



NON-PARAMETRIC EFFICIENCY, ECONOMIC, AND RISK ANALYSIS OF FARMS IN THE LIGHT OF CROP DIVERSIFICATION

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ABSTRACT

Crop diversification is the most effective risk management strategy to mitigate the uncertainties at a farm. It can influence the efficiency as well as the economic returns. Therefore, the present study aimed to analyze the efficiency, risk, and economic performance of crop diversification. Using the multistage sampling technique, a total of 100 selected farmers were interviewed. The farmers were classified into high and low diversified farmers by applying cluster analysis. The results indicated that the high diversified farmers were young, less educated, with high farming experience and had a large family size as compared to the low diversified farmers. The one-year economic analysis indicated that the high diversified farmers gained a low return of 14% per year on an asset but had zero business risk. However, low diversified farmers gained a higher return of 21% per year on an asset, but carried a chance of a negative return of 36% on an asset under price and yield variation. High diversified farmers were technically efficient with 0.79 score, but were economically inefficient. Taken together, the study suggests that the crop diversification is a new paradigm of the sustainable farming technique which is associated with lower business risk and positive return, high technical efficiency, the possibility of crop rotation for the maintenance of soil health, high generation of employment opportunities, and increased utilization of owned resources like family labors. Crops like sugarcane, wheat, maize, cotton, sesame and fodders provided positive returns be promoted in the area to increase the production and productivity of crops, and raise the income of farmers.

Keywords: business risk, crop diversification, return on asset, sustainable farming practice, technical efficiency

INTRODUCTION

Agriculture diversification is a process to allocate the productive resources to a wide range of economic activities. This diversification can be classified into two categories: horizontal or vertical. The horizontal diversification refers to an introduction of new crop cultivation to an existing farming plan (called crop diversification) or the introduction of a new farming system, e.g., livestock or aquaculture. The vertical diversification refers to the upstream and downstream processes of crops or the value addition of produce through processing, packaging, regional branding activities, and merchandising (Kankwamba *et al.*, 2012). The development of the rural area is highly dependent on agriculture. Crop cultivation is highly being affected due to climate change and

which increases the farm business risk because of severe variation in price and yield of crops. Farmers' income depends on the decision taken by them in a season. Therefore, crop diversification is one of the techniques to counter the farm risk and income fluctuation (Shahbaz *et al.*, 2017). Consequently, for sustainable earnings and employment, the rural inhabitants are reliant mainly on a high degree of diversification in crop cultivation. On top of that, crop diversification is an important approach toward high-value commodities from low-value agriculture to increase agricultural output (Dutta, 2012).

Efficiency is also a subject of the debate in the light of food crop production. In Pakistan studies regarding parametric and non-parametric efficiency of field crops were also conducted (Ullah and Perret, 2014; Haq *et al.*, 2016; Haq *et al.*, 2017; Murtaza and Thapa, 2017). which plays a significant role in

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enhancing agricultural production and reported worldwide (Bravo-Ureta *et al.*, 2007). The efficiency measurement is very imperative as it represents the efficiency of farmers in direct relation with the overall agricultural productivity (Ajibefun, 2002). The crop diversification is essential for achieving sustainable agricultural development (Das and Mili, 2012). Moreover, efficiency is an important indicator of sustainable agricultural productivity (Hani *et al.*, 2006; Gafsi and Favreau, 2010; Haq and Boz, 2017). However, the literature suggests that the impact of crop diversification on the efficiency is relatively ambiguous and diverse. Many studies have recognized that crop diversification is an important strategy for the alleviation of poverty in rural areas, especially for small farmers, mitigation of risks associated with the farming-practices, and the minimization of the farm income variation (Ceyhan *et al.*, 2004; Pingali, 2005; Hutagaol, 2006; Kahan, 2008). Similarly, Singh (2000) explained that the crop diversification is an attractive technique among farmers due to its extensive benefits like risk management under climatic and market fluctuations, employment generation, and sustainable income, besides adding insurance against insect, weed, and diseases attack and a possibility to increase the soil fertility. However, Haji (2007) revealed that the impact of diversification on the efficiency of farmers is negative in Ethiopia while Rahman (2009b) reported that it has a positive impact on farmers' efficiency in Bangladesh. As different crops need different quantities of inputs, crop diversification enables farmers to provide reasonable quantities of expensive inputs to crops (Dutta, 2012).

