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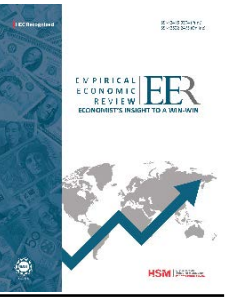

Title:	**Farmers' Characteristics, Crop Diversification and Agricultural Constraints affecting Crop Cultivation in Sindh province of Pakistan: An Empirical Evidence**
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Farmers' Socioeconomic Characteristics, Crop Diversification, and Agricultural Constraints affecting Crop Cultivation in Sindh, Pakistan: An Empirical Analysis

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Abstract

This paper investigates the various factors affecting crop cultivation both negatively and positively in the Sindh province of Pakistan. To undertake the analysis, face-to-face face interviews with farmers using a pre-tested questionnaire were conducted. Both judgment and simple random sampling methods in the two districts, namely Hyderabad and Matiari, of Sindh province/Author judgement and simple random sampling method were used to sample the farmers from the two districts of Hyderabad and Matiari, Sindh. The results of multiple linear regression analysis indicated the influence of various factors including farmers' socioeconomic characteristics (their age, education, and tenancy) and crop diversification (or crop varieties), in addition to the main agricultural constraints such as water scarcity, barren and salinized land, and lack of financial resources, that discourage crop cultivation in the province. In light of the results, several suggestions for decision-makers involved in agricultural policymaking are given at the end, specifically in view of the prevailing conditions in the Sindh province of Pakistan.

Keywords: agricultural constraints, crop cultivation, crop diversification, farmers' characteristics

Introduction

In Pakistan, specifically in the Sindh province, a variety of factors including farmers' demographic characteristics, such as their age and education, as well as crop diversification (or crop varieties) influence crop cultivation. This is because farmers remain in a compromising situation due to various agricultural constraints including water scarcity, salinization and barren land, lack of financial resources, and the unavailability of quality seeds and pesticides in the markets.

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The Sindh province, once very famous for its crop cultivation across other provinces in Pakistan, is largely a dry region as compared to them, specifically compared to Punjab and Khyber Pakhtunkhuwah (KPK) provinces. These provinces are located in the upper areas of the country with various agricultural advantages, such as greater water availability, better quality of soil, and lower salinization and waterlogging. As a result, the percentage of the salt affected areas of the total agricultural land in Sindh is greater than the other provinces. For example, salt affected (salinized) area is 34% of the total agricultural land in Sindh, whereas it is 9.1% in Punjab, 6.1% in Baluchistan, and 4.9% in the KPK province, respectively (Aslam, 2017).

The major sectors of the economy of the Sindh province are agriculture, industry, and services. The total irrigated area in the province is 1.68 million hectares (MH), which makes up 9.03% of the total irrigated land in the country comprising 18.61 MH (Government of Sindh [GOS], 2018). The total population of Sindh was 30.4 million as per the 1998 census (Pakistan Bureau of Statistics [PBS], 2019). Almost 14 million people lived in the rural areas, which were engaged directly or indirectly in the agriculture sector. The total arable area is 14.09 MH, out of which 6.80 MH are not cultivated (Chandio et al., 2016). According to PBS (2019), the uncultivated land in Sindh is 9.94 MH, which makes the highest figure of uncultivated land in comparison to other provinces in Pakistan.

Despite all these reasons, Sindh remains the second largest province in terms of agricultural production in the country. In the *Kharif* (summer) season, major crops (cotton, rice, sugarcane, maize, sorghum, green gram, millet), pulses (red gram, lentil), vegetables (bitter guard, lady finger, chillies, squash), and fruits (mango, dates, and melon) are cultivated in the province. Whereas, in the *Rabi* (winter) season, cereals (wheat, barley, gram), pulses (lentil, split peas), vegetables (cauliflower, turnip, carrot, peas), and fruits including citrus fruits (lemon, lime) and guava are cultivated. However, oil seed crops (sunflower, soybean, maize) are grown in both seasons (Hye et al., 2010).

