International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 7, Issue 2, 2015, pp.-445-449.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

EVALUATION OF RESOURCE EFFICIENCY AND DIVERSIFICATION INDEX UNDER VARIOUS FARMING SYSTEMS IN THE TRIBAL AREA OF CENTRAL GUJARAT

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Received: March 25, 2015; Revised: May 14, 2015; Accepted: May 18, 2015

Abstract- The present study examines the resource-use efficiency and extent of diversification in farming system in tribal region of central Gujarat. The maize- based farming system has been found predominant in the study area. Livestock, poultry, and cereals have been observed to be the main sources of farm income. To determine the level of diversification in various farming system different diversification index was employed. Among different index composite entropy index was found better than all other index because it considered weightage of number of crops. It was found that composite entropy index was highest (0.73) in FS-IV and lowest (0.60) in FS-I. Cobb-Douglas production function was used to estimate the resource use efficiency level. Findings revealed that the farmers were inefficient in using the resources. The seeds and irrigations were found to be over-utilized, while fertilizers, labourer and agrochemicals were found to be under-utilized. The results showed that appropriate adjustment is required for optimum allocation of resources and to maximize the revenue from the maize cultivation.

Keywords- Diversification index, composite entropy index, Cobb-Douglas production function, farming system, underutilized, optimum allocation, FS, resource use efficiency

Citation: Khorajiya M., Jadav K.S. and Darji V.B. (2015) Evaluation of Resource Efficiency and Diversification Index under Various Farming Systems in the Tribal Area of Central Gujarat. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 7, Issue 2, pp.-445-449.

Introduction

Over the period Indian agriculture confronting challenges like declining per capita availability of land in India, there is hardly any scope for horizontal expansion of land for food production. Only vertical expansion is possible by integrating appropriate farming components that require lesser space and time to ensure periodic income to the farmer. Further, modest increments in land productivity are no longer sufficient for the resource-poor farmers. Hence, intelligent management of available resources, including optimum allocation of resources, is important to alleviate the risk related to land sustainability. Due to India's geographical location, certain parts experience different climates, thus affecting each region's agricultural productivity differently. There are different types of crops that are cultivated throughout India which depends upon agro climatic condition of various region. Kharif crops are grown at the start of the monsoon until the beginning of the winter, relatively from June to November. Examples of such crops are rice, corn, millets, groundnut, moong, and urad. The basic aim of IFS (Integrated Farming System) is to derive a set of resource development and utilization practices, which lead to substantial and sustained increase in agricultural production [1].

Despite the steady decline in agriculture's contribution to the country's GDP, India agriculture is the biggest industry in the country and plays a key role in the socioeconomic growth of the country. India is the second biggest producer of wheat, rice, cotton, sugarcane, silk, groundnuts, and dozens more. It is also the second biggest harvester of vegetables and fruit, representing 8.6% and 10.9% of overall production, respectively. The major fruits produced by India are mangoes, papayas, sapota, and bananas. India also has the biggest number of livestock in the world, holding 281 million. Regions throughout India differ in types of farming they use; some are based on dhorticulture, ley farming, agro forestry, and many more. Study focused on different level of efficient utilization of existing resources which generate additional income to farming community with minimum wastage of resources. So, in the order to check the efficient use of available resources and diversification pattern in tribal region farming system approach was chosen.

Methodology

Selection of Districts

Among the six districts of Central Gujarat, Panchmahal and Dahod districts considered as tribal area where peoples are mainly depend on agriculture and labour work for their livelihood. Moreover, these districts are under developed in agriculture, economic, education and social point of view. Therefore for the development of such area it's a prime need for government as well as other institutions in implementing the development programme through available resources use management.

Selection of Sample Size

The next stage of planning was to select 120 maize growers. Looking to the financial and time constraints with the hand of the researcher, 10 respondents were selected proportionally according to different categories of the farmers, from each village for detailed study. Thus, in all, 120 (10x12) respondents of maize growers spread over 12 villages of Panchmahal and Dahod districts was comprised as the ultimate sample size for the detailed inquiry.

Measurement of Different Index for Diversification

The approach was used to study level of diversification which indicate extent and concentration of various farming activities in a given time and space. So, in the order to find extent of diversification through following diversification index were used namely [2].

Transformed Herfindahl Index (THI)

$$THI = 1 - \sum_{i=1}^{N} Pi^2$$

Since the herfindahl index is measure of concentration but for uniformity in comparison across different index, it is subtracted from one. The value of THI ranged from 0 to 1. As level of diversification increases, index become close to one and zero value in case of perfect concentration.

