Assessment of Small-Scale Farmers' Perceptions Towards the Sustainability of Soybean Cultivation in the Thal Region of Punjab, Pakistan

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ABSTRACT

The demand of soyabean is increasing since the boost in domestic poultry feed and edible oil consumption. As a result, Pakistan has witnessed its rising imports, putting pressure on the national economy. Therefore, its cultivation is prioritized for securing national food security and saving the economy. Soybean production has increasingly become a viable alternative crop in Pakistan, but its adoption among small-scale farmers is low. The semi-arid and sandy characteristics of Thal have the potential for soybean production. This was designed to explore the farmers' perception regarding the economic, environmental, and social sustainability of soybean cultivation in the Thal region in Punjab Pakistan. Research revealed that farmers consider soyabean a potentially profitable crop than traditional crops however weak market systems dent its adoptability. Farmers have understanding of soybean as environmentally sustainable crop, soil fertility improvement (M=3.89, SD=1.03), but there are issues related to pest management. Access to markets (M=2.84, SD=1.25), credit (M=2.63, SD=1.21) and extension services (M=2.74, SD=1.20) were relatively weak. The major challenges in the adoption were lack of awareness (M=4.25, SD=0.76), access to quality seed (M=4.12, SD=0.81) and poor market infrastructure (M=4.05, SD=0.88). Chi-square results showed that education (0.18.92,0.05) and farm size (0.15.38,0.05) were significant determinants of farmers' perception about soyabean sustainability. Education (β=0.24-0.27, P<0.01) and access to extension services (β=0.29-0.33, P<0.001) were the strongest predictors as confirmed by regression results. Positive correlations were obtained between economic, environmental and social dimensions (r=0.58 0.65, P<0.001). The results indicate that soybean has the potential but farmers require supportive policies aligned with extension services for upscaling its adoption.

Keywords: Soybean cultivation, sustainability, small-scale farmers, Thal region, perceptions, Pakistan.

INTRODUCTION

Agriculture is the mainstay of the economy of Pakistan as it contributes around 19% in GDP and accounts for a high share of employment, rural development and food security (Government of Pakistan, 2025). Nearly 63% of the Pakistan population lives in rural areas and a majority are directly or indirectly involved in agriculture to earn a living (PBS, 2024). Small-scale farmers, being the majority, played a critical role in national food security and sustainability. Nevertheless, they face tremendous challenges in farming, such as diminishing income, climate change, resource shortage, and a lack of access to modern technologies. This impacts their attitudes and decisions towards adopting innovations, such as sowing climate friendly yet high value crops (Ali & Khan, 2020). So, they mostly stick to low-profit, input-intensive, traditional crops and avoid trying alternative options. Problems for small farmers become particularly acute in underdeveloped and marginalized regions, such as Thal. Soybean (Glycine max), commonly known as a golden bean, is a legume crop of global significance since it contains high concentrations of protein (40-42%) and oil (18-22%) (Khan et al., 2021). Soybean crop has gained the status of staple food for livestock, as it is widely used in animal feed. Further, it is used in various other industrial products across the world. It has gained a critical position in achieving food security and economic sustainability (FAO, 2021). Soybean is a relatively less utilized agricultural crop in Pakistan compared to conventional cereals, namely wheat, rice, and cotton. However, its demand is increasing since the boost in domestic poultry feed and edible oil consumption. As a result, Pakistan has to import it in large quantities, pressurizing the national economy (Shahzad et al., 2019). The State Bank of Pakistan (2022) states that the nation spends billions of dollars on importing soybean and other oilseed products every year, which is why soybean cultivation in the country needs to be encouraged.

The Thal is a semi-arid sandy region with little rainfall and unpredictable weather (Raza et al., 2018). However, due to environmental characteristics and geographical position, it has the potential for soybean production. Cultivating soybean crop is a prospective project because of its nitrogen-fixing ability, enhancing soil fertility and minimal dependence on chemical fertilizers (Hussain et al., 2020). However, its adoption relies significantly on the awareness, views, opinions, resources and personal experiences of local farmers.

