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An assessment of farm efficiency and profitability of adopted and non-adopted farmers in Kymore plateau and Satpura hills region of Madhya Pradesh

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Abstract
The efficiency of farm of KVK adopted and non-adopted farmers (Rewa District) was estimated with 90 samples by Using non-parametric approach Data Envelopment Analysis (DEA). To find of the study revealed that in *kharif* season the technical efficiency (under VRS and CRS) was non-significant different, while In *Rabi* season the technical efficiency (under VRS) was significant different, but the technical efficiency (under CRS) was non-significant different. In both season the scale and allocative efficiency was not significantly different. In kharif season economic efficiency was non-significant, while in Rabi season economics efficiency was significant different of KVK adopted and non-adopted farm. It is observed from the farm profitability data that as the size of farms increases from small to large the farm income and input-output ratio decreases in cultivation of rice and wheat. Hence, small size of farmers used the available resources more economically as compared to medium and large farmers.

Keywords: DEA approach, KVK, adopted farmers, profitability

Introduction
Agriculture and allied sectors play a vital role in the Indian economy and account for approximately 13.9 percent of the national Gross Domestic Product. In view of the predominant position of the agricultural sector in the overall economy, an accurate and up-to-date information or knowledge of cost structure of crops is, therefore, necessary for the policy planners to advise the farmers to allocate their scarce resources in an efficient way. The farm efficiency has been conventionally assessed through the concept of efficiency. A farm is said to be efficient if its objective of maximization of production is met and inefficient if they are not (Fare *et al*., 1994) [3]. The farm level efficiency of agricultural produce is measured in different types such as allocative efficiency, technical efficiency, scale efficiency and economic efficiency. The efficiency issue needs a special attention while taking into consideration the concept of agricultural productivity in the system of agricultural production, particularly when resources are constrained and opportunities of adopting better technologies are competitive (Gaddi *et al*., 2002) [2]. A change in productivity can be caused not only by a change in efficiency but also by a change in the production technology and the environment in which the production unit operates.

Relative measurement of farm efficiency and productivity is of great importance in the agricultural sector. If efficiency has not been achieved in production, detection and correction of the source of failure would minimize the potential economic loss. For the agricultural enterprises to realize sustainable production, it is necessary to determine their farm efficiency and the factors affecting farm efficiency (Armagan, 2008) [1]. Data envelopment analysis (DEA) comes first among the classical methods used to evaluate the performance of decision-making units. Efficiency measurement with the method of data envelopment analysis is widely used in the agricultural sector as well. The measurement of efficiency, an important indicator used in the decision-making process, is widely used in production processes where different inputs and outputs are used together.

The purpose of DEA is to analyse the performance (i.e., efficiency) of a sample of units within an organization. Each unit, in the sample, has a measure of performance that is a ratio of outputs to inputs.

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The weights are a measure of the decrease in efficiency with each unit reduction of output and a measure of the increase in efficiency with each unit reduction of input (Fitzsimmons *et al.*, 2013) [5].

Methodology
Study area and data collection: The study was mainly based on primary data to the Rewa district of Madhya Pradesh which comes under the Kymore Plateau and Satpura Hills Region of Madhya Pradesh. A multistage sampling procedure was followed to select adopted and non-adopted farmers. The study was carried out purposively in three villages namely; Khokham, Padiya and Rithi under two Blocks namely; Rewa and Mauganj due to higher concentrated growing area. After finalization of the list of adopted and non-adopted farmers from different categories was selected in such a way that the major components covered under the scheme get the due representation. And further categorized on the basis of land holding as follows :(I) Small (up to 2 ha) (II)Medium (2.01 to 4.0 ha) and (III)Large size (above 4.0 ha) From each category 15 adopted farmers and 15 non-adopted farmers were selected randomly for fulfilling the objective of the study.

To examine the technical efficiency Data Envelopment Analysis (DEA) would be performed using R software. The DEA method is a non-parametric approach to measurement of efficiency. It does not assume a production function like Stochastic Frontier Analysis does. However, neither of the two can be said as better to the other (Watkins, 2013). DEA consists in preparing an efficient frontier with which to compare the inputs and outputs of the DMUs. In the terminology of DEA, a farm is a decision-making unit (DMU). Farrell (1957) [4] introduced the notion of relative efficiency in which the efficiency of a particular decision-making unit (DMU) may be compared with another DMU within a given group. Farrell identified three types of efficiency, technical efficiency, allocative efficiency (referred to by Farrell as "price efficiency"), and economic efficiency (referred to by Farrell as "overall efficiency"). Technical efficiency (TE) refers to the ability of a DMU to produce the maximum feasible output from a given bundle of inputs, or the minimum feasible amounts of inputs to produce a given level of output. The former definition is referred to as output-oriented TE, while the latter definition is referred to as input-oriented TE. Allocative efficiency (AE) refers to the ability of a technically efficient DMU to use inputs in proportions that minimize production costs given input prices. Allocative efficiency is calculated as the ratio of the minimum costs required by the DMU to produce a given level of outputs and the actual costs of the DMU adjusted for TE. Economic efficiency (EE) is the product of both TE and AE (Farrell, 1957) [4]. Thus, a DMU is economically efficient if it is both technically and allocatively efficient. Economic efficiency is calculated as the ratio of the minimum feasible costs and the actual observed costs for a DMU.