Keeping in view the overall scenario of crops and their cultivation, this research focused on farmers' socioeconomic characteristics and crop diversification, in addition to agricultural constraints such as water scarcity, and their overall impact on crop cultivation in the province which has been decreasing over the years (Aslam, 2017). For this purpose, the authors

selected the agricultural land located in two districts, namely Hyderabad and Matiari, respectively. The aim was to draw important conclusions and prescribe policy suggestions helpful for decision-makers in order to increase efficiency in agricultural production and for the sake of better agricultural policy design, specifically for the Sindh province.

Literature Review

Chandio et al. (2016) investigated the impact of various factors influencing crop production in Sindh using time series analysis. The authors found that total farm size and water availability significantly affect crop cultivation in both *Kharif* and *Rabi* seasons throughout the province.

According to Hye (2016), farmers grow major crops, such as cotton, rice, sugarcane, maize, and vegetables in *Kharif* (summer) season. Whereas, they grow wheat, barley, gram, pulses, peas, and vegetables in *Rabi* (winter) season. However, various constraints, such as agricultural credit and water scarcity, negatively affect the cultivation of these crops (Arif, 2001). Hence, farmers prefer crop diversification in order to minimise the financial risk that results from low crop production and low market prices. Shahbaz et al. (2017) found that there are various factors including farmers' age, education level, farm size, farming experience, water availability, and land tenureship which significantly affect crop diversification.

The above review is further supported by Ahmed (2011). The author empirically analyzed the institutional credit given to the farmers, specifically medium and large/small farmers who have inadequate financial resources to cultivate different varieties of crops, and determined that it plays a major role in increased crop cultivation and farm income. Khan et al. (2012) thoroughly analyzed and established that a number of land characteristics negatively influence crop cultivation, including barren land, salinity and waterlogging, as well as drought and flooding. Furthermore, socioeconomic factors, such as low-level education, lack of financial resources, large household size, and low farm income also influence crop cultivation adversely.

Rehman et al. (2012) determined that several factors including socioeconomic characteristics of farmers (low-level education, large household size, limited application of modern technology), insufficient availability of quality seeds and pesticides in the market, inadequate financial resources required to cultivate crops (such as lack of agricultural

credit), water scarcity, inadequate agricultural research and extended support, and lack of infrastructure (roads, local markets, electricity for tube wells) adversely influenced crop cultivation in District Sukker, Sindh. This research is further supported by Aslam (2017). According to the author, there are different constraints, such as barren land and salinity, water scarcity, insufficient availability of quality seeds, lack of modern technology, small farm size, and low education, which adversely affect crop cultivation all over Pakistan.

It is evident from the above literature review that different researches identified and empirically tested the influence of various factors influencing crop cultivation; however, they did not conduct a comparative analysis of these factors at district and provincial levels. The current study, therefore, addresses this research gap by comparing empirically the factors affecting crop cultivation across two districts, namely Hyderabad and Matiari, in the Sindh province of Pakistan.

Research Objectives

The objectives of the current research are outlined as follows:

1. To assess farmers' socioeconomic characteristics influencing the crop cultivation ratio across districts Hyderabad and Matiari, respectively.
2. To analyze crop diversification affecting the crop cultivation-to-farmland ratio in both districts.
3. To examine the constraints confronted by framers which adversely affect crop under- cultivation in both districts.

Research Methodology

Sampling Methods and Survey Implementation

Judgment sampling technique was used keeping in view the researcher's convenience, as well as the lack of time and financial resources, which eventually resulted in a total sample of 318 farmers. A questionnaire was administered to the selected farmers. After excluding 18 incomplete questionnaires, a sample of 300 farmers was selected including 155 farmers from District Hyderabad and 145 from District Matiari, respectively.

The minors of irrigated canals situated in the different areas of districts Matiari and Hyderabad were selected. Later, simple random sampling technique was applied to locate small, medium, and large farmers in terms