Sustainability in farming is multifaceted i.e. economic, environmental and social sustainability (Pretty, 2019). To have a sustainable soybean cultivation in Pakistan, farmers should view the crop as attractive in terms of profit, resource usage, and adaptable in local farming systems. Economic and environmental sustainability of farming depend upon   soil fertility, water efficiency, and pest resistance etc. In contrast, social sustainability is about knowledge of the farmers, institutional support, and capacity building (Altieri & Nicholls, 2017). The perceptions held by farmers are important determinants in decision-making to either adopt, reject, or abandon a crop. Misaligned perceptions, restricted access to credit, and low market connectivity may be a deterrent to the growth of soybean in areas where it is well advised to grow (Ashraf et al., 2022).

There are several studies carried out globally about farmers' perceptions towards the adoption and sustainable cultivation of soybean. As an example, profitability, technological advances and environmental effects find their reflection in the attitude of farmers in Brazil and Argentina, as they are the global leaders in soybean production (Oliveira & Hecht, 2016). Similarly, access to inputs, extension services, and market are dominant smallholders' perceptions in African nations (Chianu et al., 2009). In Pakistan, however, there is very little information available on the view of farmers on the soybean crop, as soybean has not been a priority in Pakistan's agricultural policy (Shahzad et al., 2019). This lack of experiential knowledge is especially problematic for promoting its cultivation in semi-arid areas such as Thal.

Thal has unique challenges for small farmers, especially the availability of irrigation water is relatively unstable because of deficit canal water, soil salinity and desertification (Raza et al., 2018). Besides, there is the problem of market inaccessibility, including the unavailability of stable procurement mechanisms, fluctuation in prices, and the missing infrastructure of the value chain (Khan et al., 2021). Social variables such as low-level literacy rates, lack of awareness of crop management and use of traditional farming are also prevalent in the region (Ashraf et al., 2022). Hence, it is important to assess the perceptions of the farmers, considering these specific challenges, in order to comprehend the barriers and opportunities of scaling up soybean cultivation in the area. Insights into farmers' perceptions in Thal can help the policymakers, extension agents and development practitioners devise focused policies and interventions in order to tackle the social, economic, and environmental barriers in the way of scaling up soybean adoption.

Therefore, the current research endeavors to evaluate farmers' attitudes towards the adoption and sustainability of soybean farming within the Thal area in the province of Punjab, Pakistan. By analyzing economic, environmental, and social circumstances that dictate farmers' perceptions, the study will be able to outline some of the main obstacles and possibilities regarding adoption of soybean as a alternative to traditional crops. It will help bring results to general discussion of agricultural diversification, sustainable land use and rural livelihoods in semi-arid regions.

MATERIALS AND METHODS

1.1. Research Design

This study employed a cross-sectional research design to assess the perceptions of small-scale farmers toward the sustainability sof soybean cultivation in the Thal region of Punjab, Pakistan. A quantitative survey was used to collect structured responses.

1.2 Study Area

The research was conducted in the Thal region of Punjab. Thal is a subtropical sandy area, located between the Indus River and the Jhelum and Chenab rivers, which includes the districts of Bhakkar, Layyah, Khushab, Mianwali, Jhang and Muzaffargarh. This region is semi-arid, with sandy soils and low annual rainfall, making it a critical area for assessing the sustainability of soybean cultivation. Traditionally, crops such as wheat, gram, and millet dominate the farming systems, but soybean has been recently introduced as a potential diversification option.

1.3 Population and Sampling

The target population of this study consisted of small-scale farmers (cultivating less than 12.5 acres, as defined by the Government of Pakistan), who have either adopted or have knowledge of soybean cultivation in the Thal region. A multistage sampling technique was employed for the study. First, Thal region was selected purposively based on its agro-climatic conditions and the presence of soybean cultivation. Second, two districts from the region, namely Jehlum and Jhang were selected randomly. Third, one tehsil was selected from each district randomly. At last, 150 soybean farmers from each tehsil were selected randomly to reach a sample size of 300.

1.4 Data Collection Methods

1. Primary Data

Structured Questionnaire

A pre-tested questionnaire was developed to capture farmers' perceptions of soybean crop adoption and sustainability across economic, environmental, and social dimensions. The questionnaire included both Likert scale questions (1=strongly disagree to 5=strongly agree) and open-ended items.

