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Research Article

Adoption of Soil Fertility Practices among Farmers in District Vehari: The Role of Innovativeness and Affirmation

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ABSTRACT

Soil fertility decline poses a serious threat to agricultural productivity and food security, particularly in South Punjab, Pakistan. This study investigates the role of farmer innovativeness and positive affirmation in the adoption of Soil Fertility Management (SFM) practices among 300 farmers in District Vehari. Using a cross-sectional survey, data were analyzed through descriptive statistics, Pearson's correlation, and binary logistic regression. Results revealed that crop rotation (M = 4.25, SD = 0.82) and integrated nutrient management (M = 4.10, SD = 0.89) were the most widely adopted practices, while soil testing had the lowest adoption (M = 2.95, SD = 1.08). Pearson's correlation indicated strong positive relationships between innovativeness, affirmation, and adoption, with the highest correlation between affirmation and adoption ($r = 0.702$, $p < 0.01$). Logistic regression showed that positive affirmation (B = 0.684, p = 0.000, OR = 1.982) and innovativeness (B = 0.517, p = 0.001, OR = 1.677) were the strongest predictors of adoption, alongside access to extension services and education. The model explained 57% of the variation in adoption decisions (Nagelkerke $R^2 = 0.567$) and achieved 81.4% prediction accuracy. These findings highlight the need for targeted interventions to enhance farmer confidence, promote innovation, and strengthen extension networks to improve sustainable soil fertility management.

***Keywords*:** Soil fertility management, adoption, innovativeness, affirmation, and sustainable agriculture

INTRODUCTION

One of the decisive elements in sustaining agricultural productivity and food security, particularly in agrarian economies like Pakistan, is soil fertility. It is the capacity of the soil to provide crops with the required nutrients that are adequate to guarantee maximum growth and production (Nawab et al., 2021). The issue of declining soil fertility has been critical in most developing nations, including Pakistan, due to several aspects, including intensive agriculture, inappropriate application of chemical fertilizers, the lack of replenishment of organic matter, and poor soil management practices (Ali et al., 2019; Hussain et al., 2021). These issues have had the effect of reducing crop yields, eroding land and earning farmers low profits, consequently posing a significant threat to long-term viability of the agricultural sector. The answer to this problem is the establishment of sustainable soil fertility management (SFM), where organic and inorganic fertilizers are combined, crops are grown in a rotating sequence, green manuring and compost is used, and the soil is preserved through tillage (Montes et al., 2021).

Various socioeconomic, psychological and institutional determinants influence the adoption of SFM practices by the farmers. The innovativeness of farmers, i.e. the willingness and capability to test new technologies and practices, is one of those factors among them (Rogers, 2003; Mwaura et al., 2020). The innovative farmers are the early adopters who are mostly eager to learn and to experiment with new methods, thereby affecting other members of the community. On the same note, positive attitude and beliefs of farmers regarding the benefits of a particular practice (positive affirmation) are critical in the case of lasting adoption (Spurk et al., 2020). When farmers see that it is profitable and they also believe that it matches their farming goals, they will find it easier to integrate soil fertility practices in their farming systems. Conversely, the technical soundness and economic feasibility of practices may be hindered by negative attitudes or doubts about adoption.

The decreasing soil fertility of the soil in Pakistan and South Punjab in particular is a hot issue that is threatening the livelihood of the smallholder farmers. Large agricultural centers (such as District Vehari, which is also one of the large agricultural centers of Punjab) are characterized as areas with intensive cropping systems (wheat, cotton, sugarcane and rice) (Government of Punjab, 2024). The problems in the district include low organic matter in the soil, excessive use of chemical fertilizers and lack of adequate knowledge in balanced nutrient management. The previous research has already shown that despite the government intervention and the extension services, the adoption of sustainable soil fertility practices does not take the best form (Ahmad et al., 2022). Information on the psychological and behavioral motivation and inhibition to adoption, such as innovativeness and affirmation, may be of immense use to policy makers, extension workers and development practitioners.