of their land location in the head, middle, and tail of the minors. Only those farmers were selected whose land was situated along the minor *Rahuki* and the minor *Hala.* The former is located near tehsil Tando Hyder of District Hyderabad, commencing from Akram Wah canal of Kotri Barrage, while the latter is located near tehsil Saidabad of District Matiari, commencing from the Rohri canal of Sukker Barrage. Firstly, focus group interviews of framers with different farm sizes (small, medium, and large) were conducted. Based on these focus group interviews, a questionnaire was designed and initially pretested to the farmers whose lands were located in the head, middle, and tail of the selected minors. After pretesting, the final version of the questionnaire was readied for implementing the field survey. Face-to-face interviews were conducted with the farmers to collect information regarding their farming background, crop varieties, and the constraints (or problems) they face when cultivating crops during the two seasons, that is, the *Kharif* or summer season (falling between the months of April and October) and the *Rabi* or winter season (falling between the months of October and April), respectively. After collecting the primary data, Excel was used for data entry in order to process the primary data for empirical analysis. Similarly, Stata 16 software (2018) was used for regression analysis and hypotheses testing, respectively.

Econometric Specification

In the equation below, the explained (or dependent) variable is Y_i which represents the ratio (or percentage) of the number of acres cultivated by the farmers of their total farm land. Therefore, multiple regression (see Greene, 2018; Cameron & Trivedi, 2005; Nayyar et al., 2018) was applied using the following econometric specification:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots + \beta_k X_{ki} + \varepsilon_i \quad = 1, 2, \ldots, k$$

where β_0 is an intercept (or constant), $\beta_1, \beta_2, \beta_3 \ldots, \beta_k$ are the coefficients of explanatory variables capturing their influence on the total land cultivated, $X_{1i}, X_{2i}, X_{3i}, \ldots, X_{ki}$ represent explanatory (or independent) variables namely farmers' age, land ownership, land location (the head, middle, or tail), crop varieties (cotton, wheat) grown in *Khraif* and *Rabi* seasons, and agricultural constraints, such as lack of financial resources, salinization and barren land, and lack of quality seeds and pesticides affecting the crop cultivation ratio, and ε_i represents the stochastic error (or residual) term (see Cameron & Trivedi, 2005 ; Greene,

2018). Based on the review of previous studies and field observations, a number of explanatory variables influencing the crop cultivation ratio in districts Matiari and Hyderabad were identified and their impact on this ratio in the canal command areas located in both the districts was analyzed, empirically.

Before presenting the results of empirical analysis, it is necessary to mention that descriptive statistics are illustrated by calculating averages and percentages of variables, using pie and bar charts, for making comparisons between the factors influencing crop under-cultivation across both districts. Furthermore, a multiple regression analysis using ordinary least square (OLS) method has been implemented to analyze the relationship between explanatory (or independent) and dependent variables, subsequently.

Research Results

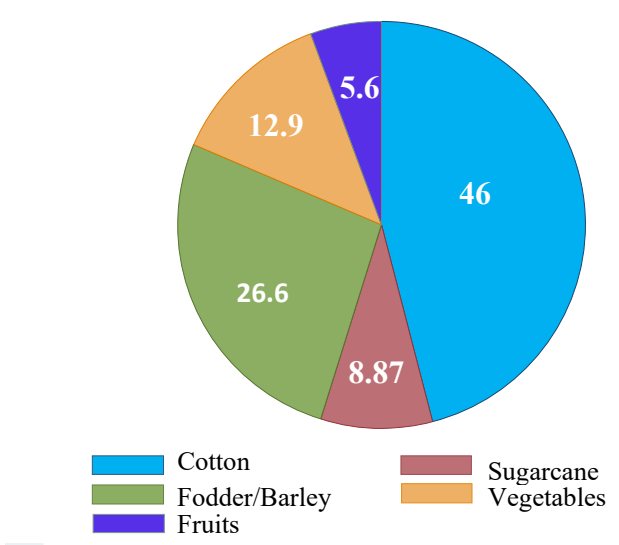
Descriptive Statistics

In total, a sample of 300 farmers was selected from districts Hyderabad and Matiari for the final data analysis. The average age of farmers included in the sample is 70 years with their average schooling of around 10 years. The average household size is 7.5 individuals, including the number of adults and children per household.

The farmers cultivate around 38 acres of land on average, whereas their total farm size (on average) across both the districts remains relatively higher, that is, 41 acres. It indicates that about 3 acres on average, which make up approximately 7% of the total farm area (41 acres), is not cultivated (see Table 1). Due to this reason (or constraint) behind crop under-cultivation, there are some farmers who cultivate their own land besides being tenants (who cultivate other farmers' land at the same time). Although, they comprise only 17% of the sample, their percentage is greater than the farmers who are tenant only and these represent only 11% of the entire sample. The majority of the farmers are landowners and represent 72% of the total sample (see Table 1). Finally, the average of cultivation-to-total farmland ratio is calculated to be about 93%, exhibiting that 7% of the farmers' land remains under-cultivated.