The technical efficiency score of the nth farm can be find out using following DEA linear programming formulation:

$$TE_n = \min_{\lambda, \theta_n} \theta_n$$

$$\sum_{i}^{I} \lambda_i X_{ij} - \theta_n X_{nj} \leq 0$$

$$\sum_{i}^{I} \lambda_i Y_{ik} - Y_{nk} \geq 0$$

s.t.

$$\sum_{i}^{I} \lambda_i = 1$$

$$\lambda_i \geq 0$$

Where subscript i, j and k are used for i^{th} farm, j^{th} input and k^{th} output. The symbol X denotes input while Y denotes output. iis the non-negative weight associated with i^{th} farm. When iis set equal to one then variable returns to scale (VRS) prevails and when this constraint is omitted then constant returns to scale (CRS) prevails. To find out scale efficiency, a ratio of technical efficiency under VRS to CRS is computed.

To find economic efficiency, following cost minimizing linear programming formulation would be used.

$$MC_n = \min_{\lambda_i X *'_{nj}} \sum_{j=1}^{J} P_{nj} X *_{nj}$$

$$\sum_{i}^{I} \lambda_i X_{ij} - \theta_n X *'_{nj} \leq 0$$

$$\sum_{i}^{I} \lambda_i Y_{ik} - Y_{nk} \geq 0$$

s.t.

$$\sum_{i}^{I} \lambda_i = 1$$

$$\lambda_i \geq 0$$

Where Mc_n is the minimum cost for the nth farm and P_{nj} is the price of jth input for n^{th} farm. Then economic efficiency would be calculated as following

$$EE_n = \frac{\sum_{j=1} P_{nj} X *'_{nj}}{\sum_{j=1}^{J} P_{nj} X_{nj}}$$

Allocative efficiency would be obtained by dividing the economic efficiency of the sample farm by the corresponding technical efficiency.

Tobit regression would be used to find out factors affecting technical and economic efficiency of adopted and non-adopted farmers' in the district.

Results and Discussion
Profitability concept
In any field of business activity profit is the prime consideration. Thus, how many a farmer earns as a net income and family labour income are the major deciding factor in operation of a farm. Hence, in this section efforts have been made to discuss the gross income, net income, family labour income, input-output ratio and cost of production of rice and wheat, presented in Table1.

Table 1: Profitability of rice and wheat production in different sample size of farms (Rs /ha)

Parameter	Rice			wheat		
	Adopted	Non-Adopted	% Difference	Adopted	Non-Adopted	% Difference
Main product (q)	38.03	33.87	12.28	40.36	36.15	11.65
Rate of main product	1700	1700	0.00	1735	1735	0.00
Gross income	72937.41	65144.67	11.96	79568.49	70792.7	12.40
Return over variable cost	54299.57	44597.28	21.76	63482.08	53972.24	17.62
Farm business income	54299.57	44597.28	21.76	63482.08	53972.24	17.62
Family labour income	41387.07	34169.63	21.12	50476.84	42478.86	18.83
Net Income	40976.02	33739.83	21.45	50220.66	42478.86	18.23
Returns to management	37779.88	30599.35	23.47	47285.88	39311.53	20.29
BCR (undiscounted)	2.08	1.88	10.64	2.71	2.48	9.27

(**Source:** Field survey 2019)

Profitability of rice and wheat cultivation: Profitability of rice cultivation was estimated and showed in Table 1. In the study area, gross income of adopted and non-adopted farm production was estimated at 72937.41and 65144.67Rs per hectare, as percent difference11.96 respectively. BCR (undiscounted) of adopted and non-adopted farmers were 2.08 and 1.88, while percent difference 10.64 respectively which indicated that production of paddy was profitable from the viewpoints of adopted farmer's investment. The result showed that adopted farm of paddy production was more profitable than non-adopted farm of paddy production. But per hectare input cost of non-adopted farm was higher than adopted farm of paddy cultivation. because of adopted farmers also provided the guidance of KVKs.

Profitability of wheat cultivation was estimated the gross income of adopted and non-adopted farm production was estimated at 79568.49 and 70792.7Rs per hectare, as percent difference12.40 respectively. BCR (undiscounted) of adopted and non-adopted farm were 2.71 and 2.48, while percent difference 9.27 respectively which indicated that production of wheat was profitable from the viewpoints of adopted farmer's investment. The result showed that adopted farm of wheat production was more profitable than non-adopted farm production.

