Research Article

Allocative Efficiency of Maize Growers in Khyber Pakhtunkhwa, Pakistan

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Abstract | This study was carried out across four agro-ecological zones of Khyber Pakhtunkhwa to analyze the allocative efficiency of inputs in maize production. This study employed a multistage stage sampling technique for choosing the sample size. The data was collected from 200 respondents using a well–designed interview schedule. Cobb-Douglas type production function was modelled to estimated allocative efficiencies of individual inputs used in maize production. The estimated allocative efficiencies of Urea and DAP were 3.24 and 2.04, respectively. This implies that these inputs were underutilized that might be due to poor farming skills of the sampled respondents, lack of information regarding application of such inputs and lack of availability of credit to them to use the appropriate and recommended dose of these inputs. Allocative efficiencies of tractor hours, FYM and labour were 1.16, 1.02 and 0.97, respectively, suggesting that these inputs were efficiently utilized. Facilitation of maize growers with subsidized and timely availability of inputs, provision of agriculture credit with reasonable interest rate and easy instalments and field based trainings are policy options for enhancing maize productivity.

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Introduction

Pakistan being an agrarian country is blessed with fertile land and suitable agro-climatic conditions for all the cereal crops' production. Among the major cereal crops; wheat, maize and rice are grown on larger scale as these crops are used as main source of food worldwide and are economically more important to the farmers.

Maize commonly known as corn with botanical name (*Zea mays L.*), is used worldwide as a staple food, for fodder purposes and as a raw material in various manufacturing units. Maize contains about 3% essential minerals, 4% each of fats and fiber, 9% protein and almost 80% starches that contributes to a healthy diet (Ahmad et al., 2014).

In 2016, maize was grown on an area 188 million hectares worldwide and its production was recorded as 1, 060 million tonnes with an average of 5.6 tonnes per hectare (FAO, 2016). United States of America was the major maize producer among all the major maize producing countries worldwide with the production of 384.77 million tonnes followed by China and Brazil with the production of 231 .83 and 64.14 million tonnes respectively (FAO, 2016).

Pakistan being an agrarian country where majority of the people depend only on agriculture to survive, is ranked as twenty second largest maize producer in the world. In 2016, maize in Pakistan was cultivated on an area of 1, 191.35 thousand hectares and the total maize production was recorded as 5, 270.9 thousand tonnes with an average yield of 4,595 kilograms per hectare (GoP, 2016). Punjab was the leading maize producer in Pakistan with the production of 4, 391.2 thousand tonnes with the yield of 6.13 tonnes per hectare, followed by Khyber Pakhtunkhwa, Sindh and Baluchistan with the production of 873.0, 3.6 and 3.1 thousand tonnes respectively (GoP, 2016).

Khyber Pakhtunkhwa is the second largest maize producer of Pakistan with the yield of 1.86 tonnes per hectare, comparatively very low than that of Punjab as well as world leading producers of maize. Table 1 shows comparison of maize yield of Pakistan and Khyber Pakhtunkhwa with the top yielders of the world during 2016. Jorden is the top most maize yielder (40,413 kg/ha) followed by United Arab Emirates (26,179 kg/ha), Saint Vincent and the Grenadines (24,743 kg/ha), Israel (22,998 kg/ha), Kuwait (16,786 kg/ha)), Qatar (12,501 kg/ha), Tajikistan (12,363 kg/ha), Uzbekistan (11,957 kg/ha), Oman (11,954 kg/ha), New Zealand (11,689 kg/ha). Maize yield of Pakistan and Khyber Pakhtunkhwa is only 11.37% and 4.61% of Jorden yield of maize. Similarly, maize yield of Pakistan and Khyber Pakhtunkhwa is only 39.31% and 15.94% of New Zealand yield of maize.

This low yield in Pakistan as well as in Khyber Pakhtunkhwa might be due to poor technology, lack of knowledge and inappropriate allocation of inputs. How this low yield of maize can be increased? Adoption of high quality seeds, modern technology and allocative efficient utilization of all the essential inputs may significantly increase the productivity of maize. Production of high quality seeds and modern technology is a long run phenomenon. It also needs a huge investment in research and development. In the short run, yield can be increased by efficient allocation of inputs given the available resources and technology. Therefore, this study was carried out across four agro-ecological zones of Khyber Pakhtunkhwa to analyze the allocative efficiency of inputs in maize production.

