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Research Article

Impact of Farmer's Socioeconomic Characteristics and Technology Adoption on Agriculture Income: Evidence from Central Punjab, Pakistan

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Abstract

The research examines the adoption of modern agricultural technologies, essential for policymakers and technology providers to evaluate existing initiatives and enhance dissemination strategies. The primary emphasis on the impact of socioeconomic characteristics and technology adoption on agriculture income is crucial for assessing economic outcomes, guiding efforts to improve farmers' well-being. Objective of the current study was to estimate the impact of socioeconomic characteristics of farmers and adoption of technology on their income and suggest policy measures. For estimation purposes, central Punjab was chosen, and data was collected. A well-organized questionnaire was distributed to 401 farmers in central Punjab. OLS technique was used for analysis to estimate the impact of independent variables on farmers' income. According to the results, adoption of advanced technology, awareness of technology, land holding, family size, and farmer education have a statistically significant impact on the dependent variable in the model. It is recommended to launch extensive awareness programs in collaboration with agricultural extension services to educate farmers on the advantages of advanced technologies, advocate for policies ensuring fair land access, recognize the role of family size in agriculture, and improve customized educational programs to empower farmers with ongoing learning and skill development, fostering a culture of innovation.

Keywords: Farmers, Socioeconomic characteristics, Technology adoption, Agriculture income: Central Punjab

Introduction

A majority of the population relies on agriculture for their livelihoods, both directly and indirectly. This means not just reducing poverty but also creating an elevation in the economic model of the people via agriculture (Aldosari et al., 2019). Sustainable development relies heavily on agriculture. As a result, it aids in the alleviation of hunger and poverty in underdeveloped countries. Food security and economic prosperity are intertwined in Pakistan's agriculture industry. However, as compared to other parts of the globe, this industry has underperformed in recent years, resulting in rising levels of poverty and unemployment. There is a growing tendency in the national population and Punjab in particular. As the population grows, so does the need for food. The modern period needs more productivity in agriculture. Agriculture productivity will be increased by using new and better agricultural technology. It is possible to increase output at a lower cost thanks to new and better agricultural technologies. Rural residents will benefit from this new technology in terms of increased job options and a decrease in poverty (Ali et al., 2021). Pakistan's economic and agricultural heartland, Punjab, is in this province. Agribusiness employs over 49% of the country's workforce and generates

56.1–61.5 percent of the country's total agricultural output. Wheat and cotton, two of Punjab's most important cash crops, play a significant role in Pakistan's economy. Cash crops such as cotton, commonly known as "white gold," are important to Pakistan's export economy and account for the majority of the country's earnings. Wheat is another important crop in Pakistan, which contributes to 2.2% of the country's GDP and 10.3% of the country's agricultural economy (Ali et al., 2022).

Food security has been a problem for Punjab for many years. Punjab had 5,249,800 farms in 2016-17, according to the agricultural census, most of which were owned by small landowners. More than half of former residents possess well over an acre of property, according to the survey. 5.87 million hectares of Punjab's 16.68 million acres of cultivated land were seeded several times throughout the year. Wheat accounted for 40% of Punjab's cultivated land in 2018-19, while cotton accounted for 11.5 percent and rice 12.8 percent of the total planted area. For the province's cattle population, 11 percent of the land was planted in fodder, with maize and sugarcane taking up 4.2% and 4.8% of the land, respectively. Less than a tenth of the land was used to grow oil seeds, lentils, or vegetables (GOP, 2019). Punjab is Pakistan's most populated province, contributing the most to its agricultural output. Pakistan's agricultural industry contributes 19 percent of the country's yearly GDP and employs 48 percent of the people. Major businesses, including leather, cotton, edible oil, sugar and rice processing all rely on agricultural products for their basic materials. Punjab accounts for 60 percent of Pakistan's overall agricultural exports, which is a third of the country's total exports (Rehman et al., 2016).