2. Secondary Data

Secondary information was obtained from reports of the Pakistan Agricultural Research Council (PARC), Punjab Agriculture Department, Food and Agriculture Organization (FAO), and peer-reviewed studies on soybean and sustainable agriculture in Pakistan.

2.5. Research Variables

The study was structured around three dimensions of sustainability:

- **Economic Sustainability**: profitability, input costs, market access, credit availability.
- **Environmental Sustainability**: soil fertility improvement, water use efficiency, pest/disease resistance, biodiversity effects.
- **Social Sustainability**: farmers' knowledge, training/extension support, community acceptance, institutional linkages.

2.6. Data Analysis

Data collected through the questionnaire were coded and entered into Statistical Package for Social Sciences (SPSS) version 26 for analysis. Both descriptive and inferential statistical techniques were employed:

- **Descriptive Statistics**: Frequencies, percentages, means, and standard deviations to summarize farmers' responses.
- **Chi-Square Test**: To analyze the association between demographic characteristics (e.g., age, education, landholding) and perceptions toward soybean sustainability.
- **Regression Analysis**: To identify the key factors influencing farmers' economic, environmental, and social perceptions.
- **Correlation Analysis**: To examine the relationships among different sustainability dimensions.

Qualitative interview data were transcribed and analyzed thematically to identify recurring patterns and provide context for the quantitative results.

2.7. Validity and Reliability

The questionnaire was validated by a panel of experts from the University of Agriculture Faisalabad and field extension officers in Punjab. A pilot test was conducted with 30 farmers outside the main sample to check accuracy and consistency. The reliability of the Likert scale items was tested using Cronbach's Alpha, with a threshold of 0.70 considered acceptable for internal consistency.

2.8. Ethical Considerations

Ethical guidelines were strictly followed. Informed consent was obtained from all participants before data collection. Respondents were assured that their information would remain confidential and be used solely for academic purposes. Participation was voluntary, and farmers had the right to withdraw at any stage of the research.

RESULTS

3.1. Demographic Characteristics of Respondents

Table 1: Demographic Profile of Small-Scale Farmers in Thal Region (n=300)

Attribute	Category	Frequency	Percentage (%)
Age	Below 30	72	24.0
	31–45	128	42.7
	46–60	74	24.7
	Above 60	26	8.6
Education Level	Illiterate	96	32.0
	Primary–Middle	102	34.0
	Matric–Intermediate	68	22.7
	Graduate+	34	11.3
Farm Size (Acres)	<5	114	38.0
	5–10	126	42.0
	10–12.5	60	20.0
Farming Experience	<10 years	78	26.0
	11–20 years	142	47.3
	>20 years	80	26.7

Table 1 shows the demographic profile of small-scale soybean farmers in Thal region of Punjab in Pakistan. The age group shows that the most considerable percentage of respondents (42.7%) are in the 31-45 years age group, and 24.7% in the 46-60 years age group. There are 24 percent of all the farmers below 30 years, whereas only 8.6 percent

were aged above 60 years. According to this distribution, soybean farming is mostly carried out by middle-aged farmers. Ali and Khan (2020) note that middle-aged farmers mostly accept new crop and technology because they have greater physical abilities and risk-taking behaviors than older ones.

Concerning education, one-third of the farmers were illiterate (32.0%), whereas one-third had completed primary to middle-level education (34.0%). A smaller percentage had matric to intermediate level of education (22.7%) and a low percentage of respondents had graduate qualifications (11.3%). These findings indicate that the lack of education is the bottleneck of the farmers in the territory of Thal, which might hinder their opportunities to access and understand technical information regarding soybean cultivation. This observation is in line with Rehman et al. (2019), who pointed out that literacy is a significant factor in adopting contemporary practices of farming and efficient utilization of resources. On the same note, Ashraf et al. (2022) also identified low education level as one of the major impediments to the adoption of oilseed crops in semi-arid areas of Pakistan. Concerning farm size, the statistics display that majority of the respondents possess a small acreage, with 38 percent cultivating an area of less than 5 acres and 42 percent of the respondents farming between 5 to 10 acres. Only 20 percent had 10-12.5 acres. These figures support the thesis of the predominance of small-scale farming in the area where land holding is very discontinuous, making it impossible to achieve economies of scale, thus discouraging new crops such as soybean. According to Shahzad et al. (2019), the issue of land fragmentation is also a significant barrier to the expansion of oilseed crops in Pakistan, as smaller landholders are more inclined to follow the traditional crops, such as wheat and gram, instead of exploring other avenues.