It is also observed from the data that as the size of farms increases from small to large the gross income, net farm income, farm business income and input- output ratio decreases in cultivation of rice and wheat. Hence, small size of farmers used the available resources more economically as compared to medium and large farmers.

Estimation of Farm Efficiency
The efficiency of farm was estimated by Data Envelopment Analysis (DEA) by using R-software for both *Kharif* and *Rabi* season respectively. The significant difference between the efficiencies of adopted and non-adopted farm units was workout a two-sample t-test at five percent level of significance. The efficiency scores of farm units are presented in table 2.
The Technical efficiency is presented under both VRS and CRS assumptions. For *kharif* season the mean technical efficiency under VRS assumptions on an average was 0.94 for adopted farm and 0.92 for non-adopted farm and under CRS assumptions was 0.87 and 0.84 for adopted and non- adopted farm respectively and the difference in efficiencies was to be non-significant at 5percent level of significance. For *Rabi* season, the mean technical efficiency under VRS assumptions on an average was 1.00 and 0.98 for adopted and non-adopted farm respectively the difference in efficiencies was found to be significant statistically and under CRS 0.91 and 0.90 for adopted and non-adopted farm respectively and the difference

in efficiencies was found to be non-significant statistically. Thus, KVK adopted farm achieve less technical efficiency for every unit of input applied in the *Rabi* season.
For *kharif* season the mean Scale efficiency was 1.08 and 1.12 for adopted and non-adopted farm the difference in efficiencies was found to be non-significant statistically which indicated that non-adopted farmers were more scale efficient. For *Rabi* season the mean scale efficiency was calculated 1.10 and 1.09 for adopted and non-adopted farm respectively and the difference in efficiencies was found to be non-significant statistically which indicated that adopted farmers were more scale efficient.
For *Kharif* season the Mean economic efficiency across adopted and non-adopted farm was calculated as 0.50 and 0.51 and the difference in efficiencies was found to be non-significant statistically which indicated that total cost of production could be reduced on an average by 50 and 49percent respectively to achieve the same level of output. For *Rabi* season the Mean economic efficiency was 0.68 and 0.69 for adopted and non- adopted farm the difference in efficiencies was found to be significant statistically which indicated that total cost of production could be reduced on an average by 32 and 31percent to achieve the same level of output.
The allocative efficiency was calculated 0.52 and 0.54 for adopted and non-adopted farm respectively and the difference in efficiencies was found to be non-significant statistically which revealed that non-adopted farmers were distributing budget more efficiently across inputs given market prices in *kharif* season. The allocative efficiency average scope for adopted farmers is 0.68 compare to 0.67 for non-adopted farmers, however the difference between the two allocative score is not significant meaning that adopted farmers were distributing budget more efficiently across inputs given market prices in *Rabi* season.

Factor affecting the level of farm efficiency
It determines the extent to which various variables along with dummy variables such as adoption status, literacy, age, caste and non-farm income can affect the farm efficiency level using the regression model. The results are shown in below the table no. 3 and 4. The adoption status was significant statistically and positively related to economic efficiency and technical efficiency (both VRS and CRS assumption) which implies that a increase in these variables resulted in improving these efficiency by 0.074, 0.055 and 0.095 respectively. The other variable area under irrigation was significant statistically and negatively related to economic efficiency, allocative efficiency, scale efficiency and technical efficiency (under CRS assumption). The variable fertilizer quantity was significant statistically and negatively related to economic

efficiency, allocative efficiency, and technical efficiency (under both VRS and CRS assumption). The variable machine to inventory ration was significant statistically and negatively related to technical efficiency (under both VRS and CRS assumption). The calculated F value> F (critical) for technical efficiency was significant while for economic efficiency, allocative efficiency, scale efficiency it is non-significant statistically.

In *Rabi* season, estimated regression coefficient of percent of the area under cultivation was significant statistically and positively related to scale efficiency which implied that for every one percent increase in these variables resulted in increasing these efficiencies by 0.281 respectively. While another variable is held to be constant. The variable labour to

machine expense ratio was significant statistically and positively related to economic efficiency and allocative efficiency.

The variable area under irrigation significant statistically and related to positively economic efficiency, allocative efficiency and technical efficiency (under CRS assumption). The variable fertilizer per acre was significant statistically and negatively related to economics efficiency and allocative efficiency.

The calculated F value> F (critical) for scale efficiency was significant while for

economic efficiency, allocative efficiency, technical efficiency (under CRS assumption) it is non-significant statistically.

