step 4: Calculate the compatibility index using the following formula: CI=(Lmax-n)/(n-1), where n is the number of criteria in the problem.

Step 5: Calculate the consistency ratio by dividing the compatibility index by the random index: CR=CI/RI (Fabianek et al., 2020).

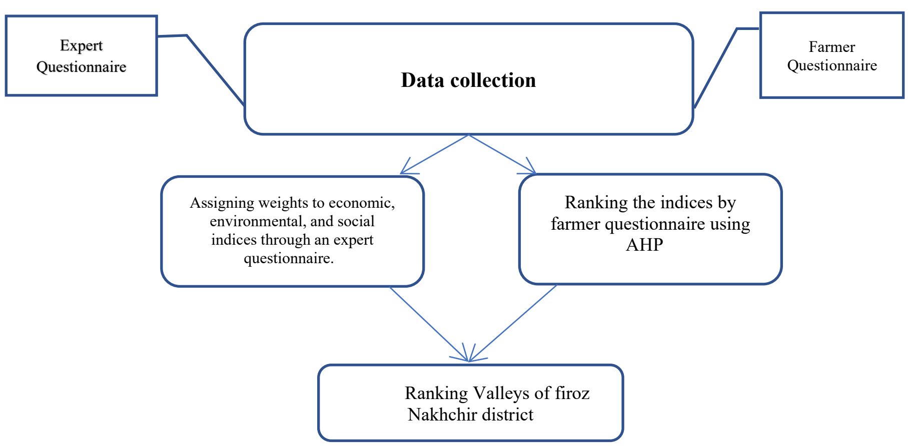

Figure 2. Research framework

3. Results

3.1 Weighting and Ranking of Sustainability Indicators

The weights and percentages of importance for each criterion in Table (4-3) are illustrated. Expert opinions in agricultural economics have been utilized to assign weights to the criteria and determine the percentages of their importance regarding sustainability. The weights for the three economic, social, and environmental criteria in overall sustainability, based on the prioritization by experts, are calculated as 0.301, 0.072, and 0.626, respectively.

According to experts' opinions and economic ranking, economic performance is the most influential factor in determining sustainability. From a social perspective, health status is the most influential factor in determining sustainability, and from an environmental perspective, the use of pesticides in agricultural sustainability holds the top rank.

Table 1. Weighting and Ranking of Sustainability Indicators

Criteria and Rank	Sub-Criteria	Rank	Weight	Scale
Social (0.072	Age	4	0.074	Year
	Education	7	0.062	%
	Family Members	6	0.07	No
	Family Labor	2	0.172	No
	Non-Family Labor	5	0.072	No
	House Facilities	3	0.141	%
	Health Status	1	0.359	%
	Migration	8	0.05	%
Economic (0.301)	Agricultural Income	2	0.361	Afg/Acre
	Non-Agricultural Income	4	0.092	Afg/Acre
	Cost	3	0.122	Afg/Acre
	Production	1	0.362	Kg/Acre
	Credit Access	5	0.064	%
Environmental (0.621)	Phosphate	6	0.052	kg/Acre
	Nitrogen	2	0.17	kg/Acre
	Animal Manure	4	0.124	kg/Acre
	Bio-Fertilizer	3	0.139	%
	Insecticide	1	0.34	Liter/Acre
	Irrigation	7	0.027	No
	Bio-Control	5	0.122	%
	Land	8	0.026	Acre

Source: Research Findings

3.2 Descriptive Statistics of Sustainability Indicators

This section describes the study population based on the specified variables, providing an overview of the current situation. Descriptive statistics, which encompass a relatively broad spectrum, have been employed to achieve this. Descriptive statistics in this research include a frequency table for gender, age, education, income, homeownership, agricultural land ownership, occupation, number of dependents, experience in the agricultural sector, and the extent of agricultural land.