Various studies in different parts of the world have reported the significance of the behaviour and perceptions of farmers as predictors of agricultural innovations adoption patterns (Jabbar et al., 2020; Afrakhteh et al., 2021). However, there is not much empirical research conducted in Pakistan to examine the interactive impact of innovativeness and affirmation on the use of soil fertility practices. This knowledge gap suggests to perform local research, which will take into account the specifics of the socio-economic and cultural context of farmers in District Vehari. Major drivers and barriers could be identified and used to develop the interventions that will facilitate the adoption of sustainable farming, promote the improvement of soil health, and enhance agricultural productivity.

The objective of the proposed research is thus to examine the application of innovativeness and affirmation in the application of soil fertility management practices among the farmers in District Vehari, Punjab, Pakistan. The specific objectives are to identify the level of the use of soil fertility control activities among the farmers, to assess the level of innovativeness and affirmation of these farmers and to determine the relationship between the farmer innovativeness, affirmation and adoption of soil fertility practices. in the District Vehari.

MATERIALS AND METHODS

Research design

A quantitative and cross-sectional research design was applied to collect data from the representative sample of farmers in District Vehari, Punjab, Pakistan. The rationale of the design is that it allows the organization of the quantifiable data that can be analyzed to establish the relationships between innovativeness of farmers, positive affirmation, and adoption of soil fertility management (SFM) practices. The degree of adoption was quantified with the assistance of a descriptive and correlational frame, and the extent to which innovativeness and affirmation influence the choice of farmers regarding soil fertility practices was determined (Creswell and Creswell, 2018).

Targeted population

The research was carried out in the District of Vehari, which is located in South Punjab, predominant in agriculture. The district is divided into three tehsils, Vehari, Burewala, and Mailsi. The main crops grown here are wheat, cotton, sugarcane, and rice. The area was selected deliberately because of its strategic location in the agricultural production of Punjab and the current issues of soil fertility and low agricultural production (Government of Punjab, 2024). These issues make it a suitable case to consider for this study. Study population was all the farmers who were actively engaged in crop production in the district. sampling was carried out on a multi-stage basis to make it representative. All three tehsils were part of the first stage of the study. In the second stage, four villages were selected randomly in every tehsil, such that a total of 12 villages were selected. In each of the chosen villages, 25 farmers were then selected randomly. The outcome of this process was that the final sample size was obtained as 300 respondents, and this was found to be statistically sufficient supported by the Coachran (1977) formula, through which the determined sample size 278. 300 was picked as a caution considering the potential non-responses and to enhance the reliability of the results.

Research tool

The primary data collection technique was the creation of a structured questionnaire. It was split in four items (1) demographic and socioeconomic information (age, education, farm size, income, farming experience, and access to extension services); (2) adoption of soil fertility management practices, including integrated nutrient management systems, crop rotation, green manuring, composting, balanced use of fertilizers and soil testing were measured on a five-point Likert scale with (1) value of Never Adopted and (5) value of Always Adopted; (3) farmer innovativeness which was measured on a scale that was adapted to Rogers (200 This was preceded by refining of the instrument through feedback of the pre-test to the main data collection.

Reliability and validity

In order to concentrate on the validity and reliability of the instrument, the content validity was established by reviewing the instrument by agricultural extension specialists, soil scientists and social scientists. The reliability was measured with Cronbach Alpha, and all the numbers above 0.70 were considered to be sufficiently good in relation to internal consistency (Hair et al., 2019). The questionnaire was completed through the face-to-face interviews which allowed the researchers to balance literacy barriers and answered the question perfectly. Data collection was done over a period of 6 weeks and was undertaken by trained enumerators. The respondents were informed of the objectives of the study, and given informed consent. The respondents were contacted on a voluntary basis and to preserve the ethics of the research, the respondents were assigned anonymity and confidentiality.