Rice, wheat, jute, sugarcane, fruits, and vegetables are some of the most important agricultural crops. Agriculture productivity in Pakistan is supported by one of the world's largest agricultural systems. Because of drought, pests, climate change, and other factors, agriculture's GDP contribution in 2019 has declined by 2.7 percent from the previous year. The fact that farmers are not aware of new inputs and advances in technology is a major problem in the agricultural business. More than half the city's population is involved in agriculture, yet they have little information of modern technology that boost yields per acre. They relied on antiquated methods that aren't capable of handling big volumes of output. The present scenario calls for the quick adoption of agricultural technologies. We shall fall far behind other nations in the fight for progress if we do not accept this as part of the global world (Ahmad & Heng, 2012). Wheat contributes around 10.3 percent of agriculture's contribution to GDP and 2.2 percent to the overall economy. Rice is both a cash crop and a food crop. Pakistan produces the greatest rice in the world, and it's often regarded as such. As a result, Pakistan's foreign currency reserves have been affected by our lack of skill in exporting large quantities of decent rice. Rice accounts for 3.1 percent of our agricultural output and 0.7 percent of our GDP (Usman, 2016).

To meet the requirements of the modern age, it is necessary to let our formers adopt agricultural technology and thereby increase its production and profits. Only this way can the farmer get more yields in less time, less labor and less capital. But it requires the farmer to build his confidence in modern technology (Feyisa, 2020). According to Anjum et al. (2020), microfinance for agricultural purpose has a positive impact on the socioeconomic characteristics of the farmers, such as income and living standards. Saqib et al. (2019) conducted a study on the livelihood strategies of small-scale farmers in Pakistan to find the relationship between agricultural diversification strategies being adopted by farmers and farmers' incomes. According to Javed et al. (2022), farmers' income has a positive impact on the farmer's utilization of credit facilities. Socioeconomic advantages of bioenergy-employment and economic gains are the main driving factors that can increase the share of bioenergy, especially in rural areas. The development of proper supply chains can provide many households with livelihood as well as employment opportunities (Rehman et al., 2020).

Seeds and fertilizer are important in agricultural productivity because they directly affect land yields, and modern machinery is closely linked with higher agricultural productivity. During the past decades in Punjab, the use of modern machinery has been increase. In 2014, Punjab was using 442,931 tractors, 140,133 thrashers, and 31,609 harvesters. For the last few decades government of Punjab has introduced development polices for the agriculture sector to introduce moderns' machinery among formers which are Kissan card scheme, fertilizer subsidy, subsidy on tube wells, subsidy on pesticides and development of Olive valley in Pothwar region and also develop high tech mechanization services centre in rural areas of Punjab (Rehman et al., 2016).

Ali et al. (2021) examined the effects of the adoption of new and enhanced agricultural technology on the region's farmers' income levels (Faisalabad). When evaluating the effect of technology adoption, researchers utilised seven different technologies. The study relied on micro panel data collected (206-07 & 2018-19). Propensity scores are estimated and matched with average treatment efficacy (ATE) to examine the influence of money on the study population. The logistic technique for pooled data is used to monitor technology uptake. Farmer poverty and income levels in the research region were positively impacted by these technologies. The farmers' income was positively and significantly influenced by the adoption of enhanced technology. In the research region, these agricultural innovations have a significant impact on farmer income and well-being. According to the findings, additional incentives should be made public in order to spur the creation and use of more advanced technologies in the future. Farmers' revenue and food production might be boosted by the use of these new technologies.

The study provides a comprehensive exploration of the socioeconomic characteristics of farmers in Central Punjab, Pakistan, offering insights into factors influencing their decision-making. This understanding is vital for developing targeted interventions and policies to address farmers' specific needs. Additionally, the research examines the adoption of modern agricultural technologies, essential for policymakers and technology providers to evaluate existing initiatives and enhance dissemination strategies. The primary emphasis on the impact of socioeconomic characteristics and technology adoption on agriculture income is crucial for assessing economic outcomes, guiding efforts to improve farmers' well-being and livelihoods. Objective of the current study was to estimate the impact of socioeconomic characteristics of farmers and adoption of technology on their income and suggest policy measures.