The farming experience inferred that the majority of the respondents (47.3%) had 11-20 years of experience in farming, 26.7% had more than 20 years, and 26% had less than 10 years. This indicates that farmers of soybeans are mostly well versed with farming, but not necessarily in soybean cultivation, since this is a relatively new crop in the region. As stated by Hussain et al. (2020), experiential learning is a significant factor in developing the vision of sustainability because experienced farmers can base their decision regarding the inclusion of new crops on their knowledge and contacts gained over time. Table 1 demographic profile provides the evidence that growing of soybean in the Thal region is characterized by middle aged, fairly experienced farmers that possess small land and relatively low levels of education. These demographic facts are to be taken into consideration when introducing specific interventions, namely farmer trainings, credit, and extension services, in making soybean cultivation more sustainable in the region.

3.2. Economic Perceptions of Soybean Cultivation

Table 2: Farmers' Economic Perceptions toward Soybean Sustainability (n=300)

Statement	Mean (M)	SD
Soybean cultivation is more profitable than traditional crops (e.g., gram, wheat)	3.42	1.12
Input costs (seeds, fertilizers, pesticides) for soybean are manageable	3.01	1.18
Access to markets for soybean is reliable	2.84	1.25
Credit and financial support are available for soybean cultivation	2.63	1.21

Table 2 indicates a moderately positive perception of the economic potential of the soybean crop expressed by farmers. The average score on profitability compared to the traditional crops, namely, gram and wheat, stood relatively high (M=3.42, SD=1.12), and this shows that many farmers consider soybean a profitable alternative. This is consistent with Shahzad et al. (2019), who stated that soybean has an important role in enhancing farm profits and lowering the country's reliance on imported edible oils.

Nevertheless, some alarming issues were seen in terms of input affordability (M=3.01, SD=1.18) as well as market accessibility (M=2.84, SD=1.25). Farmers cited expensive prices of seeds and inconsistent marketing systems as the main reasons why they were not entirely open to soybean. The same trend was reported by the study of Ali and Khan (2020), who observed that small-scale farmers in semi-arid Pakistan usually struggle to obtain cheap inputs and secure markets in crops. The perceived lowest was credit and financial support (M=2.63, SD=1.21), as farmers were unhappy with the institution's financing. The State Bank of Pakistan (2022) has also listed limited financial inclusion and absence of customized credit programs as the most significant impediments to agricultural innovation. In sum, although soybean is seen as a potentially profitable crop, weak financial and market systems dent its economic viability.

3.3. Environmental Perceptions of Soybean Cultivation

Table 3: Farmers' Environmental Perceptions toward Soybean Sustainability (n=300)

Statement	Mean (M)	SD
Soybean improves soil fertility through nitrogen fixation	3.89	1.03
Soybean requires less water compared to traditional crops	3.72	1.07
Soybean is resistant to local pests and diseases	3.12	1.14
Soybean cultivation helps maintain long-term soil health	3.81	1.09

Table 3 describes the strong understanding of the environmental advantages of soybean crop among farmers. Farmers consider soyabean beneficial to increase soil health in the long run as it fixes nitrogen in soil and increases its fertility (M=3.89, SD=1.03 and M=3.81, SD=1.09, respectively). These findings support those of Hussain et al. (2020), who proved that soybean crop can reduce the use of chemical fertilizers, thereby ensuring sustainable soil management in semi-arid production systems. Pretty (2019) added that the use of legumes in the diversification of a region leads to increases in ecosystem services, an important part of sustainable farming.