Data analysis

The data received were coded and inputted into the Statistical Package of Social Sciences (SPSS) version 25 and analyzed using it. A combination of descriptive and inferential statistics was used to conduct an analysis. Descriptive statistics like frequencies, percentages, means and standard deviation were used to summarize demographic characteristics, level of adoption, and innovativeness and affirmation scores. To classify the farmers, the scores of the entire soil fertility practices were summed to create adoption index, which was then used to divide farmers into low, medium and high adopters. Pearson then used the correlation coefficient (r) to determine the correlations between innovativeness and positive affirmation and the adoption levels. Further binary logistic regression was also conducted to establish the predictors of adoption that are significant. The independent variables, affirmation, and chosen socioeconomic characteristics, were the independent variables in this model, with adoption status (1 = adopter, 0 = non-adopter) as the dependent variable and innovativeness. The regression equation was the logistic one:

$$Logit(P)=\beta 0+\beta 1(Innovativeness)+\beta 2(Affirmation)+\beta 3(Socioeconomic\ Factors)+\epsilon$$

There were decent ethical considerations that had been followed to the letter when conducting the research. This included permission of informed consent, voluntary participation of the respondents, maintenance of secrecy of the answers, and providing the respondents with the liberty to quit their participation in the research at any time.

RESULTS AND DISCUSSION

Demographic characteristics

Demographic and socioeconomic variables of farmers need to be understood to know how they make their decisions, especially on implementing agricultural innovations such as soil fertility management (SFM) practices. The attributes provide data on the availability of resources, availability of information and the potential of farmers to use sustainable practices. Previous studies have also pointed out that the age, education, size of the farm, the income earned, experience with farming and access to extension services, are other factors that might influence the behavior of farmers towards adoption of new technologies (Iqbal et al., 2024). Table 1 summarizes these characteristics among the 300 farmers surveyed on District Vehari, Punjab in Pakistan. It is on the basis of this data that we can interpolate the adoption processes, the level of innovativeness and positive affirmation in later sections of this paper

The findings in Table 1 indicate that a significant proportion of the respondents were middle-aged farmers with 32 percent falling between the ages of 31 and 40 years, and 29 percent between 41 and 50 years. There was a lower representation (18%) of respondents having age below 30 and above 50(21%). This means that most of the farmers remain at the working age, which is a positive aspect in terms of adopting new technologies, younger and middle-aged farmers tend to be more receptive to the innovations, compared to old farmers (Hussain et al., 2021). These results are in line with the evidence-based review of Iqbal et al. (2024) who discovered that middle-aged farmers in Punjab are more interested in agricultural development initiatives since they are encouraged to pursue physical exercise and are ready to experiment new practices. The respondents had different education levels; 24%were - illiterate, 21% have primary education, 18% have middle levels., 17% have secondary education 20% respondents were having higher secondary education. This implies a relatively low level of literacy among the farmers in the study area that can disrupt their ability to understand technical information and make a good judgment regarding sustainable soil fertility practices. According to Ali et al. (2019), farmers with a higher level of education have a chance to learn about the benefits of healthy nutrition management and be willing to adopt the new agricultural practices. Talking about the size of the farm, majority of the respondents fell into small to medium size holders. There were 36%of those who owned five acres or less, and 43% with six to twelve acres of land. The remaining 21% were large-scale farmers owned more than twelve acres. This dispersion is comparable to the mean agriculture land tenure in Punjab where the small-scale farmers dominate. It was also shown in the work of Nawab et al. (2021) that the decision to use the soil improvement method is based on the size of farms, and the larger farms means more resources and the possibilities to invest in the means of improving the soil, i.e., composting, crop rotation, and soil tests. The monthly farm income statistics indicated that 39 percent of the sampled earned PKR 30,001-60,000,25 percent earned less than PKR 30, 000 monthly21 percent of the respondents earned PKR 60,001-90,000, and 15 percent have income above PKR 90,000. The numbers suggest that a large proportion of farmers have low and moderate income and this may prevent their purchasing power and investment to purchase high-quality inputs. The main disadvantage restraining adoption is lack of finance, as has been indicated in numerous studies (Ahmad et al., 2022).