Entropy Index (EI)

$$EI = \sum_{i=1}^{N} Pi * \log Pi$$

Level of index increases in the extent of diversification and vice versa. The upper value of the index is greater than one, when number of crops is higher than value of logarithms base, and it can be less than one when the number of crops is lower than base of logarithms. So it is not comparable i.e rank is not possible.

Modified Entropy Index (CEI)

$$MEI = \sum_{i=1}^{N} \{Pi * LogN(Pi)\}$$

To overcome the limitation of EI by using variable base of logarithm instead of fixed logarithm. Index varies from zero to one. Value of index is zero means specialization and if index one indicate the case of perfect diversification.

Composite Entropy Index (CEI)

$$CEI = MEI * \{1 - (1/N)\}$$

This is ideal index for measurement of diversification because it possess all the desirable properties and useful in comparison across different situation having large number of crops since it gives weightage to number of crops. In the study comparisons among different farming system was made through this index.

where,

P_i = share of net income of the i^{th} farm enterprise in per farm net income

N= Number of farm enterprises in farming system

Production Function Analysis

In order to study resource productivity and allocative efficiency in different farming systems, a modified Cobb-Douglas type of function was fitted [3,4]. This was done with a view to determine the extent to which the important resources that have been quantified, explain the variability in the gross returns of the farming systems and to determine whether the resources were optimally used in these farming systems. The original function is:

$$Y = a \cdot X_1^{b1} \cdot X_2^{b2} \cdot X_3^{b3} \cdot X_4^{b4} \cdot X_5^{b5} \cdot X_6^{b6} \cdot X_7^{b7} \cdot e^{u} \quad (i)$$

Gross income considers as dependent variable and other variables as independent variables.

where,

Y = Gross returns in rupees

a = Intercept

X_1 = Land in hectares

X_2 = Cost of fertilizer + FYM

X_3 = Cost of human labour

X_4 = Cost of bullock labour

X_5 = Cost of feed

(Note: X_5 varies in FS-II and IV)

X_6 = Chick cost

(Note: X_6 varies in FS-III and IV)

X_7 = Transportation cost

bi = Elasticity of production (i = 1 to 7)

e^u = Error term

The returns to scale were estimated directly by getting the sum of 'bi' coefficients.

Marginal Value Productivity (MVP)

The ratio of the MVP to MFC of individual resources was used to judge the allocative efficiencies. The computed marginal value product (MVP) was compared with the marginal factor cost (MFC) or opportunity cost of the resource to draw inferences. A resource is said to be optimally allocated when it's MVP = MFC. The regression coefficients of inputs obtained were used to calculate marginal value products (MVP) at their geometric mean.

$$MVPxi = \frac{bi\ \bar{Y}}{\bar{X}}$$

where,

Y = Geometric mean of output (Y),

X = Geometric mean of respective inputs (x_i) and

b_i = Regression coefficient associated with the x_i input.

$$MVP\ for\ land = \frac{bi\ \bar{Y}}{\bar{X} * Rental\ value\ of\ land/ha}$$

where, Y = Geometric mean of output (Y),

X = Geometric mean of net area of respondents

b_i = Regression coefficient associated with the land

The criterion for determining optimality of resource use was

MVP/MFC > 1 under utilization of resource

MVP/MFC = 1 optimal use of resource

MVP/MFC < 1 excess use of resources

Result and Discussion

Based on the farming activities taken up by the sample respondents identified in study area and the results are presented in [Table-1]. With the given total number of respondents (120) basically maize growers, 24 had the crop enterprises *i.e.* maize, pigeon pea, wheat *etc.* which consider as Farming System-I, 36 respondents had combined the crops with animal enterprises that is FS-II, 32 respondents had consider poultry with crops, named as FS-III and remaining 28 respondents had adopting all above three enterprises as combined for maximization of resources efficiency termed as FS-IV. Total area was showed greater variability from system to system in which area under FS-I, FS-II, FS-III and FS-IV had 59.85 ha, 130.55 ha, 84.98 ha and 113.75 ha respectively.