Figure 1

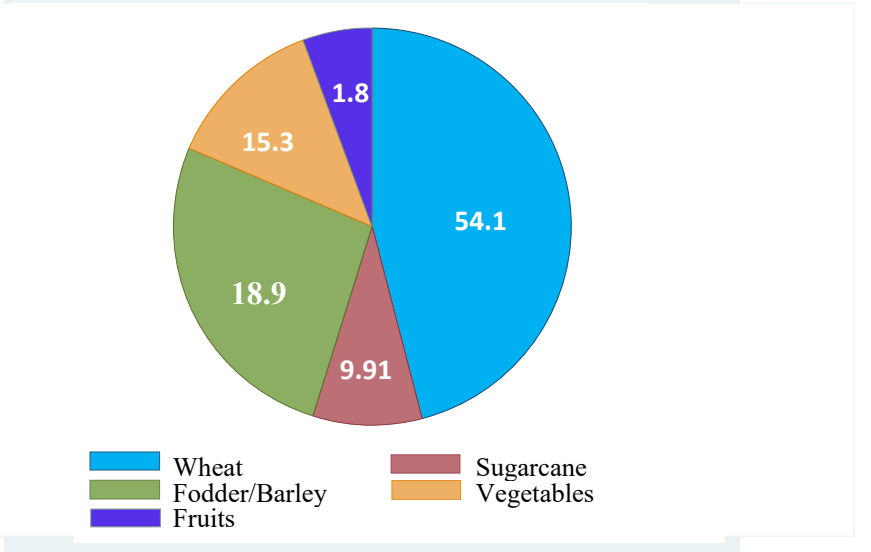
Crops Cultivated in Kharif Season Across Both Districts (% of N = *300)*



Source: Own Field Survey and Analysis 2021

Figure 2

Crops Cultivated in Rabi Season Across Both Districts (% of N = *300)*

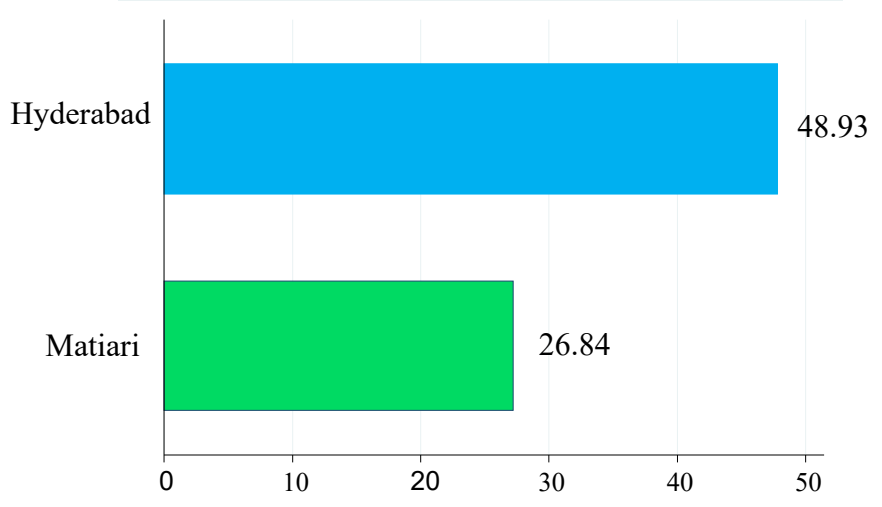


Source: Own Field Survey and Analysis 2021

Figure 3 explains crop cultivation by farmers on average (in acres) in both the districts. In Hyderabad, crop cultivation is about 49 acres on average, while it is about 30 acres on average in Matiari, respectively. Apparently, there is a substantial difference in crop cultivation on average across both the districts. However, the cultivation-to-total land ratio is higher in Matiari than in Hyderabad (see Table 2). This indicates that the crop cultivation-to-farmland ratio (CCFR) is a better indicator. Due to this reason, CCFR was selected as the dependent variable.