Farming experience: 36 percent of the respondents had 11-20 years of experience when it came to farming and 28 percent had more than 20 years' experience which suggested that most farmers had an immense amount of hands-on experience of local farming systems. Around 24 percent had 5-10 years' experience and just 12 percent were very new to farming with less than five years' experience. Experienced farmers are the best people to examine the pros and cons of new practices because they are generally better placed to judge the impacts of new practices. Instead, they might also be more conservative and non-adaptable to changes since they are more predisposed to follow the old ways as opposed to the new ones (Mugonola et al., 2023). Lastly, the results showed that 64 per cent of the farmers had access to extension services, and 36 per cent had no access to them. This is one of the weaknesses of accessibility of agricultural advisory in District Vehari. The spread of information on sustainable practices and technical advice to farmers is based on the availability of extension services. Both studies by Mugonola et al. (2023) and Hussain et al. (2021) underline that when farmers engage with extension agents, more frequently, they tend to embrace better practices in order to increase soil fertility since they become more assured and removes uncertainty. Previous studies have also pointed out that the age, education, size of the farm, the income earned, experience with farming and access to extension services, are other factors that might influence the behavior of farmers towards adoption of new technologies (Iqbal et al., 2024).

Table 1: Demographic Characteristics of Respondents (n = 300)

Characteristics	Category	Frequency (f)	Percentage (%)
Age (Years)	Below 30	54	18.0
	31 – 40	96	32.0
	41 – 50	87	29.0
	Above 50	63	21.0
Education Level	No Formal Education	72	24.0
	Primary (1–5 years)	63	21.0
	Middle (6–8 years)	54	18.0
	Secondary (9–10 years)	51	17.0
	Higher Secondary & Above (>10 years)	60	20.0
Farm Size (Acres)	Small (Up to 5 acres)	108	36.0
	Medium (6–12 acres)	129	43.0
	Large (>12 acres)	63	21.0
Monthly Farm Income (PKR)	Less than 30,000	75	25.0
	30,001 – 60,000	117	39.0
	60,001 – 90,000	63	21.0
	Above 90,000	45	15.0
Farming Experience (Years)	Less than 5 years	36	12.0
	5 – 10 years	72	24.0
	11 – 20 years	108	36.0
	More than 20 years	84	28.0
Access to Extension Services	Yes	192	64.0
	No	108	36.0

Adoption of Soil Fertility Management Practices

The adoption of various Soil Fertility Management (SFM) practices among the farmers in District Vehari is indicated in Table 2 using a five-point Likert scale, where 1 means never adopted and 5 means always adopted.

Table 2: Adoption of Soil Fertility Management Practices among Farmers (n = 300)

Soil Fertility Management Practice	Mean	SD	Rank
Crop Rotation	4.25	0.82	1
Integrated Nutrient Management (INM)	4.10	0.89	2
Balanced Use of Fertilizers	4.05	0.91	3
Composting	3.55	0.96	4
Green Manuring	3.35	1.05	5
Soil Testing	2.95	1.08	6

Crop rotation was the most popular practice with an average score of 4.25 (SD = 0.82), indicating that majority of the farmers practice crop rotation regularly to maintain their soil healthy and to improve the output of agriculture. The mentioned observation correlates with the work by Kwasi Bannor et al. (2020), who highlighted the importance of crop rotation as one of the most effective and cost-effective interventions that can manage the fertility of the soil, pests, and increase the cycling of nutrients. Next in the queue was the concept of Integrated Nutrient Management (INM) with the value of 4.10, SD = 0.89; it is a pointer that there is more awareness among farmers on the value of integrating organic and inorganic inputs in soil fertility maintenance. These results are in line with Ali et al. (2019), who discovered that INM has gained popularity among farmers in C. Punjab due to extension campaigns and due to the effectiveness of this type of soil improvement in enhancing the soil structure and yield. Balanced use of fertilizers (M = 4.05, SD = 0.91) was also relatively well adopted, which suggests that the farmers are not ignorant about the importance of applying fertilizers in their recommended ratios. However, when the gap between the adoption rates is identified, it implies that there are farmers who use fertilizers either too much or too little, which is also mentioned by Ahmad et al. (2022), since the authors emphasized that farmer education plays a crucial role in supporting an effective use of fertilizers.