Table 2. Descriptive Statistics of Sustainability Indicators

Variable	Options	Frequency	Percentage
Education	Illiterate	163	42.34
	Primary	150	38.96
	Secondary	65	16.88
	Higher	7	1.82

House Facilities	Bad	168	43.64
	Medium	157	40.78
	Good	60	15.58
Health Status	Bad	180	46.75
	Medium	146	37.92
	Good	59	15.32
Migration	Willingness	284	73.77
	Unwillingness	101	26.23
Bio-Control	Using	61	15.84
	Not Using	324	84.16
Credit Access	Accessible	297	77.14
	Inaccessible	88	22.86
Bio-Fertilizer	Using	50	12.99
	Not Using	335	87.01

Source: Research Findings

Based on the results of the above Table, most respondents (45.3%) are illiterate, and only a tiny percentage (1.4%) possess a high level of literacy. Most respondents (38.1%) have an inappropriate housing situation, while (33.1%) report having a suitable living arrangement. Most respondents (35.3%) do not have a satisfactory health condition, while (33.8%) are in good health. Most respondents (61.2%) are unwilling to migrate, indicating their satisfaction with the living conditions in their place of residence. Most grape farmers in this district (69.8%) need access to credit, leading to financial problems and challenges. Most farmers (77.7%) do not utilize biological methods to combat pests and diseases, contributing to environmental degradation and negatively impacting sustainability. Most farmers in this district (87.8%) do not use organic fertilizers to improve soil fertility.

Table 3. Descriptive Statistics of Sustainability Indicators

Variable	Minimum	Maximum	Mean	Std. Error
Age	20	75	46.17	14.873
Family Members	3	14	8.06	3.104
Family Labor	1	10	3.96	2.16
Non-Family Labor	5	45	29.9	6.983
Agricultural Income	1250	103750	9232.372	32.372
Non-Agricultural Income	0	10000	4358.5	3746.165
Cost	3000	15000	8079.14	2731.498
Production	250	1000	1628.59	2776.44
Phosphate	20	100	57.5	25.362
Nitrogen	30	150	95.92	33.908
Animal Manure	0	800	376.19	291.946
Insecticide	0	1	0.3546	0.37386
Irrigation	4	13	8.93	2.81
Land	1	8	3.086	1.4755

Source: Research Findings

According to the above Table, the minimum age of respondents is 20 years, the maximum is 75 years, and the average age is 46.17 years. The minimum number of family members for respondents is 3, the maximum is 14, and the average is 8.06. The maximum number of family laborers used in agricultural occupations is ten individuals, with an average of 3.96. The maximum number of non-family laborers used in agricultural occupations is 45 individuals, with an average of 29.9.

The minimum income obtained from agricultural work is 1,250 Afghanis, the maximum is 103,750 Afghanis, and the average is 9,232.372 Afghanis. The maximum non-agricultural income grape farmers obtain is 10,000 Afghanis, averaging 4,358.5 Afghanis. The minimum expenditure in grape orchards is 3,000 Afghanis, the maximum is 15,000 Afghanis, and the average is 8,079.14 Afghanis. The grape production in a vineyard range from 250 kilograms to 1,000 kilograms per vineyard.

The maximum amount of phosphorus fertilizer used in vineyard land is 100 kilograms, and the maximum amount of nitrogen fertilizer used is 150 kilograms. The maximum amount of animal manure used on the land is 800 kilograms, and the maximum amount of insecticide used on the land is 1 liter per vineyard. According to information gathered from grape farmers in this district, they have yet to use herbicides and fungicides, and as a result, they have been excluded from the model. The frequency of irrigation in grape orchards ranges from 4 to 13 times. The minimum land owned by grape farmers is one vineyard, the maximum is 8, and the average is 3.086 vineyards.

3.3 Economic Sustainability

Economic criteria determining agricultural sustainability include agricultural income, non-agricultural income, consumption, performance, and access to loans. All the mentioned criteria positively affect sustainability, with only consumption having a negative impact. According to experts, performance has the most significant influence (36.2%), while access to loans has the most negligible impact (6.4%) on economic sustainability. As observed in Figure (3), based on the economic sub-criteria, Sayed Abad is the most sustainable village with a weight of 0.362, while Sar-I-Sofah is the least sustainable village with a weight of 0.114.