Materials and Methods

Study universe

This study was conducted in four agro-ecological zones of Khyber Pakhtunkhwa. Khyber Pakhtunkhwa lies at 30° to 47′E, latitude and 69° to 74′E, longitude. Its elevation from the earth surface is 160m in Dera Ismail Khan and the highest is 1100 m in Chitral. Khyber Pakhtunkhwa province has been categorized into four agro- ecological zones specifically zone A, B, C and D (Inamullah and Khan, 2017). Zone A is the Northern mountainous zone including of Ranizai, Upper Dir, Swat, Buner, Chitral, Shangla and Lower Dir. Zone B is also known as Eastern mountainous zone. The Districts which belong to this zone are Toorghar (Kala Dhaka), Haripur and Abbottabad, Mansehra, Kohistan and Batgram. Zone C, sometimes also called Central Plain Valley consists of Swabi, Nowshera, Peshawar, Kohat, Mardan, Charsadda and Hangu. Zone D includes Dera Ismail Khan, Bannu, Karak, and Lakki Marwat and Tank Districts. It is also known as Southern Piedmont Plain. Due to these classifications the environmental climate of each zone are different in every aspects.

Figure 1: *District wise distribution of Khyber PakhtunKhwa on map.*
Source: *Pakistan travel forum;* http://www.pakistantravelforum.com/threads/khyber-pakhtunkhwa-kpk.64/

Sampling design and sample size

This study employed a multistage stage sampling techniques for choosing the sample size of 200 respondents. In stage 1st, from all major maize producing districts, Upper Dir from Zone A (Northern zone), Abbottabad from Zone B (Eastern zone), Peshawar from Zone C (Central zone) and Lakki Marwat from Zone D (Southern zone) were randomly chosen. In 2nd stage from each randomly selected district, from a list of major maize producing villages, four villages were selected randomly. In the last stage, from each selected district, 50 maize growers were randomly selected from selected villages by using proportional allocation sampling technique (Cochran, 1977) as follows:

$$n_i = n\left(\frac{N_i}{N}\right) \quad ...(1)$$

Where;

n_i= Sample size in selected district from ith village; n = Sample size from all four districts; N_i = Number of maize growers in ith village; N = Population of maize growers in all selected villages in each district.

Table 1: *Comparison of Pakistan and Khyber Pakhtunkhwa yield of maize with top yielders.*

Rank	Country	Yield (kg/ha)	Pakistan yield/Yield of top yielder	KPK yield/ Yield of top yielder
1	Jordan	40,413	0.1137	0.0461
2	United Arab Emirates	26,179	0.1755	0.0712
3	Saint Vincent and the Grenadines	24,743	0.1857	0.0753
4	Israel	22,998	0.1998	0.0810
5	Kuwait	16,786	0.2738	0.1110
6	Qatar	12,501	0.3676	0.1490
7	Tajikistan	12,363	0.3717	0.1507
8	Uzbekistan	11,957	0.3843	0.1558
9	Oman	11,954	0.3844	0.1558
10	New Zealand	11,689	0.3931	0.1594
64	Pakistan	4,595	1.0001	0.4054

Source: *FAO, 2016.*

Data and data sources

Data was collected using a face to face interview schedule which was pre tested in the field. All the sampled respondents were interviewed personally at their fields and at their homes.

Analytical framework

Generally, efficiency is divided into two components i.e., technical and allocative. Technical efficiency refers to achieve the maximum possible output with the existing technology while Allocative efficiency refers to the ability of firms to equate the marginal products of allocated inputs with their relative prices (Farrell, 1957). Zieschang (1983), Kopp and Diewert (1982) and Schmidt and Lovell (1979) defined allocative efficiency as an ability of the firms to equate the value marginal product (MVP) to the marginal factor cost (MFC).

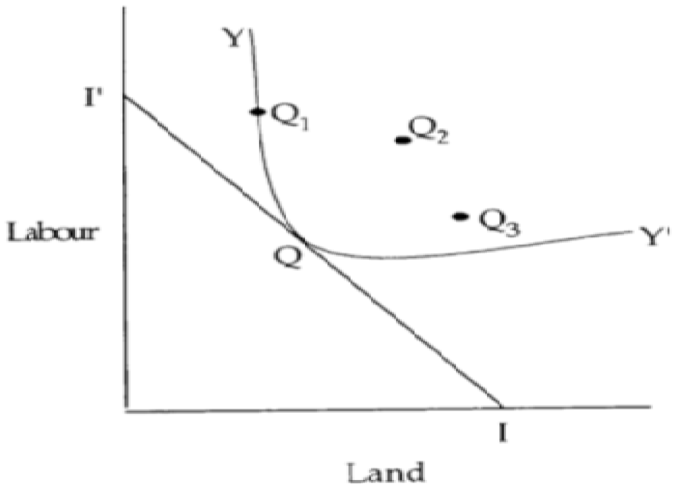

Figure 2: *Shows the combination of inputs to produce the same product where the only firm at point Q is allocating his/her resources efficiently because at this point the value marginal product becomes equal to the marginal factor cost ($MVP_x = MFC_x$).*