The results of these findings indicate a high level of heterogeneity across regions. Nevertheless, crop diversification is very important for sustainable agriculture at the same time the efficiency of farmers also cannot be ignored. On the importance of crop diversification and the efficiency under risky environment, it has been realized that either high degree of diversification has a positive association with efficiency levels of farmers or negative under consideration of the farm business risk. Therefore, the present study aimed to analyze the efficiency of farmers and to analyze the risk and economic performance of the farmers while they diversify their farm in terms of sowing different crops. The findings would provide useful information for farmers who consider crop diversification, and for extension

service personnel who plan and implement crop diversification programs for the region. In addition, different researchers and other related stakeholders would also utilize the findings of this study.

METHODOLOGY

The basic research design followed in the study was descriptive-survey research design. The pilot test was administered to check the reliability of the research instrument afterward questionnaire was modified according to the field experience with the inclusion and removal of the questions. The research team collected data for the study with the aid of structured and pretested questionnaire during the face to face interview. The demographic characteristics, including the land holding, land allocation to each crop in a year, social characteristics of the farmer (age, education, experience, family, etc.) and farm capital were collected. Further cultivation cost yield of each crop was also questioned from the farmers. The data was stored in excel and SPSS statistical software. For efficiency analysis the input output data was entered in DEA program. Hereafter, farmers were grouped and further economic, risk and efficiency analyses were performed.

Study area

The study area Faisalabad is located in northeast flat plains of Punjab, Pakistan, with longitude 73.079° E, latitude 31.418° N and at an elevation of 184.5 m above sea level. Faisalabad is one of the most important agrarian parts of Punjab province and lies in mixed cropping zone (Shahbaz *et al.*, 2017). It is categorized as apportion of northern irrigation plain and receives rainfall ranging from 125 mm to 500 mm and has a semi-arid to arid climate (Hameed *et al.*, 2017). The total cultivated land area of district is 474000 hectares (GoP, 2015) and includes five tehsils; Faisalabad, Samundri, Jaranwala, Tandlianwala and Chak Jhumra.

Sample size

A multi-stage sampling technique was used to select an appropriate sample size. For the first stage unit, the officials of Agricultural Department Faisalabad were consulted and two tehsils (Samundri and Tandlianwala) with a large number of farmers cultivating more than two crops (Sugarcane and Wheat) were selected. In order to draw an accurate sample size to represent the farming community of these two tehsils, initially the number of farmers living in

the area was obtained from the Pakistan Bureau of Statistics. Then the following sample size determination formula was used (Miran, 2002).

$$n = \frac{Np(1 - p)}{(N - 1)\sigma_{\hat{p}_x}^2 + p(1 - p)}$$

n= sample size

N= Number of farmers in Samundri and Tandlianwala Tehsils (170676) (PBS, 2018)

P=0.5 (Assuming that half of the farmers (50%) would be interested in a crop diversification practice).

Using 95% confidence interval (z=1.96) and 0.10 error term, the variance was calculated as $\sigma = e/1.96=0.05102$. These values were represented in the above formula and the sample size was calculated as 96.

For the second stage, five union councils from each tehsil were determined regarding their agricultural potential, proximity to the tehsil center, farm population, and socio-economic characteristics of the tehsil. Later one village from each union council was selected purposefully using the same criteria. In order to be consistent with the above sample size, 10 farmers from each village were decided to include in this study. This method increased the sample size to 100. The tehsil agricultural offices were consulted in advance to select the tehsils, the union councils, the villages, and the farmers. Data collection was completed in January 2018.

Grouping of farmers

For the grouping of farmers, the collected data were carefully entered into Excel sheets for data analysis. At the first instance, it was realized that the farmers were cultivating more than one crop in every season (Rabi and Kharif). The farmers who are practicing crop diversification, cultivating more than two crops in a farm can be considered as highly diversified than those who are growing only one crop on a farm. Furthermore, on the farms, where two crops were allocated, about half of the land was well diversified than one crop farms, where 90% land was allocated to only one crop and 10% to other (Kankwamba *et al.*, 2012). Considering this two concepts, K-mean cluster analysis was applied to the proportion of land to each cultivated crop in the farm. The objective of the cluster analysis was to establish homogeneous groups of the farm. More precisely the objects or observations were grouped into specific cluster or group by the cluster analysis (Hair *et al.*, 2006).