Farmers did recognize the water-saving ability of soybean compared to other crops (M=3.72, SD=1.07), especially in Thal, where there is hardly enough water to irrigate. This finding echoes Raza et al. (2018), who noted that diversification of crops is one of the strategies to address water shortage problems in dry regions of Pakistan. However, the perceptions towards pest and disease resistance were lower (M=3.12, SD=1.14), meaning that there was confusion regarding resistance of soybean to local pests. This issue aligns with the results of Ashraf et al. (2022), who pointed out the reluctance of smallholders to adopt new crop, especially when they know little in terms of how to deal with pest attacks. Overall, farmers have an understanding of soybean as an environmentally sustainable crop. Still, they need supportive efforts to counter the issue of pest management and to gain the advantage.

3.4. Social Perceptions of Soybean Cultivation

Table 4 indicates a mixed perception about social variables related to the sustainability of soybean crop. Farmers were dissatisfied with extension services (M=2.74, SD=1.20) and   government policies to encourage the farming of soybeans (M=2.83, SD=1.17). It indicates poor institutional backing, which is also pointed out by Ali and Khan (2020) and Ashraf et al. (2022). They have revealed the absence of an effective advisory and policy framework to promote crop diversification in Pakistan.

Table 4: Farmers' Social Perceptions toward Soybean Sustainability (n=300)

Statement	Mean (M)	SD
Extension workers provide adequate training on soybean cultivation	2.74	1.20
Neighboring farmers support the idea of soybean cultivation	3.38	1.10
I am willing to adopt soybean as a long-term crop option	3.56	1.15
Government policies favor the promotion of soybean cultivation	2.83	1.17

In spite of this institutional weakness, farmers proved to be open to adoption. A relatively high value on the mean score was recorded on the willingness to adopt soybean as a long-term crop (M=3.56, SD=1.15). farmers agreed that there was moderate community-level support (M=3.38, SD=1.10). This implies that even though there is policy and extension gaps, the social acceptability of soybean cultivation is increasing. This kind of eagerness can be linked to the tendencies in sub-Saharan Africa, where the adoption of soybeans was successful due to the diffusion and training efforts at the farmer-to-farmer level (Chianu et al., 2009).

3.5. Challenges Faced by Small-Scale Farmers

Table 5: Major Challenges Faced by Small-Scale Farmers in Adopting and Sustaining Soybean Cultivation in the Thal Region

Challenge	Mean	SD
Lack of awareness and technical knowledge about soybean cultivation	4.25	0.76
Limited access to quality seed and inputs	4.12	0.81
Poor market infrastructure and price uncertainty	4.05	0.88
Limited financial resources and credit facilities	3.98	0.83
Water scarcity and dependence on erratic rainfall	3.85	0.91
Lack of government policy support and subsidies	3.72	0.89
Pest and disease management difficulties	3.66	0.85
Land fragmentation and small farm size	3.54	0.79
Inadequate extension and advisory services	3.48	0.87
Low social acceptance and risk perception among farmers	3.32	0.84

The results in Table 5 show that the most significant obstacles to soybean production are primarily socio-economic and informational, rather than agronomic. The first three constraints - Lack of awareness and technical knowledge (Mean=4.25), Limited access to quality seed and inputs (Mean=4.12), and Poor market infrastructure and price uncertainty (Mean=4.05) have scored above 4.0, indicating that they are significant/ Severe constraints in the eyes of the surveyed farms. The observation is in concurrence with a broad literature on agricultural development. The importance of knowledge and technical know-how has been vividly described, especially in instances when it comes to the role of knowledge and technical know-how. Surveys such as those of Feder et al. (1985) and more recently of Anderson & Feder (2007) have pointed out that new agricultural technologies rely heavily upon successful knowledge transfer, which in turn is crippled by inefficient extension services (a problem also noted here, Mean=3.48).