Specification of the model

Following Debertin (2012), Varian (1992) and Muhammad et al. (2017), Cobb-Douglas type production function was specified as under:

$$LnYield = \beta_0 + \beta_1 LnTractor + \beta_2 LnUrea + \beta_3 LnDAP + \beta_4 LnFYM + \beta_5 LnLabour + ei \quad ...(2)$$

Where;

Yield is the output of maize in kg per acre; Tractor is the per acre tractor hours; Urea is the amount of Urea in kg per acre; DAP is the amount of DAP in kg per acre; FYM is the amount of FYM in kg per acre; Labour is the per acre labour working days; Ln is natural log; βs are the coefficients to be estimated.

Estimation of allocative efficiency

Allocative efficiencies of individual inputs were ascertained from the estimated coefficients of Cobb-Douglas type production function by the formula as follows:

$$AE_{xi} = \frac{VMP_{xi}}{MFC_{xi}} \quad ...(3)$$

$$VMPxi = PY \times MPP_{xi} \quad ...(4)$$

$$MPP_{xi} = \beta_{xi} \times APP_{xi} \quad ...(5)$$

$$\beta_{xi} = \frac{MPP_{xi}}{APP_{xi}} \quad ...(6)$$

$$MFC_{xi} = P_{xi} \quad ...(7)$$

Where;

AE_{xi} is allocative efficiency of ith input, VMP_{xi} is the value of marginal product of ith input, MFCxi is the marginal factor cost or average price per unit of it input, MPP_{xi} is the marginal physical product of ith input and β_{xi} is the estimated coefficient (elasticity) of output with respect to ith input.

Model adequacy tests

Model adequacy tests were conducted to check normality of residuals, problems of multicollinearity, and heteroscedasticity.

Results and Disscussion

Model adequacy tests

Estimated Cobb-Douglas type production function was checked for normality of residuals, multicollinearity and heteroscedasticity as under:

Normality of residuals

Normality of residuals was checked by constructing Histogram. Figure 3 shows that residuals are normally distributed as the histogram with a bell shape has symmetric distribution.

Histogram of residuals

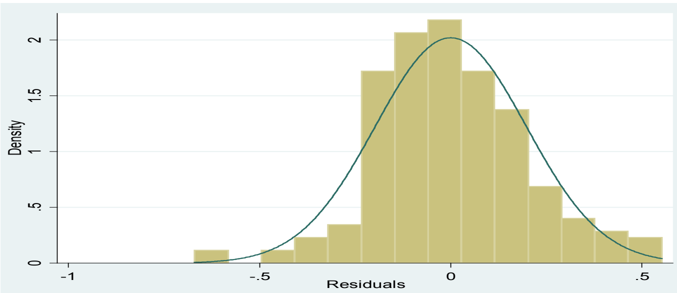

Figure 3: *Histogram of residuals*
Source: *Estimated from the residuals of estimated model.*

Multicollinearity

To check the problem of multicollinearity, correlation matrix was used. The results revealed that there was no linear relationship among all the explanatory variables. The results are given in Table 2.

Table 2: *Correlation Matrix.*

Inputs	Ln(Tractor)	Ln(Urea)	Ln(DAP)	Ln(FYM)	Ln(Labour)
Tractor	1				
Urea	0.1587	1			
DAP	0.0392	0.2982	1		
FYM	0.0434	0.0945	0.1129	1	
Labour	0.1773	0.5063	0.3309	0.1499	1

Source: *Authors' estimates from data, 2017.*

Heteroscedasticity

Breusch-Pagan/Cook-Weisberg test was used to check the problem of heteroscedasticity in the current study. The estimated chi square value was 15.96 and statistically significant at 0.01 α (p-value = 0.0000) revealing that the problem of heteroscedasticity does exist but was overcame by robust command in Stata 12.

Descriptive statistics of variables

Table 3 represents summary of the variables used in the model. Average yield of the maize was 760.42 with standard deviation of 1.77 ranging from 400 to 2100 kg per acre. Tractor hour has 15.44 ranges from 0 to 25 with standard deviation of 6.70. Similar is the case of the average user of the Urea which has recorded 57.24 with standard deviation of 51.78 range from highest 550 to lowest 0 kg acre. On the same way, the average DAP has 24.79 kg with 21.76 standard deviation ranging from 0 to 50 kg. The mean FYM was 1412.584 with the standard deviation 1664.928 range from highest 4500 to lowest 0 kg acre.