Figure 3

Average Crop Cultivation (in Acres) of Total Farmland in Both Districts



Source: Own Field Survey and Analysis, 2021

Table 2

District-wise Crop Cultivation – to – Total Farmland Ratio (in Acres)

Variable	*N*	Mean	St. Dev.	Min	Max	District
Cult-to-Farm	155	0.868	0.193	0.412	1	Hyderabad
Cult-to-Farm	145	0.924	0.174	0.346	1	Matiari
Sample (*N*)	300	0.895	0.186	0.346	1	Both

Source: Own Field Survey and Analysis, 2021

Furthermore, the current study analyzes and explains differences in farmers' socioeconomic characteristics, crop diversification, and agricultural constraints influencing the crop-cultivation ratio across both districts using Kolmogorov-Smirnov (KS) and Chi-Square (CS) tests, respectively. Instead of applying a semi-parametric Mann-Whitney U test, a semi-parametric Kolmogorov-Smirnov (KS) test was preferred for the comparative analysis (see Table 3), simply because the data is non-normal (or heteroscedastic). Table 2B (see Appendix B) show that the residuals are not constant using the Breusch-Pagan test. In other words, they are heteroskedastic. Also, the results of the Shapiro-Wilk test for normality assumption reject the null hypothesis that the residuals are normally distributed. Hence, the KS test that allows asymmetric (or non-normal) data to assume a non-normal distribution with unequal variances (Corder & Foreman, 2009) between the two samples (sub-samples of Hyderabad and Matiari districts, respectively) was applied.

Among farmers' socioeconomic characteristics, the results indicate that education and owner-tenant status of farmers do not differ significantly across both districts, as confirmed by the KS test for education and the CS test for the owner-tenant variables, respectively. Whereas, the values of the variables age, household size, and tail-ender farmer (whose land is located in the tail of the minor) significantly vary across Matiari and Hyderabad districts at 10%, 1% , and 5% significance levels, respectively.

When it comes to crop diversification factors, the results indicate that only two *Kharif* crops, namely vegetables and fruits, are significantly different at 5% and 1% significance levels, respectively. Furthermore, the results of the CS testestablish that both water scarcity and lack of financial resources influence the crop-cultivation ratio across both districts in a different way at 1% level of significance (see Table 3).

Regression Results

The multiple regression results are presented in Table 4. Due to the presence of heteroscedasticity in residuals, multiple regression was applied using robust standard errors (Greene, 2018). The value of R^2 is quite high indicating that 72% of variation in the dependent variable, that is, the crop cultivation ratio, is explained by independent (or explanatory) variables.

Table 3
Descriptive Statistics of Both Districts

Variable	Both		Hyderabad		Matiari		Test Statistic
	M	*SD*	*M*	*SD*	*M*	*SD*	
Farmers' Socioeconomic Characteristics							
Age (years)	48.8	10.40	49.5	9.73	48.1	11.06	0.14*
Education (years)	10.9	4.71	11.3	4.46	10.6	4.95	0.07
Household Size	7.6	2.29	7.2	2.08	8.00	2.43	0.30***
Both Owner-Tenant (Dummy)	0.15	0.36	0.16	0.37	0.13	0.35	0.32
Tail-ender Farmer (Dummy)	0.07	0.25	0.03	0.18	0.10	0.30	6.10**
Crop Diversification							
Kharif crops							
Sugarcane (Dummy)	0.11	0.32	0.13	0.34	0.10	0.30	0.48
Vegetables (Dummy)	0.26	0.44	0.32	0.47	0.21	0.41	5.13**
Fruits (Dummy)	0.11	0.32	0.03	0.18	0.21	0.41	22.17***
Rabi crops							
Fodder and Barley (Dummy)	0.34	0.47	0.35	0.48	0.31	0.46	0.67
Vegetables (Dummy)	0.28	0.45	0.29	0.46	0.27	0.45	0.08
Agricultural Constraints							
Water Scarcity (Dummy)	0.28	0.45	0.35	0.48	0.21	0.41	8.08***
Barren Land and Salinity (Dummy)	0.10	0.30	0.09	0.30	0.10	0.31	0.04
Lack of Fin. Resources (Dummy)	0.08	0.28	0.13	0.34	0.03	0.18	8.77***
Sample (*N*)	300		155		145		