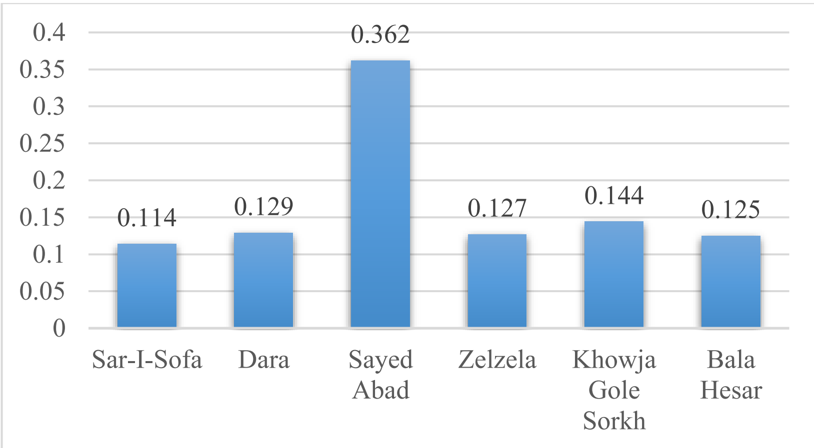

Figure 3. Economic Sustainability of Feroz Nakhchir District

3.4 Social Sustainability

As depicted in Figure (4), the social criterion includes sub-criteria such as family labor, non-family labor, age, education, family size, housing status, health status, and willingness to migrate. This criterion contributed the least to the overall sustainability of grape farmers in the Feroz Nakhchir district. According to expert opinions, willingness to migrate had the most negligible impact (0.05), while health status had the most significant impact (0.359) on social sustainability. Based on the social sub-criteria, Sayed Abad had the highest level of sustainability with a score of 0.183, while Sar-I-Sofah had the lowest with a score of 0.149.

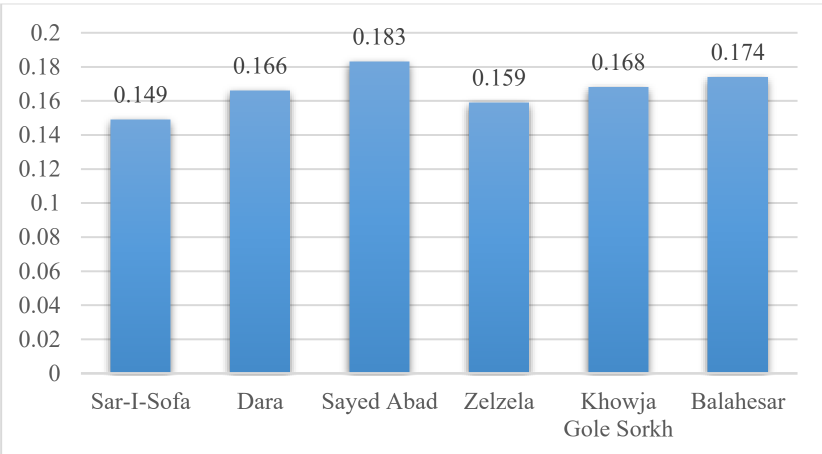

Figure 4. Social Sustainability of Feroz Nakhchir Sustainability

3.5 Environmental Sustainability

Environmental sustainability criteria, including fertilizers, pesticides, and irrigation, negatively impact sustainability, while the extent of agricultural land, biological control, biological pest control, and animal manure positively impact environmental sustainability. As seen in Figure (5), based on the environmental sustainability criterion, Khowja Gole Sorkh has the highest score of 0.192, and Balahesar has the lowest score of 0.154, indicating the highest and lowest levels of sustainability, respectively. According to the insecticide environmental criterion, with a score of 0.34, it has the most significant impact, while the extent of agricultural land, with a score of 0.026, has the most negligible impact on environmental sustainability.