Crop diversification index

There are only a few index calculation methods those can explain the conditions for a farm, either concentration (or specialization) or diversification of activities at the farm in a given time and space. These methods have been adopted in many studies related to the evaluation of diversification of farms globally including Herfindahl index, Ogive index, Simpson index, Entropy index, index of maximum proportion, Shannon Diversity Index, Gibb's-Martin index and Margalef index (Pandey and Sharma, 1996; Ashfaq *et al.*, 2008; Tsehaye *et al.*, 2009; Das and Mili, 2012; Dutta, 2012; Sichoongwe *et al.*, 2014; Mussema *et al.*, 2015 and Dube *et al.*, 2016). The Herfindahl index and Simpson index of diversity were most frequently adopted methods.

Herfindahl index is most commonly used to measure the concentration of market and its distinct characteristics and is equally effective for the calculation of diversification. It simultaneously assumes a number of activities as cultivated crops at farm and resource allocation like land among crops (Malik and Singh, 2002). Herfindahl index is calculated as follows:

It is supposed that the land allocated to the i^{th} crop by L_i (say in acre) where i equal to 1,2,3...n (number of crops cultivated at a farm) and then the proportion of the land devoted to each crop will be calculated as:

$$P_i = \frac{L_i}{\sum_{i=1}^n L_i} \quad 1$$

Where P_i is the proportion of land among each crop in Equation 1

$$\text{Herfindahl index (HI)} = \sum_{i=1}^n P_i^2 \quad 2$$

The value of index ranges from zero to one. An index value of one indicates lesser diversification and increased specialization that is when only one crop is cultivated and index approaches zero when the diversification of crop cultivation is the highest. Therefore, HI value is not only influenced by the number of crops cultivated but also by the crops cultivated in a particular land area. The second index known as Simpson Diversification index (SDI) is directly calculated from HI by using the following equation (Joshi *et al.*, 2004).

$$SDI = 1 - HI = 1 - \sum_{i=1}^n P_i^2 \quad 3$$

Intuitively, SDI probability distribution function over the sample of farmers simply reflects HI, as a higher value of SDI means a higher diversification at the farm. Its value also varies between 0 and 1. Zero indicates specialization and one indicates the highest degree of diversification (Kankwamba *et al.*, 2012).

Risk measurement

The bulk data on the yield and price for last ten years were recorded from the farmers related to each cultivated crop and economic analysis was carried out. The subjective judgment of farmers and historical data about price and yield of cultivated crops in the farm were collected to calculate the probability distribution. For that minimum, typical, and maximum crop yield and price data were collected from the questionnaire. Triangular distribution method was used to estimate the marginal subjective probabilities regarding each crop yield and price. This technique has an advantage of being applicable in the absence of sample data (continuous uncertain quantities) and whole subjective distribution was assessed by the farmers or an expert (Hardaker *et al.*, 2015). Firstly, the average price and yield were estimated and considered as normal yield or price. The one standard deviation above the normal price and yield were grouped as good price and yield, while standard deviation below the normal yield and price were considered as poor yield and price. Further, the yield and price probabilities were used to estimate the conditional probability distribution of the farm income. In this study, only business risks (yield and price fluctuations) were assessed, as no credit was received by the sampled farmers, thus no financial risk was supposed.

Efficiency model

The basic concept of efficiency, followed in the present study was as suggested by Farrell (1957). According to Farrell efficiency of any firm consists of two components, Technical and Allocative efficiency. Input oriented efficiency model was supposed to be more appropriate as a farmer having more control over the inputs rather than output. Economic Efficiency (EE) composed of Technical (TE) and Allocative Efficiencies (AE). The farmer's ability to use the minimal input to reach the given output level is depicted by TE, while the ability to use inputs in

their optimal proportions at a given price and technology is called AE (Farrell, 1957).

The efficiency score of high and low diversified farmers was estimated by using Data Envelopment Analysis (DEA). As per the suggestions of Charnes *et al.* (1978) and Banker *et al.* (1984), the efficiency model for farmers was defined. The farm gross income from all crops was taken as output (y_i) and labor (hours) and working capital (Rs.) were used as inputs. The TE for the i^{th} farmer was calculated and the data for all farmers were denoted by $K \times N$ input matrix (X) and $M \times N$ output matrix (Y). The general form of model to measure the efficiency scores of high and low diversified farmers is:

$$\begin{aligned} &\text{Minimize } \theta, \lambda \theta \\ &\text{Subject to } -y_i + Y\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned}$$

where

θ = TE score

λ = $N \times 1$ vector of weights that defines the linear combination of the peers of i^{th} farmer. The model for economic efficiency is computed as:

$$\begin{aligned} &\text{Minimize } \lambda x_i^* w_i' x_i^* \\ &\text{Subject to } -y_i + Y\lambda \geq 0 \\ &x_i^* - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned}$$