Methodology

Sampling and Data Collection

To obtain research objectives and to estimate the effects of socioeconomic factors, adoption of technologies, and different economic factors on agricultural growth. Central Punjab was selected as a study area due to the suitable nature of research because central Punjab districts are well-known in Pakistan for agricultural products such as wheat, rice, sugarcane, maize, and oranges. Through random sampling, technique data is collected from Central Punjab districts. Primary data is collected from 400 farmers through proper questionnaires. For the collection of primary data, a survey was conducted through a proper questionnaire. Central Punjab districts are the main study areas. 401 farmers are selected from Central Punjab districts Sargodha, Mianwali, Mandi Bahauddin, Okara, Khushab, Sialkot, and Jhang. All farmers are selected randomly from selected districts.

Econometric Model

The ordinary least square technique is selected for the estimation of results and estimations of an unknown parameter. Linear regression analysis is used in the methodology. This model estimates the relationship between socioeconomic factors and farmer income in farming. The regression equation of this model is following:

$$AI = \alpha + \beta_1 AAT + \beta_2 AAdT + \beta_3 LH + \beta_4 Fsize + \beta_5 MS + \beta_6 Ed + \beta_7 Ag + \beta_8 Ex + \epsilon \quad (1)$$

Dependent Variable

AI= Agriculture income (annual (per acre) ('000'PKR))

Independent variables

AAT= Adoption of advance technology (numbers of technology)

AAdT= Awareness of advance technology (numbers of technology)

LH= Land holding (Number of acre)

Fsize= Family size (numbers)

MS= Martial status (1=married, 0=single)

Ed= Farmer Education (No of schooling year)

Ag= Farmer Age (No of years)

Ex= Farmer Experience (No of years)

Explanation of Variables

Adoption of Advanced Technologies: Adoption of advanced technology is a dependent variable which means how much farmers adopted technologies in agriculture for farming. Advanced technologies have a very important role in increasing productivity and sustainable growth in agriculture.

Age of Farmers: The age of the farmers is the most significant variable, which may play an important role in their behavior regarding the adoption of technologies. The age of the respondents was measured in terms of years at the time of interviewing. It was counted from the individual's first day of birth till the time of the interview.

Farmer's education: Education is the dynamic force for growth and progress in an increasingly interconnected and globalizing world. It has a strong positive impact on individual earnings and overall economic growth. Therefore, with higher education, a farmer is expected to help adopt the recommended technology. But, farmers are a diverse set of people with most of them having no particular formal education because there are no spectacular qualifications needed to become a farmer.

Farmer's Experience: Farmer's experience means how long has a farmer been involved in the agriculture sector? Farmer's experience is a very important variable for the adoption of technologies.

Farmer's Family Size: Family size means the number of members of a family, including husband, wife, and children. In the case of a joint family, it also includes other members of the family such as parents, sisters, or brothers of the husband or wife. First, the number of children and adults proxies the human capital available for agricultural labor. Households with a larger pool of labor are more likely to adopt improved technologies and use them more intensively because they have fewer labor shortages at peak times.

Farm Labor: Farm labor is human resources that a landlord hires as servants or laborers to cultivate their land. And the landlord pats their labor to do the work. Farm labor is a substitute for machinery, which is used in the agricultural sector.

Off-Farm Income: Off-farm income is income refers to the portion of farm household income obtained off the farm, including nonfarm wages and salaries, pensions, and interest income earned by farm families. This income comes from other sources other than agriculture.

Farmers Family System: The respondents were asked about their family type: nuclear or joint. A nuclear family is a family where only the husband, wife, and unmarried children live together. Meanwhile, the joint family means a family where, in addition to the children, wife and husband, parents, sisters, or brothers of the husband or wife also live there.

Farmer's Family Expenses: The expenses of a farmer's family are the amount spent on food consumption, health, utilities paid for the education of their children, and other needs in a month.

Farmer's Martial Status: This variable is a binary variable with 1 value if a farmer is married and 0 value if a farmer is single.