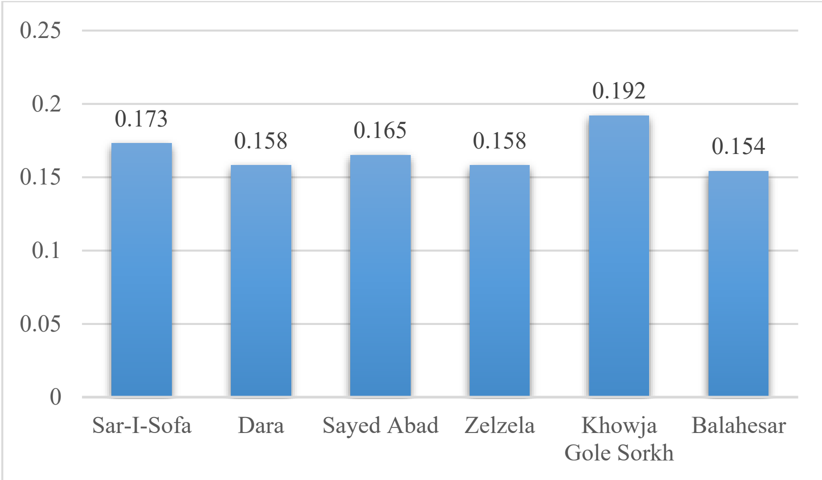

Figure 5. Environmental Sustainability of Feroz Nakhchir District

3.6 Total Sustainability

By Figure (4-4) and based on the economic, social, and environmental criteria, Seyedabad has been selected as the most sustainable village with a weight of 0.201. Following Seyedabad, Sar-I-Sofa, Khajeh Gol Sorkh, Dara, Zalzaleh, and Balahesar are prioritized with weights of 0.182, 0.16, 0.154, 0.153, and 0.15, respectively, as the subsequent priorities for sustainability in the Feroz Nakhchir district. The incompatibility rate for determining sustainability was found to be zero.

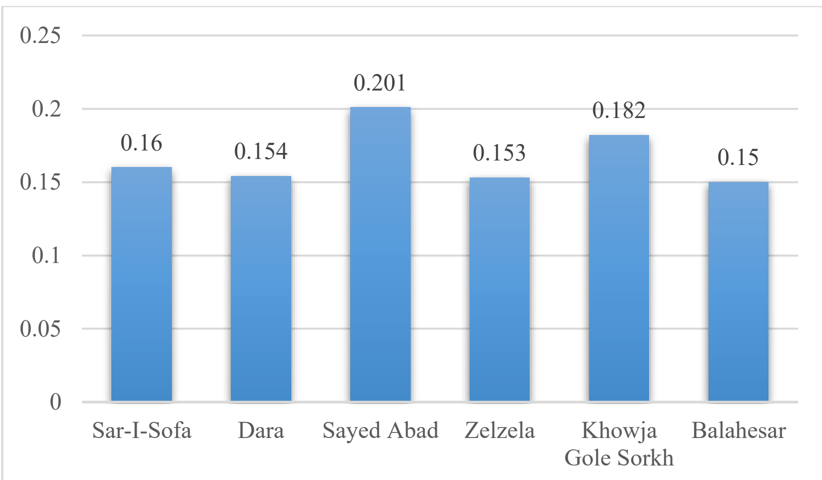

Figure 6. Total Sustainability of Feroz Nakhchir District

3.7 Sensitivity Analysis

Figure (7) illustrates the model's performance sensitivity analysis. Increasing the weight of the social criterion remains the same prioritization of sustainability in villages. Additionally, Sayed Abad continues to exhibit higher sustainability compared to other villages.