Where

w_i' = Transpose of vector of input prices and

x_i^* = cost minimizing vector of input quantities for i^{th} farmer. Both of the aforementioned functions are subject to a constant return to scale (CRS) indicating that the increases in input and output are in same proportion. The EE_{CRS} of i^{th} farmer was calculated as:

$$EE_{i,CRS} = w_i' x_i^* / w_i' x_i$$

That is, $EE_{i,CRS}$ shows the ratio between the minimum cost to observe cost where price and technology in the farm were provided (Coelli *et al.*, 2005). The farmers in the study area were performing their activities under imperfect competition because of improper information and knowledge about prices and market functionality. Therefore, the CRS condition cannot be considered in this scenario and efficiency model was transformed into the Variable Return to Scale (VRS) by adding the convexity constraint $N1\lambda = 1$. $N1$ shows $N \times 1$ vector of ones and λ is an $N \times 1$ vector of

constant of the first model mentioned above. As a result of the addition of convexity constraint, TE decomposed into Pure Technical Efficiency (PTE) and Scale Efficiency (SE). PTE reflects the farmer's capability to produce maximum output at an optimal scale. SE represents the skill of a farmer to choose the input's optimal level that will generate the expected output level (Kumar and Gulati, 2008). SE is calculated by using the ratio between TE score of the farmer under CRS to TE score under VRS. Such that $SE = 1$ means TE at CRS will be equal to TE at VRS which indicates that the farmers are supposed to be at efficient scale. The comparison of the farmers based on scale inefficiency was determined by comparing their efficiency scores under the non-increasing return to scale (NIRS) with TE score under CRS. When $SE < 1$ and $TE_{NIRS} = TE_{CRS}$ then the farmer will be scaled to be inefficient due to the increasing return to the scale. When $SE < 1$ and $TE_{NIRS} > TE_{CRS}$, then the farmer will be scaled to be inefficient under the decreasing return to the scale. The AE is expressed as:

$$AE_i = EE_{i,VRS} / TE_i$$

RESULTS AND DISCUSSION

Group formation by cluster analysis

The results of the cluster analysis suggested the existence of two major clusters or two types of farmers in the data. Those cultivating more than one crop were characterized as diversified farmers. No specialized farmer was found in the collected data; therefore, the farmers were categorized into low and high diversified farmers. Consequently, the first group was considered as the low diversified farmers and the second one as the highly diversified farmers based on the land proportion to each crop through cluster analysis. The results are in state with Shahbaz *et al.* (2017) in grouping the farmers which described the same behavior of the farmers in allocation of land to crops. The results of the cluster analysis are presented in Table 1.

The frequency distribution of farmers and their percentage in each group are presented in Table 2. Thirty-two farmers were considered as low diversified on the basis of the allocated land proportion among the crops at the farm and 68 farmers were considered as highly diversified. Considering the overall land allocation, the first group allocated the largest proportion of land to sugarcane (56.69%) and it was followed by

wheat (22.51%). The second group was relatively large with the land allocation to each crop for a year. Sugarcane, wheat, and fodder crops were devoted to more than 9% of the land; however, other crops like cotton, maize, and rice were having the land share not less than 1%. Shahbaz *et al.* (2017) also explained that the low diversified farmers were devoting more than 50 percent of higher agricultural land to sugarcane. Similarly, the land allocation by the highly diversified farmers was uniform for each crop. They devoted their land to sugarcane, rice, fodder crops, and wheat, which was significantly higher than those devoted by low diversified farmers except for cotton, maize, and sesame.