Table 2: Estimation of Farm efficiency

Particular	*Kharif* season			*Rabi* season		
	A	NA	Significance of Difference	A	NA	Significance of Difference
Technical efficiency (VRS)	0.941	0.929	Non-Significant	1	0.982	Significant
Technical efficiency (CRS)	0.877	0.843	Non-Significant	0.918	0.903	Non-Significant
Scale efficiency	1.089	1.127	Non-Significant	1.100	1.097	Non-Significant
Economic efficiency	0.501	0.515	Non-Significant	0.680	0.698	Significant
Allocative efficiency	0.527	0.549	Non-Significant	0.680	0.671	Non-Significant

A: Adopted Farm units
NA: Non-Adopted Adopted Farm units

Table 3: Factor affecting the level of farm efficiency in the *Kharif* season

Independent Variable	Dependent Variable				
	Economic Efficiency	Allocative Efficiency	Scale Efficiency	Technical Efficiency (VRS)	Technical Efficiency (CRS)
Adoption status Yes	-	-	-0.068 (-1.786)	0.037 (1.860)	0.087** (2.657)
Adoption status small	0.074* (2.000)	-	-	0.055* (2.457)	0.095* (2.464)
Area under irrigation	-0.032*** (-4.762)	-0.031*** (-5.317)	-0.049** (-2.818)	-	0.0164* (2.431)
Fertilizer quantity	-0.0024*** (-6.393)	-0.003*** (-6.463)		-0.007*** (-2.929)	-0.006 (-1.698)
Machine to inventory ratio	-	-	-	-0.644*** (-3.89)	-0.587* (-2.289)
Caste OBC	-	-	0.109** (2.841)	-	-0.092** (-2.686)
F statistic (F critical)	17.6 (2.209)	17.06 (2.209)	4.763 (2.20)	5.401 (2.123)	2.937 (1.953)
AIC	-72.93871	-85.86739	-40.8239	-155.9058	-86.51997

Figures in parenthesis are calculated t-values
Significant codes: ***, **, and* at 1, 5, and 10 percent level.

Table 4: Factor affecting the farm efficiency of *Rabi* season

Independent Variable	Dependent Variable				
	Economic Efficiency	Allocative Efficiency	Scale Efficiency	Technical Efficiency (VRS)	Technical Efficiency (CRS)
Area under cultivated	-0.104** (-2.915)	-0.104** (-2.915)	0.281** (2.964)	-	-0.083** (-3.063)
Area under irrigation	0.109** (3.015)	0.109** (3.015)	-0.286** (-3.025)	-	0.0846** (3.069)
Fertilizer per acre	-0.00175*** (-3.564)	-0.0015*** (-3.564)	0.002*** (3.904)	-	-
Labour to machine expense ratio	0.0395*** (3.290)	0.395*** (3.920)	-	-	-
F statistic (F critical)	6.204 (2.211)	6.204 (2.2113)	4.847 (2.007)	608.2 (1.715)	2.26 (2.006)
AIC	-131.6502	-131.6502	-150.209	-6213.71	-194.51

Figures in parenthesis are calculated t-values
Significant codes: ***, **, and* at 1, 5, and 10 percent level.
NS: Non-significant.

Conclusion

In first step, the farm efficiency measures were calculated using the non-parametric data envelopment analysis (DEA) model by using the R-software. In the second step, the estimated economic efficiency, allocative efficiency, scale efficiency and technical efficiency scores were regressed on a set of explanatory variables which included area under cultivated, adoption status, literacy, caste non-farm income and various indicators for adoption of technology. In *kharif* season, the technical efficiency (under VRS and CRS assumption) of KVK adopted and non-adopted farm was non-significant different statistically. In *Rabi* season the technical efficiency (under VRS assumption) of KVK adopted and non-adopted farm was significant different statistically. While the technical efficiency (under CRS assumption) of KVK adopted and non-adopted farm was non-significant different statistically. In scale efficiency of KVK adopted and non-adopted farm was non-significant different statistically for both *Kharif* season and *Rabi* season. In *Kharif* season, the economics efficiency of KVK adopted and non-adopted farm was non-significant different statistically. In *Rabi* season, the economics efficiency of KVK adopted and non-adopted farm was significant different statistically. The allocative efficiency of KVK adopted and non-adopted farm was not significant different statistically in both *Rabi* season and *Kharif* season. The scale efficiency was significant while economic, allocative and technical (under CRS assumption) efficiency was non-significant statistically for KVK adopted and non-adopted farm. The economic, allocative and technical (under CRS assumption) was significant statistically while, the scale efficiency was non-significant statistically of KVK adopted and non-adopted farm. Our finding was also supported by Hailu *et al*. (2014) who identifying the determinants of agricultural technology adoption decision and examining the impact of adoption on farm income. The regression result also revealed that agricultural technology adoption has a positive and significant effect on farm income by which adopters are better-offs than non-adopters

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