Table 3: *Descriptive statistics of variables.*

Variables	Mean	SD	Min	Max
Yield	760.4214	1.7792	400.00	2100.00
Tractor	15.4456	6.7037	0.00	25.00
Urea	54.6827	38.31	0.00	111.11
DAP	24.7976	21.7607	0.00	50.00
FYM	1412.5840	1664.928	0.00	4500
Labour	13.7690	1.7452	1.00	25.00

Source: *Authors' estimates from data, 2017.*

Estimates of Cobb-Douglas type production function

Results of Cobb-Douglas type production function are presented in Table 4. The estimates of regression analysis revealed that Hybrid seeds were having positive and significant effect on maize yield. The results showed that the farmers using the hybrid varieties were producing 45 percent more yield than local seed growers. Tractor being an important factor which makes the soil suitable and porous for production, played a positive and significant role in maize production such that a 1 percent increase in tractor hours increased the total output by 8.6 percent. This result also similar with (Muhammad et al., 2017). The results of the study revealed that the coefficient of labor was positive and statistically significant such that a 1 percent increase in the labor working days increased the output by 34 percent. This result also similar with (Muhammad et al., 2017). Chemical Fertilizer are dynamic factors which affect the production of any crop everywhere. DAP and Urea both were having positive and significant effect on yield so that an increase of 1 percent in each will increase the production by 12 and 24 percent respectively. This result also similar with (Muhammad et al., 2017).

Table 4: *Estimates of Cobb-Douglas type production function.*

Variables	Coefficients	Std. Dev.	t-ratio	p-value
Constant	5.878131	0.078869328	74.53**	0.000
Ln(Tractor)	0.0860943	0.022362156	3.85**	0.000
Ln(Labor)	0.3403727	0.085306441	3.99**	0.000
Ln(DAP)	0.1225381	0.050635579	2.42*	0.017
Ln(Urea)	0.2401958	0.054098153	4.44**	0.000
Ln(FYM)	0.088858	0.04076055	2.18*	0.030
F (6, 193)	64.91			
R-squared	0.6562			

Source: *Authors' estimates from data, 2017;* **Note:** *** and * depicts significance at 1% and 5% levels, respectively.*

FYM (Farm yard manure) is the cheapest and natural source of fertilizer. The estimated results revealed that a 1 percent change in FYM increased the output by 8.8 percent significantly. This result dissimilar with (Muhammad et al., 2017). The R-Square of the estimated model revealed that the model was good fit taking the value of 0.65, showing that 65 percent change in the dependent variable was due to the explanatory variables. The summation of all the coefficients of the explanatory variables was estimated at 1.32, revealing that the sampled respondents in the study area were in the first stage of the production (increasing return to scale).

Allocative efficiencies of the inputs in Khyber Pakhtunkhwa

Estimated allocative efficiencies of individual inputs are shown in Table 5. Allocative efficiencies of tractor hours, urea, DAP and FYM and labour were 1.16, 3.24, 2.07, 1.02 and 0.97, respectively. These results are consistent with the findings of Muhammad *et al.* (2017) expect for FYM. These results implies that Urea (3.24) and DAP (2.04) were underutilized that might be due to poor farming skills of the sampled respondents, lack of information regarding application of such inputs and lack of availability of credit to them to use the appropriate and recommended dose of these inputs. Tractor hours (1.16) and FYM (1.02) and labour (0.97) were efficiently utilized as these value are approximately equal to 1. These results are in accordance with the results of Muhammad et al. (2017).

Table 5: *Allocative efficiencies of the inputs in Khyber Pakhtunkhwa.*

Inputs	APP_{xi}	MPP_{xi}	MFC_{xi}	VMP_{xi}	AE_{xi}
Tractor	359.32	30.94	800.00	928.06	1.16
Urea	14.12	3.39	31.43	101.78	3.24
DAP	32.61	4.00	58.00	119.89	2.07
FYM	0.57	0.05	1.50	1.53	1.02
Labour	52.36	17.82	550.00	534.68	0.97

Source: *Authors' estimates from data, 2017.*

Allocative efficiencies of the inputs across districts

Separate regression analysis was also conducted to estimate the allocative efficiencies of inputs' utilization for each selected district and given in (Supplementary Tables 1-4). The allocative efficiencies estimated for each and every district are given in Table 6.