Note. For continuous variables (such as age, education, and hiusehold size), Kolmogorov-Smirnov (KS) test was applied, while for dummy variables (such as owner-and-tenant, tail-ender farmer, sugarcance), Chi-Square (CS) test was applied in order to empirically compare these factors across both the districts. Aestriks *(**)*** refer to statisitically significant differences at 10%, 5% and 1% significance levels, respectively. Source: Own Field Survey and Analysis 2021

Table 4

Multiple Linear Regression Results

Variable	Coefficient	Robust *SE*	*p*
Farmers' Socioeconomic Characteristics			
Constant (Intercept)	0.944	0.018	0.000
Age Group 1 (30 – 49 years)	0.061	0.017	0.000
Age Group 2 (50 – 65 years)	0.038	0.024	0.030
Matric (Education)	- 0.021	0.024	0.382
Intermediate (Education)	0.035	0.011	0.002
Both Owner-Tenant (Dummy)	0.122	0.019	0.000
Tail-ender Farmer (Dummy)	- 0.113	0.029	0.000
Crop Diversification			
Kharif crops			
Sugarcane (Dummy)	- 0.050	0.022	0.027
Vegetables (Dummy)	0.051	0.019	0.010
Fruits (Dummy)	0.082	0.016	0.000
Rabi crops			
Fodder and Barley (Dummy)	- 0.055	0.012	0.000
Vegetables (Dummy)	- 0.041	0.021	0.049
Agricultural Constraints			
Water Scarcity (Dummy)	- 0.285	0.033	0.000
Barren Land and Salinity (Dummy)	- 0.050	0.040	0.131
Lack of Financial Resources (Dummy)	- 0.078	0.018	0.054
Model Fit Statistics			
R^2	0.72		
F (15, 285)	53.04		0.000
Sample (N)	300		

Note. Asterisks *(**)** refer to 10% (5%) 1% statistical significance levels, respectively.

F-statistic is also statistically highly significant at less than 1% level. Except for the level of education, almost all of the farmers' socioeconomic characteristics including age group 1, age group 2, intermediate education level, owner and tenant farmer, and tail-ender farmer are statistically and highly significant at 5% and 1% levels, respectively. However, the coefficient for the tail-ender farmer (a farmer whose land is located in the tail of the minor) is negative, indicating that the particular farmer cultivates less land than the farmers located in the head and middle of the minors.

Crop diversification is represented by a variety of crops cultivated in both *Kharif* and *Rabi* seasons in districts Hyderabad and Matiari, respectively. The coefficients for all the diversified crops including sugarcane, vegetables, and fruits grown in both seasons indicate that these significantly affect the crop cultivation ratio. Moreover, cultivating sugarcane in the *Kharif* season and fodder, barley, and vegetables in the *Rabi* season affect the crop cultivation ratio negatively, possibly because of inadequate water availability.

Lastly, all of the agricultural constraints as envisaged have the expected negative signs, which exhibits that water scarcity, barren and saline land, and lack of financial resources negatively but significantly affect the crop cultivation ratio across both districts. However, amongst all constraints, water scarcity has the highest coefficient which indicates that the inadequate availability of water required for maximum crop cultivation is a major constraint. Finally, Variance Inflation Factor (VIF) test was applied to the multiple regression model and it was found that the mean VIF is equal to 1.6 (Table A1, Appendix A). This figure is very low and confirms that there is no multi-collinearity among the explanatory variables (Nayyar et al., 2018; Akinwande et al., 2015).

Conclusion

In the Sindh province of Pakistan, various factors including farmers' socioeconomic characteristics and crop diversification affect crop cultivation. This is because farmers are restricted due to different agricultural constraints confronted by them. These constraints mainly include water scarcity, salinization and barren land, inadequate financial resources, and unavailability of quality seeds and pesticides in the market. These factors, which generally result in crop under-cultivation, have been investigated for many decades, especially in the context of developing countries including Pakistan.