Table 1. Proportional area devoted to crops cultivated in a year (percentage)

Crops per year	Low diversified farmers	Highly diversified farmers	p-value
Sugarcane	56.69	26.61	0.00
Cotton	0.39	1.18	0.14
Rice	1.13	4.09	0.05
Corn Maize	5.50	7.63	0.20
Sorghum/Maize	7.07	18.99	0.00
Wheat	22.51	30.37	0.01
Sesame	0.92	1.32	0.66
Bar seem/Lucerne	5.80	9.82	0.00

Table 2. Frequency and percentage of farmers

Farm categories	Frequency	Percentage
Low diversified farms	38	38.0
Highly Diversified Farms	62	62.0

Diversification index

The first SID shows that the diversification level of high diversified farmers is significantly higher with the mean of 0.72 point index as compared to the low diversified farmer group with the index value of 0.57 as indicated in Table 3. Similarly, HHI explains the low index value of farmers entitling them as high diversified farmers. The mean index value of 0.28 for the group was considered as the highly diversified index and also these farmers with the mean index value were significantly higher than the mean value of 0.43 for the other group. Shahbaz *et al.* (2017) also described the low diversification index at low diversified farms with value 0.55 as compared to high diversified farms with the score 0.68.

Demographic characteristics of farmers

The demographic characteristics of farmers are represented in Table 4. The high diversified farmer group was younger in age than the low diversified farmer group with the mean

difference of two years. This result is consistent with the findings of Mishra and El-Osta (2002), those were also found that older people are less likely to be diversified farmers. The high diversified farmers attended school for about eight years while low diversified farmers went to school for about ten years. The farming experience of high diversified farmers was significantly higher than those of the low diversified farmers. Ashfaq *et al.* (2008) also explained that high farming experience positively correlates with the crop diversification. Further, the high diversified farmer group on an average has a large family size; however, the low diversified farmer group, on the other hand, has a family size of two members on average. The significant difference was found among the farmers' education and family size. Agriculture is an important sector for the generation of employment opportunities in Pakistan as this sector accounts for 42.3% of country labor (GoP, 2017). With regard to the generation of employment opportunities, the high diversified farmers were employed with an average of 2.07 members, while the other group on an average employed 1.58 members. The low diversified farmer share more labor than the high diversified farmers. Furthermore, the high diversified farmers employed more members of the family as family labor in their farms while reducing the dependency on the labor market. This is in accordance with the finding of Abdalla *et al.* (2013), which suggests that the family size is positively correlated with crop diversification as larger families are more likely to have a higher family labors. Besides, the highly diversified farms produced higher employment opportunities with an average of 2.07 working men. Behera *et al.* (2007) also explained that crop diversification also promotes the employment in the farm. The average working hours for a person in a farm were 10.81 and 10.13 for the high and low diversified farmer groups, respectively.

Farm characteristics

Land holdings

A similar land holding pattern was recorded as described previously by Haq *et al.* (2016). A novel approach to determine the cropped area was used in the present study. A cropped area is equal to the sum of land cultivated under each crop in a year on the farm. The high diversified farmers owned larger land area than the low diversified farmers as presented in Table 5. The owned area for the highly diversified farmers

was significantly higher by 8.53%. However, in the low diversified farmer group, the rented area was significantly higher. The highly diversified farmers rented out the area that was far away from their access. Their rented out area was about 0.25 acre. Both types of farmers shared the area in agreement with the land owner for sharing the cost and return from land. The operational land holding was not significantly different for both farm categories. The cropped area of low diversified farmers was higher by 18.79% relative to the operational land holdings. Furthermore, for the highly diversified farmers, the cropped area relative to operational holdings was 37.66%. The overall comparison of these two groups indicated a significantly higher cropping of the land (9.75%) as compared to the low diversified farmers.

Table 3. HHI and SID index for the low and high diversified farmers

Index	Low diversified farmers		High diversified farmers		
	Average	Std. Deviation	Average	Std. Deviation	P-value
SID	0.57	0.13	0.72	0.08	0.00
HHI	0.43	0.13	0.28	0.08	0.00

Table 4. Demographic characteristics of the farmers

Characteristics	Low diversified farmers		High diversified farmers		
	Average	Std. deviation	Average	Std. deviation	P-value
Age	43.68	13.40	41.77	11.13	0.44
Schooling Years	9.11	4.00	7.15	5.26	0.05
Experience	19.50	12.77	20.16	10.46	0.78
Family Size	5.34	1.49	7.23	3.11	0.00
Labor					
Family Labor	1.08	0.49	1.63	1.48	
Hired Labor	0.50	0.83	0.44	0.67	
Working Hours at farm	10.13	2.30	10.81	2.73	

Table 5. Land holdings and cropped area by the farmers (acres)

Land using rights	Low diversified farmers		High diversified farmers	
	Average	Std. deviation	Average	Std. deviation
Owned Area	7.39	4.99	8.02	6.56
Rented in	3.55	6.99	2.14	4.24
Rented out	0.00	0.00	0.21	1.16
Shared in	0.03	0.16	0.43	1.42
Shared out	0.00	0.00	0.00	0.00
Operational Land	10.96	7.62	10.38	6.51
Cropped area	13.02	7.59	14.29	9.12
Land Rent (US \$)	298.84	26.65	284.12	59.95

Economic performance

The economic indicators are presented in Table 6. The results of the economic analysis suggest that a higher diversification is accompanied by a lower return. Similarly, Rahman (2009^a) reported the low return at diversified farm in Bangladesh.