Table 6: *The Allocative efficiency of the inputs across districts.*

Inputs	APP_{xi}	MPP_{xi}	MFC_{xi}	VMP_{xi}	AE_{xi}
Upper Dir					
Tractor	483.40	46.41	800.00	1392.28	1.74
Urea	41.77	1.58	31.43	47.51	1.51
DAP	56.97	1.26	58.00	37.85	0.65
FYM	8.39	0.27	1.50	8.24	5.50
Labour	53.83	16.68	550.00	500.52	0.91
Abbottabad					
Tractor	244.69	-0.42	800.00	-12.52	-0.02
Urea	32.76	4.16	31.43	124.72	3.97
DAP	94.37	2.16	58.00	64.77	1.12
FYM	4.12	-0.02	1.50	-0.71	-0.47
Labour	58.40	-1.60	550.00	-48.12	-0.09
Peshawar					
Tractor	316.08	36.41	800.00	1092.27	1.37
Urea	24.92	0.87	31.43	26.07	0.83
DAP	148.59	3.67	58.00	110.10	1.90
FYM	21.95	0.65	1.50	19.42	12.95
Labour	71.27	8.58	550.00	257.48	0.47
Lakki Marwat					
Tractor	332.03	89.88	800.00	2696.34	3.37
Urea	12.77	0.21	31.43	6.42	0.20
DAP	52.11	3.10	58.00	92.91	1.60
FYM	6.59	0.21	1.50	6.29	4.20
Labour	41.52	7.28	550.00	218.47	0.40

Source: *Authors' estimates from data, 2017.*

Upper Dir (Zone A)

Estimated allocative efficiencies for tractor hours, Urea and FYM were greater than 1 having values of 1.74, 1.51 and 5.50 respectively revealing that these inputs were underutilized while DAP and Labour were over utilized because their allocative efficiencies were less than 1 i.e. 0.65 and 0.91, respectively.

Abbottabad (Zone B)

The results were quite surprising in district Abbottabad because the allocated allocative efficiencies for main variables such as tractor hours, FYM and Labour were estimated as negative because of their negative marginal physical product (MPP). Such results revealed that maize growers in Abbottabad were in the third stage of production

Peshawar (Zone C)

The allocative efficiencies for Tractor hours, DAP and FYM in district Peshawar were estimated as 1.37, 1.90 and 12.95, respectively, greater than 1 revealing that these inputs were underutilized whereas Urea and Labour were over utilized with their allocative efficiencies of 0.83 and 0.47, less than 1.

Lakki Marwat (Zone D)

The estimated allocative efficiencies of inputs like Tractor hours, DAP and FYM were 3.37, 1.60, and 4.20, respectively, showing that these inputs were underutilized while Urea and Labour with allocative efficiencies of 0.20 and 0.40 respectively were over utilized.

Conclusions and Recommendations

This study was carried out across four agro-ecological zones of Khyber Pakhtunkhwa to analyze the allocative efficiency of inputs in maize production. Cobb-Douglas type production function was modelled to estimated allocative efficiencies of individual inputs used in maize production. The estimated allocative efficiencies of Urea and DAP were 3.24 and 2.04, respectively. This implies that these inputs were underutilized that might be due to poor farming skills of the sampled respondents, lack of information regarding application of such inputs and lack of availability of credit to them to use the appropriate and recommended dose of these inputs. Allocative efficiencies of tractor hours, FYM and labour were 1.16, 1.02 and 0.97, respectively, suggesting that these inputs were efficiently utilized. Government needs to facilitate maize growers with subsidized and timely availability of inputs. Provision of agriculture credit with reasonable interest rate and easy instalments for purchase of inputs, particularly urea and DAP is a good policy option. Extension department should arrange field based trainings for optimal use of inputs for enhancing maize productivity in province.

Novelty Statement

This study found out allocative efficiencies of indi-vid-ual inputs used in maize production across four agro-ecological zones of Khyber Pakhtunkhwa prov-ince of Pakistan using Cobb-Douglas type produc-tion func-tion.

Author's Contribution

Aftab Khan conducted this study, reviewed literature, analyzed data and wrote first draft of the manuscript. Shahid Ali developed main theme of the study in collaboration with Aftab Khan. He supervised and helped in model specification and statistical anal-ysis also. Murtaza processed the data in excel file and helped in model estimation. Sufyan Ullah Khan helped in technical writing and editing of the man-uscript and incorporated and corrected references. Syed Attaullah Shah helped in data analysis, writing conclusions and recommendations.

Supplementary Material

There is supplementary material associated with this article. Access the material online at: http://dx.doi.org/10.17582/journal.sja/2019/35.3.913.919

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