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An Evaluation of Technical Efficiency and Garret Ranking Technique of Paddy and Wheat Farmers in Dabra Block Gwalior District M.P.

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Objective: An evaluation of technical efficiency and garret ranking technique of paddy and wheat farmers has been conducted.

Methods: Multistage random sampling method was used to acquire sample farmer. A list of paddy and wheat growing farmers was prepared from Dabra block and twenty villages were selected randomly thereafter, a list of paddy and wheat farmers from each selected village was prepared then classified into five major categories on the basis of their land holding i.e. marginal(less than 1ha), small (1-2 ha), semi medium (2-4 ha), medium (4-10 ha), and large (greater than 10 ha). Then a sample of 30 farmers were selected in each category by simple random sampling technique under proportionate allocation from 20 villages treated as strata thus, 150 paddy and 150 wheat farmers were selected hence total sample size were 300.

Finding: The likelihood test ratio (LR test) for the inefficiency term on paddy farms was observed at

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32.91 which was significant and suggesting that the inefficiency component is present in the model. In the case of wheat farms, the likelihood test ratio (LR test) was noted 1.02 which was insignificant and suggesting that the inefficiency component is not present in the model. The highest technical efficiency (88%) was found on the paddy farms as comparison to wheat farms (72%).This implied that on an average 12 per cent and 28 per cent of the technical potential was not achieved by paddy and wheat growers respectively.

Novelty: The studies establish that wheat farmers have more opportunity to amplify the yield by adopting modern crop management practices, training activities as compared to paddy farmers.

Keywords: Paddy and wheat; technical efficiency; garret ranking technique.

1. INTRODUCTION

Paddy and wheat is the India's prominent and most essential food grain crops. The production of paddy and wheat is an important part of the national economy because these two food crops together feed more than half of the country's population. India is the second largest producer of paddy and wheat in the world after china. Paddy is one of the oldest cultivated grain crop and has been cultivated in India for several thousand years. In India paddy is cultivated under 43.79 million hectares with the production of 112 million tones and productivity 2,578 Kg/ha whereas, wheat occupies an area about 29.58 million hectares with a production and productivity of 99.70 million tonnes and 3371 kg/ha. In Madhya Pradesh, paddy is grown mainly as a kharif crop on 2.04 million hectare with the production of 4.12 million tones and productivity 2,026 kg/ha while wheat is grown on area about 5.32 million hectares with a production and productivity of 15.91 million tonnes and 2,993 kg/ha, respectively. Thus rice and wheat production not only make the country a food sufficient nation, but also strengthens its agrarian economy. Since agriculture is the major source of income for most of the population of country, rice and wheat being the majorly grown crops play key role in enhancing income of the farmers [1] based on the above importance of both the crops in Indian agriculture economy a study was conducted to evaluate technical efficiency and garret ranking technique of paddy and wheat farmers.

2. RESEARCH METHODOLOGY

The study was confined to Gwalior district of Madhya Pradesh because this district has remarkable position under paddy and wheat crops in the gird zone. Gwalior district has four blocks namely; Bhitarwar, Dabra, Morar and Ghatigaon. At the first stage of sampling, Dabra Block was selected purposively, because of its maximum area under paddy and wheat cultivation (37,710.03 ha and 47,961.20 ha respectively), at the second stage of sampling, a list of the paddy and wheat growing villages were prepared from the selected block (Dabra), then 20 villages namely; Akbai Badi, Masudpur, Salaiya, Kardu, Beer Muhana, Lakhiya, Khareya, Girgheda, Patha Panihar, Anat Path, Beru Gawan, Kheri Parashasar, Rampura, Khidwae, Maharajpur, Chomo, Chhimak, Ikona, Patharra, and Ghamad Pura were selected randomly, and the third stage of sampling, a list of paddy and wheat growing farmers from each selected village was prepared, then classified into five major categories on the basis of their land holding i.e. marginal (less than 1ha) small (1-2 ha), semi medium (2-4 ha), medium (4-10 ha) and large (10 ha and above). Then a sample of thirty 30 farmers were selected in each category by simple random sampling technique under proportionate allocation from twenty villages treated as strata with the help of given a formula is given below.

$$ni = \frac{N_i}{N} \times n$$

Where,

ni = i^{th} stratum sample size, N_i = i^{th} stratum size, N = Population size and n = total sample size.