Organic practices, on the other hand, such as compost and green manuring, were moderately and lowly adopted. The score of composting (3.55 SD = 0.96) indicates that some farmers think that composting is a good way to increase soil fertility, but many of them are constrained by the hard work, time, and technical expertise required to effectively make compost. Huang et al. (2019) also found the same and explained that the level of implementation of labor-intensive technologies, composting, remains low until the technical advice and training are given to farmers. Green manuring was the second least adopted method (mean =3.35 SD = 1.05) and thus rankedfive in the list. This could be explained by the fact that awareness is poor. It was also observed that the farmers in Punjab do not opt to use green manuring because they are primarily concerned with the immediate economic benefits at the cost of the long-term benefits of soil quality (Mazhar et al., 2021). Soil testing had the lowest adoption with a mean of 2.95 (SD = 1.08) suggesting that a higher percentage of the farmers do not practice soil testing to guide them on how to apply the fertilizers. This low adoption may be explained by the fact that soil testing laboratories were not very accessible, there was no assistance from extension, and people were not aware of the benefits of scientific soil diagnosis. Likewise, both Izuchukwu. (2022) and Mugonola et al. (2023) identified poor infrastructure and lack of proper extension service among the major challenges confronting modern farming technology adoption, such as soil testing. This tendency demonstrates the necessity of paying attention to the training of farmers, their awareness, and improving the availability of services and resources by policy-makers, researchers, and extension agencies.

Farmers'Innovativeness

Table 3 highlights the levels of innovativeness among farmers in District Vehari based on five dimensions derived from Rogers' (2003) Diffusion of Innovations Theory**:** openness to new ideas, willingness to experiment, information-seeking behavior, adaptability to change, and risk-taking behavior.

Table 3: Farmer Innovativeness in District Vehari (n = 300)

Indicators of Innovativeness	Mean	SD	Rank
Openness to New Ideas	4.22	0.81	1
Willingness to Experiment	4.08	0.85	2
Information-Seeking Behavior	3.96	0.88	3
Adaptability to Change	3.78	0.91	4
Risk-Taking Behavior	3.55	0.97	5

The findings have demonstrated that the highest mean value for openness to new ideas, with a mean of 4.22 (SD = 0.81). This means that the majority of farmers in the region under study are receptive to new agricultural practices and are generally receptive to new approaches to soil fertility management. According to Rogers (2003), innovators and early adopters can be described as open to new ideas due to their ease in diffusing the technology, as a result of developing a positive attitude towards change. Adego et al. (2021) have also found similar results and found that farmers with increased access to extension services and agricultural training are more likely to explore and adopt new practices, most of which are sustainable soil management practices. The second one was the willingness to experiment, and the average score was 4.08 (SD = 0.85). This implies that the majority of farmers in District Vehari would be happy to test new soil fertility methods on a small scale before they fully embrace them. It is a slow process that will allow farmers to determine the benefits of an innovation, as well as the challenges in their specific farming setting, minimizing the potential risks. Ahmad et al. (2019) state that the adoption process involves an experimentation phase, particularly for the smallholder farmers who need to balance between innovation and scarcity. This was closely connected with information-seeking behavior; it occupied the third (M = 3.96, SD = 0.88) rank. The observation shows that farmers are dynamic in search of information on various platforms, such as agricultural extension officers, peers, local dealers, and more recently, online platforms. As I have indicated, access to and timely information is essential in curbing the degree of uncertainty and enhancing the process of making decisions by farmers on whether to embrace new technologies in their farming activities or not (Aryal et al., 2020a).

Flexibility to change was rated moderately on the one hand, with a mean value of 3.78 (SD = 0.91). This demonstrates that other farmers are versatile and can readily embrace other practices and technologies, but others face challenges due to financial limitations, traditional mindset, or due to the absence of technical expertise. Aryal et al. (2020b) also found that among the factors that contribute to the failure of many farmers in Punjab to move to modern soil fertility management practices are institutional support and high input prices. The last dimension was risk-taking behavior, and its average score was 3.55 (SD = 0.97). This means that farmers are unwilling to practice farming with such high financial or production risk. This type of risk aversion is typical of small farmers who rely on agriculture as their livelihood and who are not able to take risks. According to Adego et al. (2021), the risk perception greatly influences the innovation adoption rate because farmers will choose to remain with the practices that have been proven to be reliable compared with untested technologies. Overall, it can be noted that the attitude to agricultural innovation is rather positive, as farmers in District Vehari are rather receptive to new ideas and ready to experiment. However, their average adaptability and reduced risk-taking habits show that facilitating measures such as training the farmers, financial support, and extension services availability are needed.