Table 1- Details of farming systems identified in the study area

Farming systems	Main crops		Non crop enterprise	Total Number of respondents	Total Area (ha)	Total Number of Animals	Total Number of Birds
	Kharif crops	Rabi crops					
FS-I	Maize + Pigeon Pea	Wheat	-	24	59.85	-	-
FS-II	Maize + Pigeon Pea	Wheat	Animal husbandry	36	130.55	218	-
FS-III	Maize + Pigeon Pea	Wheat	Poultry	32	84.98	-	620
FS-IV	Maize + Pigeon Pea	Wheat	Animal husbandry + Poultry	28	113.75	184	581
Total				120	389.13	402	1201

Diversification Index of Different Farming Systems

Diversification index for different farming systems was calculated separately using the different index formula to know the level of diversification. Index was calculated based on the share of respective enterprises in net income of given farming system. It revealed from the [Table-2] that, the CEI was higher in FS-IV (0.73) followed by FS-II (0.65), FS-I (0.60) and FS-III (0.58). Higher index reveals more diversification in given farming systems consider less risky farming system. It also reveals from the [Table-2] that diversification index in FS-III was lowest among the farming systems prevailing in the tribal area of Central Gujarat. It is due to the adoption of poultry enterprises not as commercial one but only as backyard and hence the share of this enterprise found lower (9.67 per cent). Moreover THI and EI was higher in FS-III while MEI was observed higher in FS-I and FS-III. The results reported by Murty [5] and Torane, et al [6] were closer to these findings.

Table 2- Diversification index of different farming systems

Particular	FS-I	FS-II	FS-III	FS-IV
THI	0.61	0.58	0.69	0.64
EI	1	1.09	1.26	1.24
MEI	0.91	0.78	0.91	0.77
CEI	0.6	0.65	0.58	0.73

Resources Efficiency and MVP to MFC Ratios for FS-I

The results showed that the elasticity's of production were found positive as well as negative [Table-3]. It is inferred that among the explanatory variables, land and cost of human labour were found positive whereas the fertilizer + FYM and bullock labour costs were negative under FS–I. The value of land (X_1) was found statistically significant at 5 per cent, which indicates that one per cent increase in the land area would bring 0.1004 per cent increase in the gross income. The fertilizer + FYM (X_2) and bullock labour (X_4) showed negative elasticity that is -0.0009 and -0.0079, respectively. Though, it was statistically non-significant indicating excess utilization of these resources. It may be due to lack of knowledge about the scientific crop cultivation practices among the tribal farmers. The elasticity of human labour (X_3) did not contributed to the gross income as they were statistically non-significant, indicating that at the current level they were applied at optimum level. The value of co-efficient of multiple determinations (R^2) was 0.53. The sum of regression co-efficient (Σbi's) was 0.24, indicates the diminishing returns to the scale. It means the gross income of this farming system decreases proportionately with an increase in the variable factors. The estimated marginal value products (MVP), factor costs and their ratio were computed and the results are given in [Table-3]. The data revealed that the MVP/FC ratio was 0.22 in land, -0.022 in fertilizer + FYM, 0.87 in human labour and -0.15 in bullock labour indicating that resources were found over utilized. The production function analysis gave statistically non-significant and negative value to the fertilizer + FYM and bullock labour. The MVP-Factor Cost ratio indicated that an additional expenditure of one rupee on fertilizer + FYM and bullock labour would reduce the gross revenue by Rs -0.022 and Rs -0.15, respectively. Hence, economically efficient farmers have to reduce the expenditure on fertilizer + FYM and bullock labour.

Table 3- Resources use efficiency estimates and MVP/ MFC ratios for FS-I

SNo	Particulars	Coefficients	Estimated Values (Std. error)	Factor Cost	MVP : MFC Ratios
1	Intercept	a	8.8340 (1.1975)	-	-
2	X_1 - Land (ha)	b_1	0.1004** (0.0371)	1	0.22
3	X_2 - Fertilizer + FYM cost (Rs/ha)	b_2	-0.0009 (0.0389)	1	-0.022
4	X_3 - Human labour cost (Rs/ha)	b_3	0.1511 (0.1332)	1	0.87
5	X_4 - Bullock labour cost (Rs/ha)	b_4	-0.0079 (0.07458)	1	-0.15
		R^2	0.53		
		Returns to scale	0.24		

Figures in parentheses indicate standard error

** Significant at 5% level of significance

Resources use efficiency estimates and MVP/MFC ratios for FS -II

The regression coefficients of resources included in the FS-II are presented in the [Table-4]. It could be observed from the [Table-4] that, the regression coefficients for all resources used by the farmers were positive except bullock labour. The regression coefficients of feed (X_5) was found statistically significant at 10 per cent, which indicates that one per cent increase in the feed cost per animal would bring 0.4336 per cent increase in the gross income. The elasticity of land (X_1), fertilizer + FYM (X_2) and human labour (X_3) found 0.0098, 0.0160 and 0.1372, respectively which indicated that these