Thus, a total of 300 farmers (150 paddy growers and 150 wheat growers) were selected for the study. After selection of respondents the primary data (2019-20, kharif and rabi) as regards quantity of input used in the production with their price, yield, gross income, price received per quintal and constraints were collected through pre-tested interview schedule by survey method.

2.1 Analytical Tools

The yield potential may be interpolated from yield of research managed plots [2] or the most efficient farmer in a sample [3] The latter approach was adopted for this study to find out yield potential of wheat and paddy farmers in the study area. The production function maps the maximum possible output can be achieved for a given quantity of a set of inputs. Most farmer fail to operate on their production due to technical inefficiency [4].The production technology of each farm was characterized by Cobb Douglas production function and estimated by using the ordinary least square method. Experience has shown that it is desirable to use a simple function involving as few parameters as is practically feasible and perform best, since convergence problem in the estimation process can occur when there are a large number of independent variables in the estimated equation. The Cobb Douglas function form is a compromise between a complex production process and a complex estimation technique. The estimated equation was used to examine Timmer's measure of technical efficiency and Kopps's [5] measures of allocative efficiency of inputs utilized in paddy and wheat production . The Timmer's measures of technical efficiency of *jth* farm is the ratio of actual output to potential output ,given the level of input use in *jth* farms. Thus it indicates how much extra output could be obtained if *jth* farm are on frontier. The specification of stochastic Cobb Douglas production function in general form is:

$b^i e^{uj}$

This can be written in double log linear form as

$$\ln Yj = b_0 + \sum_{i=7}^{n} bi \ln Xij + U_j$$, where

ln = Natural logarithm

Y_j = Production of jth crop (qth/ha)

bi = Regression coefficient to be estimated

b_0 = constant

U = Stochastic error incorporating the effect of unknown and unexpected variable, e= natural exponent, and i = 1, 2 …7

X_i = inputs like, quantity of seed (kg/ha), quantity of fertilizer (kg/ha), human labour (man days/ha), machinery labour (hrs/ha), plant protection chemical (liter/ha), quantity of manure tons/ha, number of irrigation /ha.

The random distribution U_i are assumed to follow a one side distribution (e.g. truncated normal, gamma, exponential) and independent and identically distributed. In addition, the sets of inputs (Xi) are assumed to be independent of the disturbances. Therefore, the frontier function takes the form: [6]

$$\ln Y^* = b_0^* + \sum_{i=7}^{n} bi \ln Xij + Uj$$

Where, $\ln Y_i^*$ = Frontier level of production.

b_0^* = Corrected intercept estimate.

Technical efficiency (TE) = $\frac{\ln Yj}{\ln Y*J} < 1$

$\ln Y_j$ = Actual production of j^{th} crop

$\ln Y^*_j$ = Potential production of j^{th} crop

The stochastic frontier production has been specified as follows:

$$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + (v_i - u_i)$$

Where,

Y = Output (quintal/ha)

X_1 = Quantity of seed (kg/ha)

X_2= Quantity of fertilizer (kg/ha)

X_3 = Human labour (man days/ha)

X_4 = Machinery labour (hrs/ha)

X_5 = Plant protection chemical (liters/ha)

X_6 = Quantity of manure tons/ha

X_7 = Number of irrigation /ha

a = Constant

b_1 ... b_7 Regression coefficient of respective inputs

$v_i - u_i$ = Random error

ln = Natural logarithm

The model was estimated by using STATA software

2.2 Allocative Efficiency

Allocative efficiency is a marginal condition for profit maximization i.e. for efficient resources allocation, one should use more of the resources as long as the value of the added product is greater than the cost of the added amount of resources in producing it. The resources are to be considered efficiently used and profit will be maximum when the ratio of marginal value productivity (MVP) to marginal factor cost (MFC) approach one or in other word, MVP and MFC for each input are equal. When the marginal physical product (MPP) is measured in monetary term, it is called MVP. MFC is the price of one additional unit of input, the MVP of a particular resource represents the additional to gross return in the value terms caused by an addition of one unit of that resources while other inputs are held constant .The most reliable and perhaps the most useful estimate of MVP was obtained by taking resources (Xi) as well as gross return (Y) and their geometric means. MVP, which was computed by multiplying the production coefficient of given resources with the ratio of geometric mean of gross return to the geometric mean of the given resources i.e. [7, 8].