Farmer's Agriculture Assets: Farmer's agriculture assets are agricultural land, buildings for farming, livestock, and machinery (tractors, tube-wells, threshers, etc). In this study, agriculture assets measured in the unit will be the fair price on which assets will be sold in Pakistan rupees (000PKR).

Tenure Status: Land tenure is a system of farming in which property rights to land are to be allocated. In this research, three systems include owner, tenant, and cum-tenant owner. For estimation, give owner to 1, tenant to 2, and cum-tenant owner to 3.

Land Holding: Landholding means how much land a farmer owns? It is measured in terms of an acre.

Awareness of Advanced Technologies: Awareness of advanced technologies is how much

Results and Discussion

Socioeconomic Characteristics

Age: A person's age is considered to be one of the most important factors regarding adoption behavior. The age of respondents was measured in terms of years at the time of the interview. It was counted from the individual's first day of birth until the time of the interview. Table 1 depicted that middle-aged (30>50) respondents, with 54.86% of respondents, adopted technology in farming, and 20>30 young respondents (28.67%) adopted agriculture technology. And old age (50>70) adopted technology is only 16.45%.

Farmer's Education: Table 1 shows that the majority of farmers are middle-class, which is 32.7% of the 401 farmers. 15.4% of farmers have matric education, 24.2% of farmers have higher secondary education, 14.4% of farmers have graduation education, and on the least number, only 13.2% of the farmers have master's education.

Table 1. Demographic profile of the respondents.

Attributes	Frequency	Percentage
Age		
Young (20 > 30)	115	28.67
Middle (30 > 50)	220	54.86
Old (50 > 70)	66	16.45
Farmer's Education		
primary	56	13.9
Middle	75	18.7
High	62	15.4
Higher secondary	97	24.2
Graduation	58	14.4
Masters	53	13.2
Farmer's Experience		
2 to 10 years	144	35.9
10 to 20 years	154	38.4
20 to 30 years	66	16.45
30 to 40 years	37	9.22
Family Size		
1 to 3 members	28	6.9
4 to 7 members	253	63.09
8 to 10 members	120	29.9
Farm Labor		
00 members	23	5.7
1 to 3 members	288	71.82
4 to 8 members	90	22.44
Off Farm Income		
0 thousand	98	24.4
5 to 20 thousand	117	29.1

21 to 60 thousand	180	44.88
61 to 70 thousand	6	1.4
Family System		
Nuclear 0	126	31.4
Joint 1	275	68.6
Family Expenses		
10 to 20 thousand 10 to 40	254	8.4
21 to 40 thousand 41 to 80	135	54.8
41 to 60 thousand 81 to 100	12	28.1
Marital Status		
Single 0	97	24.2
Married 1	304	75.8
Agriculture Assets		
0 thousand	69.0	17.2
10 to 100 thousand	58.0	14.4
110 to 500 thousand	191.0	47.6
510 to 1000 thousand	83.0	20.6
Tenure Status		
Tenant 1	245	61.1
Owner-cum-tenant 2	30	7.5
Owner 3	126	31.4

Farmer's Experience: The experience of farming is expected to help an individual make decision. The use of technology in agriculture is an important activity. A person also learns from his own experiences. Overall, 10 to 20 years of experience is the highest number (38.4%) of technology use. And 30 to 40 years of experience is the lowest number (9.22%) of technology use.

Family Size: Table 1 revealed that 6.9% of respondents had 1 to 3 members in family size, which is the lowest number as compared to others, and 63.9% of respondents had 4 to 7 family members in their household. And 29.9% of respondents had 8 to 10 families in their household.

Farm Labor: Farm labor is also an important factor for adoption behavior. Most farmers have 4 to 7 members of labor, which is the highest number (63.09%) of the farmers. And 1 to 3 members have the lowest number, which is 6.9% of the respondents of the total farmers.