The rank of input access as a major barrier is in accordance with studies on the significance of seed systems. As stipulated by Sperling et al. (2020), the availability of quality-certified and high-quality seed is one of the central

attributes to enhance crop productivity and resilience, a problem shared by smallholders in developing economies. Market-related issues, including price fluctuations and deficient infrastructure, are constantly cited as primary deterrents to farmers to invest in, as in the case of the soybean crop. The study by Barrett et al. (2022) regarding market access points out that in the absence of sustainable and lucrative market channels, farmers will continue in the subsistence mode, which also has close relations to the high score observed in this challenge. Constraints like Limited financial resources (Mean=3.98), Water scarcity (Mean=3.85) and Lack of policy support (Mean=3.72) are positioned in the middle. Credit availability is a perennial suspect in rural development, well-represented in the agricultural-finance literature (e.g., Karlan et al., 2014). Issues of water scarcity and reliance on rainfall indicate a wider need to consider the role of climate variability and how it affects rain-fed agriculture, which is gaining traction in research (IPCC, 2022).

Interestingly, some traditional production barriers, such as Pest and disease management (Mean = 3.66) and Land fragmentation (Mean = 3.54), have been ranked lower. This indicates that when they appear, they can be considered less threatening or secondary compared to the underlying roots of the problems of knowledge, input and market access. Nevertheless, their high values indicate that they are still relevant. The moderate score of low social acceptance (Mean=3.32) suggests a presence of a socio-cultural barrier and it may influence adoption decisions, as noted by Rogers (2003) innovation-diffusion theory. This table shows that the main barriers to soybean production in the mainstream weak agricultural system, which fails to address farmers' issues, namely deficiencies in knowledge, insufficient input distribution channels, and flaws in market systems.

3.6. Inferential Analysis
3.6.1. Chi-Square Test

Table 6: Chi-Square Test Results for the Association between Demographic Characteristics and Farmers' Perceptions of Soybean Sustainability

Demographic Variable	Chi-Square Value (χ^2)	Df	p-value	Association
Age	12.46	6	0.052	Not Significant
Education Level	18.92	9	0.026*	Significant
Farm Size (Landholding)	15.38	6	0.017*	Significant
Farming Experience	10.73	6	0.098	Not Significant

Note: *P<0.05 indicates statistical significance.

Table 6 shows the Chi-Square test statistics to determine the association between the demographic attributes of farmers and their viewpoints on the sustainability of soybean farming in Thal region. The findings indicate that level of education (χ^2=18.92, df=9, p=0.026) and farm size (χ^2=15.38, df=6, p=0.017) have a significant relationship with perceptions of sustainability of soybeans. This signifies that farmers who are more educated and have bigger farms may tend to consider the production of soybeans as a sustainable alternative. Similar results have been provided by Rehman et al. (2019), who stated that education contributes to awareness and the readiness to adopt non-traditional crops. Similarly, Chandio et al. (2020) found that the adoption of innovative crops in Pakistan positively correlates with farm size.

Conversely, age influence and years of experience (χ^2=10.73, df=6, p=0.098) did not indicate any significant correlation, which means that the perception of soybean sustainability is not substantially affected by age or the number of years a person has been engaged in farm activities. This is in line with Ashraf et al. (2022), who underscored that young and elderly farmers tend to be in agreement on soybean farming risks and market issues. The findings suggest that concerted efforts, i.e., farmer training programs, seed access initiatives, and awareness campaigns, would be less effective if they are age or experience-oriented, and would be more effective if designed on educational and structural factors in order to improve the soybean adoption rate in the Thal region.

3.6.2. Regression Analysis

Table 7: Regression Analysis of Factors Influencing Farmers' Perceptions Toward Soybean Sustainability

Independent Variables	Economic Perceptions (β)	Environmental Perceptions (β)	Social Perceptions (β)
Age (years)	0.08 (SE=0.05, t=1.62, p=0.108)	0.05 (SE=0.04, t=1.20, p=0.230)	0.03 (SE=0.05, t=0.64, p=0.520)
Education Level	0.24* (SE=0.07, t=3.42, p=0.001)	0.21 (SE=0.08, t=2.63, p=0.009)	0.27* (SE=0.07, t=3.86, p=0.000)
Farm Size (acres)	0.19 (SE=0.06, t=3.05, p=0.003)	0.17 (SE=0.07, t=2.43, p=0.016)	0.14 (SE=0.08, t=1.78, p=0.076)
Farming Experience (years)	0.09 (SE=0.05, t=1.85, p=0.066)	0.07 (SE=0.05, t=1.42, p=0.156)	0.06 (SE=0.05, t=1.25, p=0.212)
Access to Extension Services	0.31* (SE=0.06, t=5.17, p=0.000)	0.29* (SE=0.07, t=4.42, p=0.000)	0.33* (SE=0.06, t=5.50, p=0.000)
R^2	0.42	0.38	0.44
Adjusted R^2	0.40	0.36	0.42
F-statistic (p-value)	21.35 (0.000)	18.21 (0.000)	23.12 (0.000)