$$\ln Y = \ln a + bi \ln Xi$$

$$\frac{dY}{dxi} = bi \ \frac{Y}{Xi}$$

$$\text{Therefore, MVP Xi} = bi \ \frac{\overline{Y}_{(GM)}}{\overline{X}_{i\,(GM)}}$$

Y = Mean value (GM) of gross output
Xi = Mean value of the *ith* variable input
ln = Natural logarithm and i =1, 2…7
GM = Geometric mean

$\frac{dY}{dYi}$ = Slope of the production function as well MVP of *ith* input

2.3 Garret Ranking Technique

Garret ranking technique was used to find out most prominent constraints faced by paddy and wheat growers in the study area. This technique helps in converting the changes of orders of constraints in to numerical scores [9]. Several constraints were noted and enlisted in tabular form based on prevailing conditions in the selected area. During the survey, respondents were requested to rank the constraints without any bias. The ranks were then converted to the per cent position by using the formula shown below. [10]

Per cent position = $100 \times (R_{ij} - 0.5) / N_j$

Where, Rij = Rank given for the ith factor by *jth* farmer.
Nj = No. of constraints ranked by the *jth* person.

Using Garrett's conversion table, the calculated percent positions were converted to Garrett score. The sum and mean values of Garrett scores were worked out from the scores attributed to each constraint by the individual respondents. Mean score obtained for each constraint were arranged in an ascending order and the constraint with the maximum mean score was identified as the serious problem faced by the paddy and wheat farmers in the study area.

3. RESULTS AND DISCUSSION

The stochastic Cobb Douglas production function was used to evaluate the parameter of the frontier model individually for both the crops (paddy and Wheat), which are presented in table 1 which shows that estimated value of the variance parameters under both the cops was observed statistically significantly.[11]It indicates that the technical efficiency parameter has an important impact on the yield of paddy and wheat production. Further, the result shows that the estimated value of λ (Lambda) and Sigma square were observed to be significant in both crops (paddy and wheat), implying that the selected model was characterized by better goodness of fit, and the distributional assumption of the inefficiency /efficiency term was acceptable. Further, the table revealed that the value of lambda was observed as 3.30, and 0.84 in the paddy and wheat crop production respectively for the half-normal model which implying that the one-sided error term "U" dominated, implying that variation in the yield of two crops in the study area was due to the variation in farm-characteristics like, age, learning, experiences, cultural practices, knowledge, training, and technology, etc. The Likelihood test ratio (LR test) for the inefficiency term on paddy farms was observed at 32.91, which was significant suggesting that the inefficiency component is present in the model. For wheat farmers, the likelihood test ratio (LR test) was noted 1.02 which was insignificant and suggesting that the inefficiency component is not present in the model. On the paddy farms, all the independent factors have positive coefficient and all were observed statistically to be insignificant, except X_1 (seed) X_2 (fertilizer), and X_3 (human labour) which were positive and significant indicating that the efficiency of paddy farms could be enhanced by optimum use of the significant factors namely; X_1 (seed), X_2 (fertilizer), and X_3 (human labour).incase of wheat farms, the estimated value of coefficients X_2 (fertilizer) X_4 (machinery) and X_7 (irrigation) were observed positive and statistically highly significant, indicating that the efficiency of wheat farms could be augmented by rational use of these factors in the production. The estimated value of X_1(seed), [12] X_3 (machinery) and X_5 (plant protection) were observed negative, and non-significant except X_1 indicating overuse of these factors in the production.

Table 1. Estimated parameters of the Stochastic Frontier normal/ half Normal model of paddy and wheat production