The low diversified farmers were more specialized and were earning high return per cropped area in a year; their return to the asset in a fiscal year was 21%, while for the low specialized farmers, it was 14%. The low diversified farmers on an average owned total current asset of US \$ 3120.88 and the total asset value of the other group was US\$ 2815.08. The high diversified farmers were spending US \$ 356.59 per acre and in return, they were earning the total net return of US \$ 390.62. On the contrary, the low diversified farmers were earning US\$ 663.37 per acre after spending US\$ 334.75.

Table 6. Economic indicators of the farmers

Indicator	Low diversified farmers		High diversified farmers	
	Average	Std. deviation	Average	Std. deviation
Return per cropped area	998.11	281.40	747.21	232.62
Variable cost per cropped area	211.93	68.43	225.80	44.00
Gross margin	786.18	287.72	521.41	237.60
Net return	663.37	164.91	390.62	106.81
Current asset value	3120.88	2119.07	2815.08	2473.80
Current year return on asset	0.21	0.08	0.14	0.04

Risk analysis

Table 7 presents the results of risk analysis for both the groups. The low business risk was associated with the highly diversified farmers even though they had a low return on the asset for a year as compared to the low diversified farmers. Harwood *et al.* (1999) also suggested that an individual farmer can handle and lower the business risk in the farm by the combination of favorable activities, which have different outcomes and fluctuating levels of expected return. The one-year economic analysis suggested a low return of 14% to the asset by the high diversified farmers but there was no business risk due to the fluctuating prices and climate conditions. Furthermore, the risk analysis for low diversified farmers revealed that they had higher risk, suggesting that moving toward specialization may increase the business risk yet may lead to a high yearly return. As the prices of inputs and outputs are very important determinants of income of the farmers, the yield also plays a vital role, which is highly dependent on climatic conditions. The low diversified farmers were facing high price risk associated with crop yield, where they received bad price and had a risk of negative return in a combination of normal yield and bad price.

Consequently, the low diversified farmers had 36% higher chances of negative return. Overall, the high diversified farmers had no chances of negative return, thus they had no business risk and enjoyed secure business return even in the fluctuating environment with regard to price and yield. The high return enables the high diversified farmers to conduct the business on a sustainable basis. Kasem and Thapa (2011) also reported that crop diversification is best in maintaining a stable flow of income in a farm and also smoothens the crop price fluctuations.

Table 7. Business risk for the farmers

Combination	Low diversifies farmers			Highly diversified farmers		
	Return on asset (%)	Probability of occurrence	Cumulative probability	Return on asset (%)	Probability of occurrence	Cumulative probability
BY, BP	-10.62	0.09	0.09	0.70	0.09	0.09
BY, NP	-2.28	0.13	0.22	18.08	0.14	0.23
BY, GP	6.07	0.08	0.30	35.46	0.09	0.31
NY, BP	-5.22	0.14	0.44	11.58	0.12	0.44
NY, NY	4.12	0.20	0.64	31.22	0.19	0.63
NY, GP	13.47	0.12	0.76	50.85	0.12	0.75
GY, BP	0.17	0.07	0.83	22.46	0.07	0.82
GY, NP	10.52	0.11	0.94	44.35	0.11	0.93
GY, GP	20.87	0.06	1.00	66.23	0.07	1.00

Efficiency of farmers

In this study, the efficiency level of farmers was studied considering the different types of efficiency (TE and PTE) even with the decomposition of TE in PTE and scale efficiency. The results are presented in Table 8. A significantly high difference was observed between the TE levels of both the groups. The TE score of 0.79 for the highly diversified farmers explains that the diversification is also an important technique to increase the efficient use of inputs to achieve the maximum output. Similar findings were also reported by Ogundari (2013), which suggest that the crop diversification increases the technical efficiency. A significantly lower AE score for the low diversified farmers explains that these farmers were inefficient in using inputs to their optimal proportion with the given price of inputs and technology. The diversified farmers were economically inefficient. Czyżewski and Smędzik-Ambroży (2015) demonstrated that the farms with the specialization in production achieve higher economic efficiency. The PTE and scale efficiency of high diversified farmers were better than low diversified farmers. It suggests that the high diversified farmers are

highly skilled than the low diversified farmers. In low diversified farms, the main cause for the significantly lower TE is the technical inefficiency.