***Note:** *P<0.05=significant; **P<0.01=highly significant; **P<0.001=very highly significant*

The regression analysis (Table 7) was conducted to know what variables play a dominant role in the perceptions of small-scale farmers regarding soybean sustainability on economic, environmental, as well as societal levels in the Thal district of Punjab Pakistan. Findings indicated that the predictors of the perceptions of farmers were their level of education, access to extension services and farm size, indicating that these predictors, except farm size, had a significant and high level of impact.

In particular, education level positively and statistically significantly influenced all three categories of perception (economic β=0.24, P<0.01; environmental β= 0.21, P<0.01; social 0,27, P<0,001). This implies that farmers who have attained greater education will better utilize the longer-term advantages of soybean cultivation, including better earnings, soil fertility, and greater acceptance at the community level. A similar conclusion was made by Hussain et al. (2018), who cited that education helps farmers become more competent to implement sustainable farming and make sound decisions on crop diversification. Similarly, Abid et al. (2016) wrote that education can provide farmers with knowledge that will help them to analyze environmental risks and introduce sustainable measures. Access to extension services emerged as the most important determinant of perceptions, with large, significant positive coefficients on the economic (β = 0.31; P < 0.001), environmental (β = 0.29; P < 0.001), and social (β = 0.33; P < 0.001) scales. This implies that farmers who receive proper guidance and technical assistance from extension agents believe that cultivating the soybean crop is sustainable. The past research in Pakistan and other developing nations also supports that the contact made by the extension is critical towards the enhancement of knowledge of farmers, adoption of advanced technologies, and their perception of sustainability (Memon et al., 2019; Khan et al., 2020).

The size of farm significantly affected economic (β=0.19, P<0.01) and environmental perceptions (β=0.17, P<0.05), implying that farmers with greater land holdings will have more financial freedom and are likely to be more adventurous when engaging soybean farming. Bigger farms also enable good crop rotations and soil management activities, which might explain the higher relationship with environmental sustainability. This finding is congruent with the predictions of Ashraf et al. (2022), who stated that the size of the land holding is directly proportional to the level of resources and sustainable agricultural innovations in the state of Punjab. Age and farming experience did not have statistically meaningful effects within the three perception categories. Even though all these factors can affect the traditional farming activities, they seem to have no role in the perceptions of sustainability in relation to emerging crops like soybean. This finding is consistent with those of Shahbaz et al. (2021), which showed that demographic attributes, such as age, tend to have less significant influences on adoption behavior than institutional and educational aspects.

The regression models overall explained a large proportion of variance in perceptions (R^2=0.42 in the case of economic, 0.38 in the case of environmental, and 0.44 in the case of social), showing that selected variables were effective in identifying major sources of sustainability perceptions. These results indicate that one of the key elements that should be used in efforts trying to overcome the resistance of small-scale farmers in Pakistan to the cultivation of soybean crops should be bolstering the education and extension services.

3.6.3. Correlation Analysis of Sustainability Dimensions in Soybean Cultivation

Table 8: Correlation Analysis of Sustainability Dimensions in Soybean Cultivation

Sustainability Dimensions	Economic Perceptions	Environmental Perceptions	Social Perceptions
Economic Perceptions	I	0.62***	0.58***
Environmental Perceptions	0.62***	I	0.65***
Social Perceptions	0.58***	0.65***	I

*Note: *P<0.05=significant; **P<0.01=highly significant; **P<0.001=very highly significant*

The results of correlation (Table 8) show strong relationship amongst small-scale farmers in the Thal region relating to the perception of the three pillars of soybean sustainability- economic, environmental and social. The findings indicated a significant positive relationship among the dimensions, which shows no individualism in the perception of sustainability among the respondents.