Positive Affirmation

Table 4 illustrates the farmers' positive affirmation toward Soil Fertility Management (SFM) practices in District Vehari. Positive affirmation refers to the beliefs, attitudes, and confidence that farmers hold regarding the benefits of adopting sustainable practices. The results reveal that farmers have a generally favorable perception of SFM, with varying levels of agreement across different indicators.

Table 4: Farmers' Positive Affirmation toward Soil Fertility Management Practices (n = 300)

Indicators of Positive Affirmation	Mean	SD	Rank
Belief that SFM improves crop yield and soil productivity	4.35	0.74	1
Confidence in long-term benefits of SFM practices	4.22	0.78	2
Positive attitude toward adopting SFM for sustainable farming	4.15	0.81	3
Perception that SFM reduces dependency on chemical inputs	3.95	0.89	4
Motivation to continue and promote SFM among other farmers	3.78	0.94	5

The highest-ranked indicator that SFM improved soil productivity and crop yield had a mean score of 4.35 (SD= 0.74). This indicates that farmers are well aware of the immediate benefits of SFM in terms of increasing agricultural output and the health of the soil. This was also stated by Brown et al. (2022), who added that farmers tend to employ soil fertility practices more often in situations where they have a vivid sense of an increase in the yield. Rogers (2003) also brought out this point when he added that the conviction in the positive outcomes of an innovation results in a quicker process of diffusion and adoption among the farming communities. The second loudest was belief in long-term rewards of SFM practices and the average score was 4.22 (SD = 0.78). This means that many farmers are likely to be aware of the sustainability and long-term impacts of SFM on soil conservation and sustainability, which influences their willingness to practice it in the long term. Chaiya et al. (2023) also found similar outcomesthat farmers subjected to the knowledge of the benefits of sustainable practices in the long term tend to have a higher likelihood of continuing with them and even increasing their adoption. Surprisingly, the positive perceptions towards adoption of SFM to achieve sustainable farming followed immediately with a mean of 4.15(SD=0.81). It implies that the majority of farmers believe that SFM is the future of agriculture that exhibits an environmental sustainability mentality. The same sentiments were observed by Aryal et al. (2020b) among the farmers in Punjab, and they observed that positive perceptions play a crucial role in overcoming resistance to new farming methods.

The indicators at lower levels provide hints as to the barriers to adoption in general. In fact, the perception that SFM will reduce the dependence on chemical input was rated fourth and the average score of this was 3.95 (SD = 0.89). Though many farmers acknowledge that SFM may help decrease over-reliance on synthetic fertilizers, some of them still take care of chemical inputs first, as they are more accessible and the results can be observed much quicker. Chaudhary et al. (2022) argued that this kind of dependence is typically determined by the illiteracy of farmers and their inability to find other organic inputs. The least ranked indicator was the aspiration to persist and sell SFM to other farmers because the mean value is 3.78 and SD = 0.94. This means that when more farmers are implementing SFM in their farms, less farmers are facilitating the spread of sustainable farming practices among their colleagues. de Carvalho et al. (2023) noted that peer-to-peer knowledge and community intervention played a critical role in the spread of sustainable practices in farming. Overall, the findings indicate that the farmers in District Vehari have faith and confidence in SFM that will bear a positive impact, especially in boosting crop production and the sustainability of soil. Nevertheless, the average motivation to share knowledge scores and low perceived decreased chemical dependence scores show that there are gaps that need to be bridged.