Factors	Paddy (N= 150)				Wheat (N =150)			
	Coefficient	**Std. Error**	**Z**	**P> |z|**	**Coefficient**	**Std. Error**	**z**	**P> |z|**
X_1=Quantity of seed (kg/ha)	0.0487**	0.0230	2.12	0.034	-0.7645***	0.1774	-4.31	0.000
X_2= Quantity of fertilizer(kg/ha)	0.7933***	0.0357	22.49	0.000	1.110***	0.2058	5.40	0.000
X_3=Human Labour (man days /ha)	0.6285**	0.0327	1.92	0.055	-0.2024	0.1307	-1.55	0.121
X_4= Machinery Labour(hrs/ha)	0.0194	0.0162	1.20	0.231	0.3762***	0.1575	2.39	0.01
X_5=Plant protection chemical(liters/ha)	0.1533	0.3205	0.48	0.632	-0.0935	0.214	-0.44	0.663
X_6= Quantity of manure (tons/ha)	0.2189	0.0325	0.67	0.501	0.2684	0.1695	1.58	0.113
X_7= Number of irrigation(/ha)	0.3024	0.02760	1.10	0.273	0.4865***	0.2035	2.39	0.01
Constant	-1.4274***	0.0110	-12.89	0.000	-0.2555	0.8449	0.30	0.762
/lnsig2v	-6.147***	0.2948	-20	0.000	-1.0948***	0.2056	-5.32	0.000
/ lnsig2u	-3.7537***	0.1661	22.59	0.000	-1.4279**	0.7078	2.02	0.044
Sigma_ v	0.04624	0.0068			0.5784	0.0594		
Sigma_ u	0.15307	0.0127			0.4896	0.1733		
Sigma2	0.02556	0.0037			0.5743	0.1291		
Lambda	3.30980	0.0164			0.8465	0.2201		
Log likelihood	**135.74**				**-147.99**			
Prob > chi2	**0.000**				**0.000**			
Wald chi2 (7)	**21476.47**				**438.00**			
LR test of sigma _u=0 : chibar2(01)	**32.91**				**1.02**			

Source: Author computation by STATA software. Note asterisks (, ** ***) indicate significance at the10, 5, and 1% levels respectively. (Primary Data 2020-2021)*

3.1 Efficiency wise Distribution of Paddy and Wheat Growers

The Technical Efficiency (TE) derived from the stochastic frontier production model for paddy and wheat growers is presented in Table 2 and Fig. 1. It was evident from the results that there were wide variations in the level of technical efficiency between paddy and wheat farmers in the study area due to farm characteristics. The average level of technical efficiency was found to be highest (88%) on the paddy farms as compared to wheat (72%)[13] .This implied that on the average, 12 per cent and 28 per cent of the technical potential was not achieved by paddy and wheat farmers respectively. Therefore wheat growers having more opportunities to increase the yield as compared to paddy growers by adopting crop management practices without having to increase the level of application of inputs. About 61 per cent majority of the paddy farmers operated under technical efficiency levels of more than 90 per cent. About 26 per cent of farmers lied between 80-90 percent level of technical efficiency, 7 per cent farms lied between 70-80 per cent of technical efficiency level, and reaming 6 percent farmer operated below 60 per cent level of technical efficiency. In essence, about 87 per cent of the farmers were operating in the zone of 70-90 per cent technical efficiency level. As regarding wheat farms 55 per cent majority of the wheat farmers operated under technical efficiency levels 70-80 per cent, about 29 per cent wheat farmers lied between 60-70 per cent of efficiency level, 6 percent of the wheat farmer operated between 80-90 percent technical efficiency level, 5 per cent wheat farmers lied more than 90 per cent of technical efficiency level and reaming 5 per cent farmer lied below 60 percent level of technical efficiency. In essence, around 84 per cent of farmers were operating in the zone of 60-80 per cent technical efficiency.