The association between economic and environmental perceptions was value-added (r=0.62, p= less than 0.001). This would mean that farmers in the country who perceive soybean as a financially worthwhile crop- based on its ability to supplement income and minimize importation of goods into the country and to increase farm diversity-have a greater likelihood of appreciating its ecological advantages, including improvement of soil fertility and maintenance of water amount following its use as opposed to their usage of wheat and cotton. The same can be detected in the work by Ullah et al. (2020), who wrote that Pakistani farmers frequently view profitability as a long-term health indicator of the soil and ecological stability. A high correlation was also found between environmental and social perceptions (r=0.65, P<0.001), indicating that when the environmental benefits appear to be true in the eyes of the farmers, there also lies a belief that soybean can produce social acceptance, enhance the extent of cooperation at the community level, and increase food security. This result conforms to a work by Rahman and Chima (2018), which affirmed that environmentally sound farming practices have not only all the positive effects on the environment but also promote social cohesion through collective learning and innovation. In regions like the Thal, where agriculture is frequently an aspect of communities, these ecological advantage/social outcomes synergies are significant. Economic and social dimensions correlations were just above robust (r=0.58, P<0.001). This implies that income benefits as a result of adopting soybean have the propensity to boost social well-being among the farmers by ensuring

food security, education and acceptance of soybean as an alternative crop. These conclusions are reflected in Ashraf et al. (2022), who discovered that rural residents of Punjab accept new agricultural techniques only after economic stability has been established.

The inter-dimensional positive correlations of the three sustainability dimensions accentuate the interrelatedness of how farmers perceive things. Economic, environmental and social benefits are not seen as isolates on the part of the farmers, but as reinforcing one another. This can be mentioned in relation to the sustainability framework by Diao et al. (2021), who state the decision of farmers, in developing countries, is based on the combined calculation of profitability, the sustainability of the ecosystem, and social acceptability. The results suggest a need to stimulate soybean production in the Thal area based on policy measures and interventions that openly reveal its economic, environmental, and social benefits.

CONCLUSIONS

This paper evaluates the perceptions of small-scale farmers on the cultivation of soybeans in Thal region in Punjab, Pakistan with respect to its economic, environmental and social sustainability. The results indicated that farmers, in general, do not have a negative perception towards soybean as a potentially good crop that can improve the farm income, soil management, and food security. Notwithstanding, a number of obstacles have limited the adoption of soyabean crop. Most significant barriers are lack of awareness, poor access to quality seed and inputs, poor market infrastructure and poor institutional support. Education and size of the farm were also proved to be significant factors determining the farmers' perceptions about soybean sustainability. In addition, the powerful correlation between the economic, environmental and social dimensions indicates that farmers perceive sustainability as an integrated issue rather than a set of several distinct elements. This shows that soybean crop can be potentially used to provide income diversification, improve soils health, and increase community resiliency in the area. In order to tap this potential, it is necessary that specific measures like farmer training, better extension services, input supplies and favorable policy should be adopted. Market linkages and the provision of incentives can go a step further. In general, soybean presents opportunity for both rural development and national food security, provided the obstacles are dully worked out.

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Conflicts of Interest

Authors have no conflicts of interest.

Data Availability

Data will be available from the corresponding author upon request.

Ethics Statement

The Institute of Agricultural Extension, Education, and Rural Development at the University of Agriculture, Faisalabad, gave its approval to the human subjects' study. The studies were carried out in compliance with institutional norms and local laws. To take part in this study, the subjects gave their written informed consent.

Authors' Contribution

Muhammad Arslan; Conceptualization, Data Curation, Methodology, Data Original draft, Formal Data Analysis, Writing, Review and Editing, Data Analysis and Data Collection, Syed Muhammad Taha Hussaini; Writing, Review and Editing, Data Analysis and Data Collection, Ali Raza; Formal Data Analysis, Writing, Review and Editing, Data Analysis and Data Collection

Generative AI Statements

The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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