Table 8. Technical, allocative and economic efficiency level of the farms

Level	Low diversified farms		High diversified farms		
	Average	Std. deviation	Average	Std. deviation	p-value
TE	0.73	0.19	0.79	0.14	0.09
AE	0.78	0.20	0.65	0.24	0.01
EE	0.57	0.23	0.52	0.23	0.31
PTE	0.54	0.22	0.59	0.21	0.22
scale	0.72	0.19	0.75	0.20	0.59

Based on the scale efficiency analysis, the low percentage of high diversified farmers (4.84%) had a constant return to the scale as compared to the low diversified farmers presented in Table 9. The percentage of the low diversified farmers having decreased return to the scale was higher than the others. Of the high diversified farmers, 82.26% received a high return to the scale. Türkten *et al.* (2017) also explained higher return to scale in the pest control methods adopter categories as compared to the nonadopter categories.

Table 9. Summary of return to the scale for the sampled farmers

	Low diversified farmers		High diversified farmers	
	No.	Percentage	No.	Percentage
DRS	5.00	13.16	8.00	12.90
CRS	3.00	7.89	3.00	4.84
IRS	30.00	78.95	51.00	82.26
Total	38.00	100.00	62.00	100.00

CONCLUION AND RECOMMENDATION

The differences among the farmers were rather for the relative land allocation for each crop, which categorized them into low and high diversified farmers. A significant portion of the sampled farmers was highly diversified in crop cultivation in the study area and had a better land allocation system than the low diversified farmers. The high diversified farmers were of young age, less formally educated, and having large family size with high farming experience as compared to low diversified farmers. Consequently, they well utilized the family labors, while the low diversified farmers were more dependent on the external labors.

Although the one-year return was low, the high diversified farmers were not in loss. Similarly, the stronger position of high diversified farmers in business was proved by a low associated risk. On the basis of the data on

price and yield fluctuations, the high diversified farmers were at zero business risk while the low diversified farmers had 36% probability of a getting loss. Based on efficiency analysis, the high diversified farmers were more technically efficient than other farmers. Their efficiency level could be improved further by the implementation of knowledge on market situations.

Taken together, the results of the present study regarding efficiency and business risk suggest that the crop diversification is a new paradigm of the sustainable farming techniques with multiple benefits in social, economic and environmental dimensions. The low business risk and high technical efficiency with positive return reveal the potential of diversified cropping as a sustainable system as compared to the specialized one. Nevertheless, the diversification promotes crop rotation and the usage of synthetic inputs based on different requirements of crops that keep the soil healthy and also accelerates the utilization of resources such as family labor.

The study recommends that the farmers should be trained for crops selection to diversify their farm which gives positive return like sugarcane, wheat, maize, and fodder crops rather than focusing on just one or two crops at whole land of farm. The farmers should not cultivate the rice crop which required high irrigation which increases the production cost and faces high business risk. The main role of the government would be to promote and educate the farmers on the profit earning crops in the study area.

The results of the present study regarding efficiency and business risk suggest that the crop diversifications a new paradigm of the sustainable farming techniques with multiple benefits which tries to minimize the in social, economic and environmental dimensions. The low business risk. High technical efficiency ensures with positive returns that enormously reveal the potential of diversified cropping as a sustainable system as compared to the specialized one. Nevertheless, the diversification promotes crop rotation and the usage of synthetic inputs based on different requirements of crops that keep the soil healthy and also accelerates the utilization of resources such as family labor. Therefore, farmers should be trained for crops selection to diversify their farm which gives positive return like sugarcane, wheat, maize, and fodder crops rather than focusing on just one or two crops at whole land of farm. However, it is strongly recommended

that the farmers should not cultivate the rice crop which required high irrigation which increases the production cost and faces high business risk. Hence, the role of government would be to promote and educate the farmers on the profit earning crops in the study area.

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