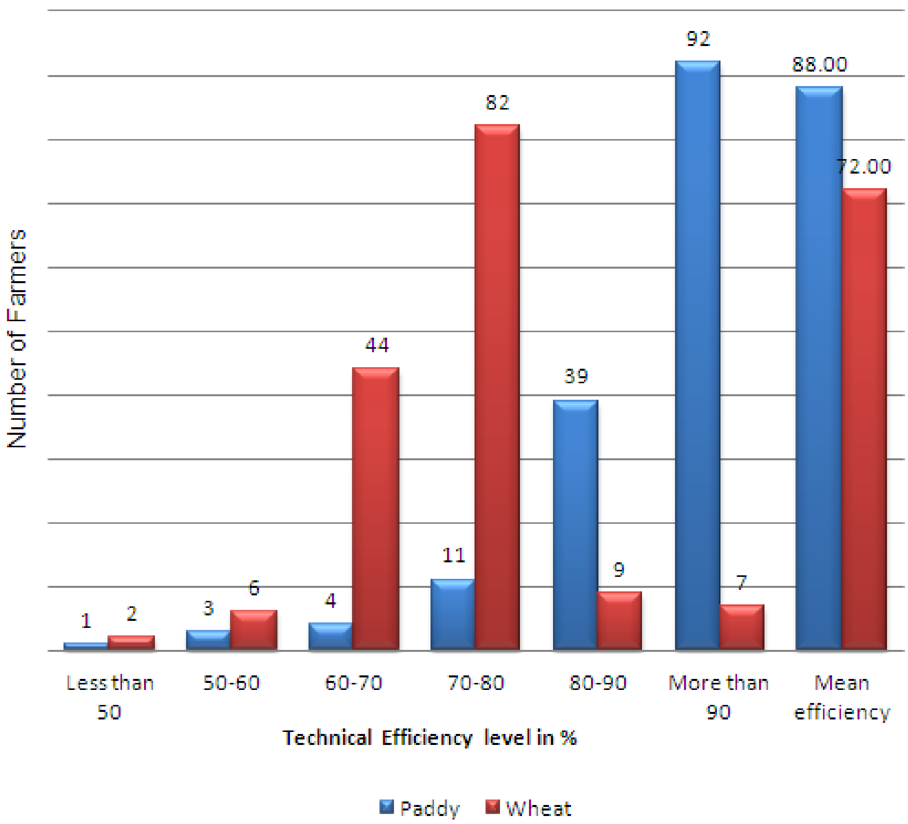

Fig. 1. Efficiency wise distributions of paddy and wheat growers

Table 2. Efficiency-wise, distribution of paddy and wheat farmers

Technical Efficiency level (in per cent)	Paddy		Wheat	
	Number of farmers	Per cent to total	Number of farmers	Percent to total
Less than 50	1	1%	2	1%
50-60	3	2%	6	4%
60-70	4	3%	44	29%
70-80	11	7%	82	55%
80-90	39	26%	9	6%
More than 90	92	61%	7	5%
Total farmers	**150**	**100%**	**150**	**100%**
Mean Technical Efficiency	**88 %**		**72 %**	

Source: STATA software (Primary Data 2019-2020)

Table 3. Factor wise allocative efficiency in paddy and wheat production

Factors	Paddy				Wheat			
	MVP	MIC	MVP/MIC Ratio	Allocative Efficiency	MVP	MC	MVP/MIC Ratio	Allocative Efficient
X_1 (Seed)	0.09	1	0.09	Not achieved	-0.17	1	-0.17	Not achieved
X_2 (Fertilizer)	0.07	1	0.07	Not achieved	0.10	1	0.10	Not achieved
X_3 (Human labour)	0.067	1	0.067	Not achieved	-1.40	1	-1.40	Not achieved
X_4 (Machinery labour)	1.24	1	1.24	Not achieved	1.08	1	1.08	Not achieved
X_5 (Plant protection)	0.33	1	0.33	Not achieved	-2.74	1	-2.74	Not achieved
X_6 (Manure)	1.28	1	1.28	Not achieved	1.34	1	1.34	Not achieved
X_7 (Irrigation)	0.20	1	0.20	Not achieved	3.32	1	3.32	Not achieved

Note - MVP and MC represents marginal value product and marginal cost respectively.*
MVP/MIC Ratio = 1 (Allocative Efficiency Achieved)
MVP/MIC Ratio = Greater than 1 or Less than 1(Allocative Efficiency not Achieved)

3.2 Allocative Efficiency

The allocative efficiency of each input was calculated separately for both the crops (paddy and wheat) production at the overall farm level. The Multiplicative Regression Model was used to calculate the elasticity of each input. The elasticity of input multiplied by the ratio of a geometric mean of the output to the geometric mean of the respective inputs for calculating MVP if marginal value product (MVP) and marginal Cost (MC) ratio are equal to1, implied the optimum use of that resource, more than one indicates that the output may be enhanced by extra unit using of that resources and value of less than one inferred that the unprofitable level of resource use which should be decreased to minimize losses. The estimated MVP of different inputs is presented in Table 3. It is observed from the table that MVP all the inputs except machinery and manure in paddy production were observed to be less than unity whereas; in wheat production the MVP of all inputs less than unity except irrigation, manure and machinery. Hence it is concluded that more profit can be obtained by increasing the use of machinery and manure in both the crop and increasing the number of irrigation is profitable for wheat production only. Finally, it was observed that farmers of paddy and wheat production in the study area have the potential to increase the productivity of both the crop by attaining full efficiency through rational and optimal allocation of productive resources. Thus the use of resources is to be adjusted to unity depending upon the ratio to achieve full efficiency.