Off-Farm Income: Table 1 revealed that 24.4% of respondents have no off-farm income because they have no other source of income other than agriculture. And 29.1% of respondents have 5 to 20 thousand per month in income. Most respondents (44.88%) belong to 21 to 60 thousand per month income, which is high-level income, but most highly level income 61S to 70 thousand per month have only 1.4% respondents of the 401 farmers.

Family System: Family status is also an important factor in determining the adoption behavior. The table revealed that most farmers belong to the joint family system, 68.6% of respondents belong to the joint family system and the remaining 31.4% of respondents belong to the nuclear family system.

Family Expenses: Family expenses are also a factor in the adoption behavior of technology. Table 1 shows that most of the respondents (54.8%) have family expenses from 21 to 40 thousand as percentage of income and

28.1% respondents belong to 41 to 60 thousand expenses as percentage of income. Lower expenses are 2.9% respondents who have 81 to 100 thousand expenses as % of income.

Marital Status: The Table 1 revealed that third-fourth of the respondent belonged to married status. 75.8% respondent was married of the 401 farmers. And 24.2% respondent belongs to single status.

Agriculture Assets: Agricultural assets refer to machinery, equipment, facilities, land or livestock used in agriculture farming. Most respondents (47.6%) belonged to most high-level assets which value is 110 thousand to 500 thousand. One-fourth of respondents (20.6%) belong to high-level agriculture assets. On the least 14.4% of the farmers have 10 to 100 thousand values of agriculture assets.

Tenure Status: The Table 1 shows that a majority two-thirds of the respondents were owners of this land, which is 61.1 of the 401 farmers, and only 7.5% of respondents were tenants. Similarly, 31.4% of respondents were owner-cum-tenant of their land.

Descriptive Statistics

Results of Table 2 shows that income from agriculture has highest value of mean 51.45 with standard deviation of 20.46. While on the other hand, tenure status has lowest value of mean 0.68 with the standard deviation of 0.46. Results revealed that average adoption of technologies of the farmers is 3.63 with standard deviation of 1.34, which shows data is clustered around the mean. Average age of our respondent is 37.73 with the standard deviation of 11.77, which show that data are more spread out. Farmer's average education is 10.71 and standard deviation is 3.46 which that data is clustered around the mean. Average experience of our farmers is 16.53 with the standard deviation of 9.96. Average family size of the farmers is 6.52 with standard deviation of 2.04, which show data is clustered around the mean. Farmer's average farm labor is 2.19 with the standard deviation of 1.47, which show that data is clustered around the mean. Farmer's average off farm income is 22.89 with standard deviation of 18.88, standard deviation value show data are spread out. Average of family status is 0.68 with standard deviation of 0.46 which show that data is clustered around the mean.

Table 2. Descriptive statistics.

Variables	Mean	Std. Deviation
Adoption of Technologies (Dependent variable)	3.6309	1.34292
Farmer's age	37.7307	11.77295
Farmer's education	10.7132	3.46699
Farmer's experience	16.5337	9.96115
Family size	6.5212	2.04332
Farm labour	2.1920	1.47497
Off farm income	22.8953	18.88608
Family system	.6858	.46478
Family expenses	40.8105	15.93531
Marital status	.7581	.42877
Tenure Status	.6858	.46478
Awareness of advance technology	5.9526	1.56213
Income from agriculture	51.4589	20.46287
Agriculture Asset	2.0815	1.00279

Average of marital status is 0.75 with standard deviation of 0.42 which show that data is clustered around the mean. Average of Awareness of advance technology is 5.95 with the standard deviation of 1.56. Average of agriculture assets is 2.08 with standard deviation of 1.00 which show that data is clustered around the mean.

Impact of Socioeconomic Characteristics and Technology Adoption on Agriculture Income

In this model analyzed the impact of socioeconomic characteristics and technology adoption on agriculture income.

Adoption of advanced technology: Table 3 revealed that the adoption of advanced technologies has a significant impact and positive relation with agricultural income. Table 3 shows that if one number increases in the adoption of advanced technologies, there will be a 1.826 thousand PKR increase in agricultural income.