In the distant past, Sindh province was very well-known for its agricultural crop cultivation as compared to the other provinces in Pakistan. However, in the recent past, in the wake of the 'Green Revolution' and with the introduction of modern and multiple seed varieties, which require more water, fertilizers, and pesticides for their crop yield, crop cultivation has been steadily declining in Sindh. This is due to a variety of agricultural constraints confronted by the farmers, such as water scarcity, barren and

salinized land, lack of financial resources, and unavailability of quality seeds, pesticides, and fertilizers.

The current empirical analysis, based on a multiple regression model, found that agricultural constraints both adversely and significantly affect the crop cultivation ratio. Besides, the above results also exhibit that the crops, which could be grown both in *Kharif* and *Rabi* seasons and require less irrigation water and fertilizers, are preferably cultivated by the farmers.

However, crops, such as sugarcane, fodder, and barley, are not preferably cultivated because these require more water, fertilizers, and financial resources for their cultivation. Furthermore, farmers' socioeconomic characteristics also play a crucial role in crop cultivation. Middle-age and old-age farmers, falling in the age groups of 30 – 49 and 50 – 65 years respectively, positively and significantly affect crop cultivation. Also, the results also indicate that higher (or an intermediate) level education positively and significantly influences crop cultivation. Cultivating own agricultural land besides tenancy (cultivating other farmers' land at the same time) is a highly significant factor that positively encourages more crop cultivation. However, if a farmer's land is located in the tail of minors then it adversely affects crop cultivation. This is because farmers receive a low amount of water in the tail end, as compared to the head and the middle location.

Future Research Directions

Based on the findings, several suggestions are given to the decision-makers for policy-making, specifically for the agricultural and related policies designed for the Sindh province of Pakistan.

Firstly, water availability in terms of its reliability and equity must be ensured by the Irrigation Department of the provincial government. Also, Water and Power Development Authority (WAPDA), working under the federal government, must be taken into confidence to warrant reliable electricity supply required to sustain tube well (or groundwater) based irrigation. Secondly, the drainage system must be re-operationalized by the provincial government in collaboration with other relevant departments, including the Sindh Irrigation and Drainage Authority (SIDA). Thirdly, very low-credit soft loans must be available to small farmers so that they can purchase agricultural inputs, such as seeds, fertilizers, and pesticides as well as farm machinery, such as tractors and cultivators. The Sindh Micro

Finance Bank can play an important role in this direction. However, a biased implementation of the above suggestion, for example, loans' availability restricted exclusively to large farmers, must be avoided. Fourthly, the high quality of seeds, fertilizers, and pesticides available in the market must be ensured by the provincial government. In this context, a constant and rigorous check and balance approach should be implemented by effectively involving Sindh Seed Cooperation in collaboration with Sindh Agriculture, Supply, and Prices Department. Fifthly and finally, the Agricultural Extension Department should be constantly supported and updated by agricultural research institutes regarding new crop varieties, cultivation methods, and farm mechanization.

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Appendix A

Table A1

Variance Inflation Factor (VIF) Test for Multicolinearity

Variable	VIF	1/VIF = Tolerance Level
Vegetables (Grown in Kharif)	2.43	0.411
Fodder and Barley	2.39	0.418
Age Group 1 (30 – 49 years)	2.30	0.434
Age Group 2 (50 – 65 years)	2.20	0.454
Barren Land and Salinity	1.64	0.610
Water Scarcity	1.56	0.643
Lack of Financial Resources	1.35	0.742
Matric (Education Level)	1.29	0.775
Both Owner and Tenant	1.29	0.786
Sugarcane	1.23	0.816
Education (Intermediate)	1.19	0.839
Fruits	1.17	0.854
Vegetables (Grown in Rabi)	1.16	0.862
Land in the Tail Area	1.15	0.869
Mean VIF	1.60	

Appendix B

Table A2

Breusch-Pagan Test for Heteroscedasticity and Shapiro-Wilk Test for Normality

Breusch-Pagan test	Chi-squared	p	Reject the Null?
Null Hypothesis: Variance is constant	57.62	0.0000	Yes
Shapiro Wilk test	W (Z) statistics		
Null Hypothesis: Residuals are normally distributed	0.958 (5.147)	0.0000	Yes