3.4 Major Constraints Faced by Paddy and Wheat Farmers in the Study Area

Several constraints have been identified in the cultivation of paddy and wheat crops in the study area which is presented in Table 4 which revealed, the major constraints such as insufficient water/electricity, insufficient credit, unavailability labour during peak period, insufficient machinery during peak period, crop insurance, high cost of inputs, insufficient knowledge of improved variety, balanced dose of fertilizer, lack of marketing facility, lack of soil testing and product quality, lack of training, minimum support price, price fluctuation, processing, and transportation were reported by paddy and wheat cultivators. So a total of 15 general constraints in the paddy and wheat crop were selected and asked to farmers to give rank for each factor based on its severity in their area. Then constraint analysis carried out using Garrett's ranking technique. The results depicted that the major constraint faced by most of the majority of the paddy farmers were high input cost [14] with garret score of 64.90 followed by insufficient of water/electricity during peak period[15] (57.80), balance dose of fertilizer (54.52), insufficient credit (53.00), insufficient labour during peak period (51.60), lack of transportation facility (47.60), unavailability of machinery during peak period (49.57), crop insurance (48.97), lack of soil testing and product quality (48.80), lack of marketing facility (47.57), lack of training (47.57), price fluctuation (46.53), processing (46.07), MSP (43.60) and lack of knowledge of improved variety (43.34). As regarding wheat crop, the major constraints were reported by the majority of wheat cultivators viz. insufficient water and electricity during peak period with a maximum garret mean score (65.41), followed by high input cost (65.31), balance dose of fertilizer (54.52), insufficient credit (53.81), insufficient knowledge of improved variety (51.58), crop insurance (49.50), price fluctuation (49.19), transportation (47.55), lack of marketing facility (47.05), processing (44.81),lack of training (44.55), availability of machinery (44.21), MSP (43.88), labour (43.79) and lack of soil testing and product quality (42.22).

Table 4. Major constraints faced by the majority of paddy and wheat farmers in study area

Constraints	Paddy (n = 150)		Wheat (n = 150)	
	Mean garrets Score	Rank	Mean garrets Score	Rank
Insufficient of water/electricity	57.80	II	65.41	I
Insufficient of credit	53.00	IV	53.81	IV
Insufficient of machinery during peak period	49.57	VII	44.21	XII
Lack Crop insurance	48.97	VIII	49.50	VI
High cost of inputs	64.90	I	65.31	II
Labour	51.60	V	43.79	XIV
Insufficient knowledge of an improved variety	43.34	XIV	51.58	V
Balance dose of fertilizer	53.77	III	54.52	III
Lack of marketing facility	47.57	X	47.05	IX
Insufficient soil testing and product quality	48.80	IX	42.22	XV
Insufficient training	47.57	XI	44.55	X
Minimum Support Price	43.60	XIV	43.88	XIII
Price fluctuation	46.53	XII	49.19	VII
Processing	46.07	XIII	44.41	XI
Transportation	49.60	VI	47.55	VIII

Source: Field survey (Primary data 2019-20)