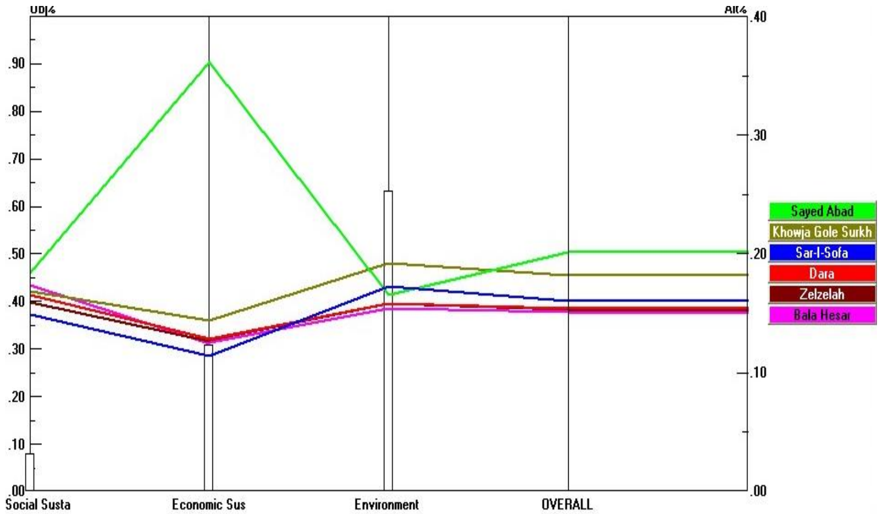

Figure 7. Sensitivity Analysis of Agricultural Sustainability

Changing the weight of environmental, social, and economic sustainability does not change the prioritization of village sustainability. Sayed Abad continues to be identified as the most stable village. Sensitivity analysis was also conducted in other scenarios. In the first scenario, the weight of all criteria was equal, and in the remaining scenarios, a weight of 0.5 was assigned to one criterion while the others were assigned a weight of 0.25.

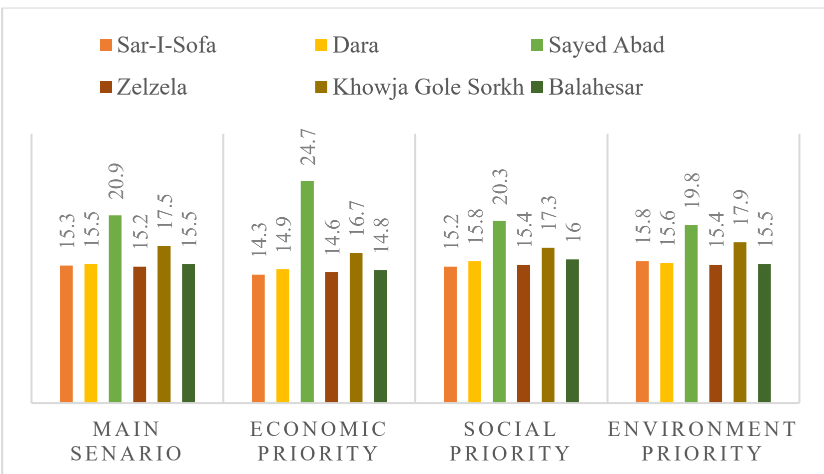

Figure 8. Sensitivity Analysis at the Level Criteria

Equalizing the weights of criteria did not lead to any changes in sustainability, and Sayed Abad remains the most stable village, while Sar-I-Sofa and Zelzela remain the least stable villages. In another scenario, the economic criterion was assigned a weight of 50%, while the weights of the other two criteria were set at 25%. In this scenario, Sayed Abad remains the most stable village, and Sar-I-Sofa remains the least stable. In the social scenario, Sayed Abad is again the most stable, and Sar-I-Sofa is the least stable. In the environmental scenario, Sayed Abad remains the most stable, and Zelzela remains the least stable village.

4. Conclusion and Discussion

In recent decades, the heedless utilization of production factors to enhance performance has doubled the importance of attending to the sustainability of exploitation systems and the continuity of production concurrently with preserving natural resources, resulting in environmental degradation. In this regard, the present research is dedicated to measuring, analyzing, and elucidating the sustainability of agricultural crop exploitation systems in the Feroz Nakhchir district. This study examined the area based on various indicators such as cultivated area, performance, agricultural production, and the like. To calculate sustainability indices and determine the most sustainable crops, a hierarchical analysis method was employed, aligning with previous studies conducted by Dantsis et al. (2010), Ziaee & Mehrabi Boshrabadi (2019), Bartzas and Comnitzas (2019), Rezaee et al. (2021), and Rahmani et al. (2022). For applying agricultural sustainability 22 sub-criteria was selected using various research studies, including Nijkamp and Vreeker (2000), Gafsi et al. (2006), Cauwenbergh et al. (2007), Dantsis et al. (2010), Bartzas & Comnitzas (2019), Asaadi et al. (2021), Rezaee et al. (2021), Rahmani et al. (2022), and Moreno Miranda and Dries (2022).

Sustainable agriculture is a biological process that attempts to mimic the critical characteristics of a natural ecosystem, thereby complicating the agricultural ecosystem. The efficiency of nutrient cycling in this type of agriculture increases, and harnessing the sun as the primary energy source for propelling the system becomes desirable.