Awareness of advanced technology: Table 3 results revealed that awareness of advanced technology has a significant impact on agricultural income but negatively affects income. According to Table 3 results, if one number increases in the awareness of advanced technology, there will be 1.6 thousand PKR decrease in agriculture income.

Table 3. Impact of socioeconomic characteristics and technology adoption on agricultural income.

Variables		B	Std.Error	Sig.
(Constant)		18.760	6.239	.003
Adoption of advance technology	AAT	1.826	.731	.013
Awareness of advance technology	AAdT	-1.600	.655	.015
Land holding	LH	.160	.027	.000
Family size	Fsize	3.497	.513	.000
Marital status	MS	6.060	2.576	.019
Farmer Education	Ed	.868	.284	.002
Farmer Age	Ag	.296	.123	.016
Farmer Experience	Ex	-.528	.134	.000

Dependent Variable: AI (Agriculture Income).

Land Holding: Results show that land holding has a highly significant impact and positive relation with agriculture income, with 0.16 thousand PKR increases in agriculture income due to a one-point increase in farmers' acre land. The results are similar to the results of Javed et al. (2023).

Family size: Results show that family size also has a significant impact and positive relation with agricultural income. Agriculture income increases by 3.49 thousand PKR due to an increase in the number of members in a family. The results are similar to the results of Javed et al. (2023).

Farmer's Education: Results show that farmer's education has a significant impact and positive relation with agriculture income, 0.868 thousand PKR increases in agriculture income due to one number of schooling increases of farmers.

Farmer's Age: Farmers' age also has a significant and positive impact on agriculture income, with a 0.296 thousand PKR increase in agriculture income due to an increase of one unit of years of farmers.

Farmer's Experience: Results show that farmer's experience has a highly significant impact but negative relation with agriculture income, 0.528 thousand PKR decreases in agriculture income due to increase in one number year of experience of the farmer.

Conclusion and Recommendations

The adoption of technologies has a direct relation with income. Technologies increase the productivity of the land in a short time. Farmers increase their income by using their land twice a year through advanced technologies. However, awareness of advanced technologies has an inverse relation to income. Farmers who believe in the old ways of farming do not use modern technology; therefore, despite being aware, it does not have positive effects on income. Or maybe farmers are already aware and no longer taking advantage of it.

Landholding has a positive relation with farmer's income; the more land a farmer has, the more it will be used, which will increase the production of land and increase the farmer's income. Family size has a direct relation with income; in a larger family size, more people will participate in farming, increasing the land's productivity. Marital status has a positive relation with income, and if the farmer is married, then he has more responsibilities for the house, so he works harder to increase the yield of his land. But if he is unmarried, he does not work so hard because he has little responsibility. Farmers' education directly relates to income; educated farmers use technology and inputs properly in farming and are aware of all circumstances, so they are increasing their income from land. Farmers' age positively relates to income because mature and aged farmers have more knowledge about farming. But farmers experience has an inverse relation with income; maybe some farmers have a lot of experience in farming for which they cultivate their land through old methods, and as the result their income does not increase as much as their experience.

It is recommended that awareness initiatives aimed at educating farmers on the advantages of embracing advanced agricultural technologies be launched. Emphasize the positive effects on crop yield, efficient resource utilization, and sustainability. Establish partnerships with agricultural extension services and technology providers to effectively disseminate this valuable information. Enact policies that promote fair and inclusive access to land. Consider implementing land reform strategies, redistribution initiatives, or programs designed to assist smallholder farmers in acquiring and maintaining land ownership. Robust landholding has been linked to heightened productivity. Acknowledge the significance of family size in agricultural endeavors. Develop policies that establish social support structures for larger farming families, encompassing provisions for education, healthcare, and other essential services. This holistic approach aims to ensure the overall well-being of families and enhance the agricultural workforce. Enhance educational programs tailored for farmers, underscoring the continual importance of learning and skill development. Foster collaborations with educational institutions, extension services, and vocational training centers to empower farmers with knowledge. Educated farmers are more inclined to embrace innovative practices.

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