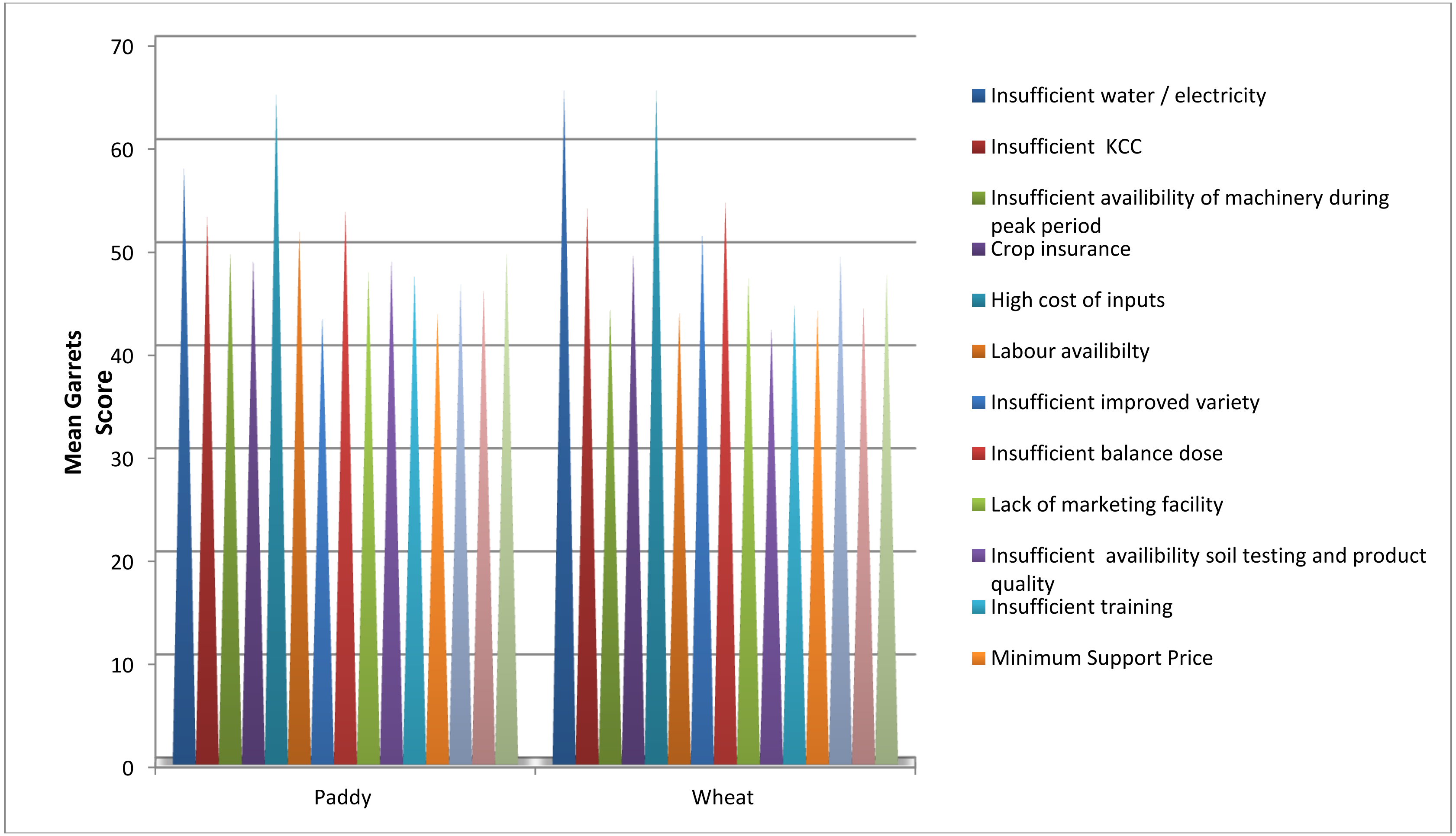

Fig. 2. Major constraints faced by paddy and wheat growers in the study area

4. CONCLUSION

It is concluded that the Likelihood Test Ratio (LR test) for the inefficiency term on paddy farmers was observed at 32.91, which was significant thus suggesting that the inefficiency component is present in the model. In the case of wheat farmers, the Likelihood Test Ratio (LR test) was noted 1.02 which was insignificant and suggesting that the inefficiency component is not present in the model. In stochastic frontier model factor X_1 (seed), X_2 (fertilizer) and X_3 (human labour) were observed as significant indicating that the efficiency of paddy farms could be enhanced by using high yield variety and rationally use of fertilizer and human labour. While on the wheat farms factor X_2 (fertilizer) X_4 (machinery) and X_7 (irrigation) were observed statistically significant, indicating that the efficiency of wheat farms could be augmented by optimal use of these factors in wheat production. The average level of technical efficiency was found to be highest (88%) on the paddy farms as comparison to wheat (72%).This implied that, on an average the 12 per cent and 28 per cent of the technical potential was not achieved by paddy and wheat farmers respectively. Therefore wheat growers having more opportunity to increase the yield as comparison to paddy farmers by recommending crop management practices, providing training on input use without having increasing the level of inputs. About 87 per cent of paddy farmers were operating at 70-90 percent technical efficiency level and around 84 per cent of wheat farmers were operating in the zone of 60-80 per cent technical efficiency level. The major constraints faced by the majority of paddy farmers were high input cost, unavailability of water/electricity, inadequate balance dose of fertilizer, unavailability of credit un availability of labour during peak period, in case of wheat major five constraints were reported by the majority of wheat cultivators viz. unavailability of water and electricity during peak period, high input cost, inadequate knowledge of nutrient dose, and unavailability of credit.

5. POLICY IMPLICATION

It was observed from the study that paddy farmer have high technically efficient as compared to wheat farmers due to they have greater knowledge in respect to rational input use. Hence government should provide more training to farmers on rational inputs use in the production, provide subsidized based inputs to farmers and aware farmers regarding government schemes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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