Pearson's Correlation Analysis

Table 5 presents the results of the Pearson correlation analysis, which was conducted to identify the correlation between farmer innovativeness and positive affirmation and the level of adoption of Soil Fertility Management (SFM) practices in District Vehari. The findings indicate that all the three correlations of the previously mentioned variables were positive and were statistically significant at the 0.01 level (2-tailed). This means that the more the farmers are positive and innovative in their affirmation, the higher the uptake of SFM practices.

Table 5: Pearson's Correlation Coefficients among Innovativeness, Affirmation, and Adoption of SFM Practices (n = 300)

Variables	Innovativeness	Positive Affirmation	Adoption Level
Innovativeness	1	0.621**	0.674**
Positive Affirmation	0.621**	1	0.702**
Adoption Level	0.674**	0.702**	1

Note: Correlation is significant at the 0.01 level (2-tailed)* $p < 0.05$, p < 0.01

Level of adoption was most significant with positive affirmation (r = 0.702), meaning that farmers, who strongly believe in attitude and confidence towards the utility of SFM, are more likely to adopt the practices on a routine basis. This fact was proven by Dixon et al. (2020), who argued that positive perceptions and attitudes play a key role in influencing the decision by farmers to adopt sustainable agricultural developments. Farmer innovativeness and the degree of innovativeness were also found to have a strong positive relation (r = 0.674), which depicts that the innovative farmers will tend to practice SFM in relation to the less innovative farmers. The innovativeness is the capacity of the farmer to be receptive to new ideas, to experiment and to be adaptable to change which is critical in the introduction of new forms of agriculture. This is in agreement with the Diffusion of Innovations Theory of Rogers

(2003) that underlines the significance of innovators and first adopters in promoting agricultural technologies. Innovativeness was also strongly and positively correlated with positive affirmation (r = 0.621). This indicates that more innovative farmers have a more positive attitude and beliefs concerning the SFM practices. In other words, new farmers are not only willing to experiment with new approaches, but they are more likely to focus on their future benefits and be assured of their success. This combination of innovativeness and affirmation creates a reinforcing cycle wherein positive attitudes may result in experimentation and experimentation, in its turn, will cause confidence in new practices, as Gathala et al. (2021) observe. Overall, the correlation analysis proves all above hypotheses.

Binary Logistic Regression

Table 6 presents the results of the binary logistic regression model that was used to identify the predictors of adoption of Soil Fertility Management (SFM) practices that were found to be significant. The dependent variable (adoption status) was given codes: 1 adopters, 0 non-adopters. The independent variables included innovativeness, positive affirmation, and some socioeconomic factors, which entailed age, education, farm size, income, farming experience, and access to the extension services.

Model Summary

- -2 Log Likelihood: 208.35
- Cox & Snell R^2: 0.422
- Nagelkerke R^2: 0.567
- Overall Model Prediction Accuracy: 81.4%

Table 6: Binary Logistic Regression Results for Predictors of SFM Adoption (n = 300)

Predictor Variables	B (Coefficient)	S.E.	Wald	Exp(B) (Odds Ratio)	p-value
Constant	-3.215	0.875	13.50	0.040	0.000**
Age (Years)	-0.042	0.019	4.89	0.959	0.027*
Education (Years of Schooling)	0.215	0.081	7.05	1.240	0.008**
Farm Size (Acres)	0.084	0.043	3.78	1.088	0.052
Income (PKR/Month)	0.000012	0.000005	5.56	1.000012	0.018*
Farming Experience (Years)	0.067	0.026	6.64	1.070	0.010**
Access to Extension Services	0.823	0.291	7.99	2.278	0.005**
Innovativeness Score	0.517	0.162	10.18	1.677	0.001**
Positive Affirmation Score	0.684	0.174	15.42	1.982	0.000**