The Feroz Nakhchir district is considered one of the most important producers of horticultural products in Samangan province. However, due to soil erosion through water and wind, pollution, reduction of organic matter, decreased fertility, and physical soil degradation, achieving food security for the growing district and province population becomes problematic. Therefore, due to the climatic-environmental conditions prevailing in the Feroz Nakhchir district, any food production must be contingent upon the proper and rational use of local resources. Consequently, in recent policy initiatives, addressing this issue and focusing on the criteria and principles of agricultural development and sustainable agriculture have been emphasized.

Numerous studies have addressed assessing agricultural sustainability at various levels using various methods. Among these methods, the Analytic Hierarchy Process (AHP) has found extensive application in agricultural issues. Since the primary objective of this technique is to rank based on minimizing the distance from the ideal point, in the current study, this method has been employed to evaluate agricultural sustainability and ranking of products in this district.

In this research, various variables in the economic, social, and environmental sustainability sectors were utilized, with a cumulative weight of 0.36 assigned to identify the most sustainable crop. Potatoes, beans, and wheat, with weights of 0.27, 0.21, and 0.15, respectively, were prioritized in the subsequent sustainability rankings of the Feroz Nakhchir district. Sensitivity analysis revealed that altering the weights of social and environmental criteria does not affect sustainability, but an increase in the economic sustainability weight results in potatoes being selected as the most sustainable crop.

In light of the challenges faced by the Feroz Nakhchir district, it is imperative to encourage community-based initiatives that promote sustainable agriculture. Collaborative efforts involving local farmers, community leaders, and non-profit organizations can help implement practical and context-specific solutions. Establishing farmer cooperatives, where knowledge sharing and collective decision-making are facilitated, can effectively pool resources and implement sustainable practices at a larger scale. Moreover, these initiatives can serve as platforms for exchanging traditional and local knowledge, fostering a sense of ownership and commitment to sustainable agricultural development within the community.

Recognizing the importance of indigenous knowledge in sustainable agriculture, there should be a deliberate effort to integrate traditional farming practices into modern approaches. Engaging with local farmers to understand their historical methods, crop rotations, and pest management strategies can offer valuable insights. Research should focus on bridging the gap between traditional wisdom and contemporary agricultural science, emphasizing the relevance of indigenous knowledge in achieving long-term sustainability. This approach respects local heritage and contributes to the resilience of agricultural systems against environmental challenges unique to the Feroz Nakhchir district.

To ensure the successful implementation of sustainable practices, the district needs to strengthen agricultural extension services. Extension programs should be tailored to the specific needs of local farmers, providing them with the latest information on sustainable farming techniques, technological innovations, and market trends. Investing in extension officers who can work closely with farmers, offering guidance and support, will contribute to building a knowledgeable and empowered farming community. These services should not only focus on the technical aspects of agriculture but also encompass broader topics such as financial literacy, risk management, and marketing strategies to enhance the overall sustainability of farming practices.

Given the climatic challenges faced by the Feroz Nakhchir district, research efforts should prioritize developing and promoting climate-resilient crop varieties. Collaborate with agricultural research institutions to study crop varieties that can thrive in the region's specific environmental conditions. Additionally, explore the feasibility of introducing drought-resistant, pest-tolerant, and heat-tolerant crop varieties that align with the changing climate patterns. Disseminating the results of such research to local farmers will empower them to make informed decisions about crop selection, ultimately contributing to increased agricultural resilience and sustainability in the face of evolving climate challenges.

5. Statements and Declarations

5.1 Competing Interest

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.

5.2 Data availability

Data will be made available on request.

5.3 Acknowledgments

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5.4 Disclosure statement

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5.6 Ethics Approval

Not Applicable

5.7 Consent to participate/Consent to publish

Not Applicable

5.7 Author Contributions

Conceptualization, H. R. and Z. R.; methodology, H. R., Z. R. and H. RD.; investigation, H. R., Z. R. and H. RD.; writing—original draft, H. R. and Z. R.; writing—review & editing,H. R. and H. RD.; supervision, H. R.

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