Note: Significant at p < 0.05 *(), Highly Significant at p < 0.01 (**)**

The model explained a large proportion of the variance of the adoption behavior with Nagelkerke $R^2 = 0.567$, indicating that the adoption decision variation was attributed to these variables by approximately 57 percent. The model also became the most predictive, with only 81.4 percent of cases put in the correct category, which points to the fact that the variables put in the model are very predictive as to whether farmers employ SFM practices or not. The results had shown that positive affirmation was the most influential one in predicting adoption. Its coefficient (B = 0.684, p = 0.000) was quite large, and its odds ratio (Exp(B) = 1.982) indicates that more likely that a farmer will turn into an SFM practitioner, the greater the increase in positive affirmation. This shows that good-believing, confident farmers with positive attitudes towards sustainable soil management have high chances of adopting and maintaining the practices. This finding is in line with other research articles by FAO (2024) and Hussain et al. (2021) that pay attention to the significance of perceptions and psychological factors of farmers when making adoption decisions. Likewise, another strong predictor was innovativeness (B = 0.517, p = 0.001) with an odds ratio of 1.677, which implies that an innovative farmer was almost 68 percent more likely to adopt SFM practices compared to a less innovative farmer. This observation is consistent with the Diffusion of innovations Theory by Rogers (2003), which suggests that open people who are open to change and experimentation tend to adopt new farming technologies and methods first.

One of the most significant predictors was found to be access to extension services (B = 0.823, p = 0.005), odds ratio of 2.278, i.e. farmers who had access to extension services were more likely to practice SFM by more than two times compared to those who did not. This is the reason why the agricultural extension programs are so vital in informing, demonstrating, and providing technical assistance to farmers. Similarly, the level of education also made a significant contribution to its adoption (B = 0.215, p = 0.008), which is probably going to show that educated farmers will be more inclined to see the benefits of sustainable farming and adopt the new methods effectively. Income and farming experience were other important predictors (p = 0.018) and (p = 0.010), so that more successful and experienced farmers are better placed to invest in practices that tend to enhance the fertility of the soil. On the other hand, adoption was significantly and negatively associated with age (B = -0.042, p = 0.027), implying that younger farmers are more open to adopting new practices, and older farmers could be more resistant to change, but the conclusion was shared by Chaudhary et al. (2022) in the same regard.

Overall, these results suggest that positivity and innovativeness (psychological factors) have the most powerful predictive factors of the adoption of SFM, and the second factor is the accessibility of extension services and education. This means that adoption is not entirely dependent on physical resources or farm characteristics, but also on the mindset of the farmers, their beliefs, and access to new information. Therefore, it is recommended that policymakers and extension service providers come up with interventions that would not only instill confidence in farmers but also empower farmers to think innovatively and make the extension networks robust.

CONCLUSION

The paper has centered on the adoption of Soil Fertility Management (SFM) practices by the farmers in District Vehari (Punjab), but with a specific emphasis on the role of innovativeness and positive affirmation. It was revealed that the majority of the practices, such as crop rotation, integrated nutrient management (INM), and balanced use of fertilizers, were practiced compared to knowledge- and resource-intensive practices, including soil testing and green manuring. It implies that low-cost, traditional approaches are more acceptable among farmers than those that might require greater technical expertise or more financial investment and aligns with the findings of Vanlauwe et al. (2015) and Ahmad et al. (2022). Another conclusion of the paper was that innovativeness and positive affirmation are the essential psychological drivers of SFM adoption. Open-minded farmers who believed in the benefits of SFM had a far greater opportunity to implement the new developments into their agricultural systems. The logistic regression analysis established that positive affirmation was the strongest determinant in adoption, followed by innovativeness and access to extension services. It shows the necessity to address the beliefs and attitudes of farmers and provide technical assistance and training (Rogers, 2003; Meijer et al., 2015). based on results, the study recommends that policies that serve the purpose of increasing the levels of adoption should strive to enable the circle of extensions, motivate the learning of peers, and offer certain financial and technical assistance. Sustainable soil management can be improved by developing the development of innovativeness and trust in farmers as the guarantor of long-term agricultural products and environmental stability of District Vehari and other sites.

Recommendations

1. Independent Agricultural extension services and Train Farmer.
2. Promote Farmer Innovativeness, Incentives and Knowledge Platform.
3. To Promote Positive Affirmation Nurture with the help of the Awareness Campaigns and Peer Influence.

Declarations

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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 Aftab; Conceptualization, Data Curation, Methodology, Data Original draft, Formal Data Analysis, Natasha Malik; 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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