variables did not contributed to the gross income as they were statistically non-significant, indicating that at the current level they were applied at optimum level. The bullock labour (X_4) showed negative elasticity (-0.0041) however, it was statistically non-significant indicating excess uses of these resources. Farmers should reduce the use of bullock labour which causes reduction in bullock labour cost. The value of R^2 showed about 0.71. Further, the value of return to Scale presented in [Table-4] was 0.59 indicates that the respondents of FS-II operated in zone-II. The ratios of MVP to MFC were greater than unity for feed cost (3.70) and human labour cost (1.08) means an addition of one rupee in feed cost and human labour cost would yield returns of Rs 3.70 and Rs 1.08, respectively. The ratio was less than unity for land (0.025) and fertilizer + FYM (0.85). The reduction in the use of unit of land and fertilizer + FYM will add to gross return in given sample farms. The negative ratio of bullock labour (X_4) indicates excess use of this resource means, expenditure of Rs 1 in bullock labour cost would reduce the gross revenue by Rs 0.17. So, farmers can increase gross returns by reducing bullock labour cost.

Table 4- Resources use efficiency estimates and MVP/MFC ratios for FS-II

SNo	Particulars	Coefficients	Estimated Values (Std. error)	Factor Cost	MVP : MFC Ratios
1.	Intercept	a	5.8549 (2.2629)	-	-
2.	X_1 - Land (ha)	b_1	0.0098 (0.0927)	1	0.025
3.	X_2 - Fertilizer + FYM cost (Rs/ha)	b_2	0.0160 (0.0982)	1	0.85
4.	X_3 - Human labour cost (Rs/ha)	b_3	0.1372 (0.4428)	1	1.08
5.	X_4 - Bullock labour cost (Rs/ha)	b_4	-0.0041 (0.1649)	1	-0.17
6.	X_5– Feed cost (Rs/ animal)	b_5	0.4336* (0.2162)	1	3.70
		R^2	0.71		
		Returns to scale	0.59		

Figures in parentheses indicate standard error
*Significant at 10% level of significance

Resources use Efficiency Estimates and MVP/MFC Ratios for FS-III

Data presented in [Table-5] indicated that the regression coefficients for all resources used by the farmers were positive except fertilizer + FYM and bullock labour. Land (X_1) was positive and highly significant, while cost of human labour (X_3) and chick cost (X_6) was significant at 10 per cent level of significant which showed positive impact of these three variables on gross income. Elasticity of land (X_1), human labour (X_3) and chick cost (X_6) indicates that one per cent increase in these variables would bring 0.1450, 0.1711 and 0.0518 per cent increase in the gross income. The elasticity of feed cost (X_5) and transportation cost (X_7) were non-significant indicating the current level they were applied at optimum level. The fertilizer + FYM (X_2) and bullock labour (X_4) showed negative elasticity (-0.0034) and (-0.0498). However, it was statistically non-significant indicating excess uses of these resources. The value R^2 was 0.5 and return to scale was 0.48 indicating decreasing return to scale. MVP/FC ratio was the highest in case of chick cost (66.26) followed by transportation cost (10.20) and feed cost (6.75). It means that an addition of one rupee in chick cost per bird, transportation cost and feed cost per bird would yield return of Rs 66.26, Rs 10.20 and Rs 6.75, respectively. The ratio of rental value of land was 0.26 and for human labour it was 0.96, which indicates excessive use of this resource in the tribal area of Central Gujarat. So these inputs were to be minimized to get the optimum level of output. The labour cost ratio was positive and less than unity, indicating over utilization means the contribution will increases by increasing the efficiency of labour. Value of cost of fertilizer + FYM was non-significant and negative, hence, it is needed to reduce the cost of fertilizer and bullock labour will increase gross income.

Table 5- Resources use efficiency estimates and MVP/MFC ratios for FS-III

SNo	Particulars	Coefficients	Estimated Values (Std. error)	Factor Cost	MVP : MFC Ratios
1	Intercept	a	7.9731 (0.9761)	-	-
2	X_1 - Land (ha)	b_1	0.1450*** (0.0448)	1	0.26
3	X_2 - Fertilizer + FYM cost (Rs /ha)	b_2	-0.0034 (0.0072)	1	-0.13
4	X_3 - Human labour cost (Rs /ha)	b_3	0.1711* (0.0950)	1	0.96
5	X_4 - Bullock labour cost (Rs /ha)	b_4	-0.0498 (0.0419)	1	-0.91
6	X_5– Feed cost (Rs / bird)	b_5	0.0651 (0.0465)	1	6.75
7	X_6 – Chick cost (Rs / bird)	b_6	0.0518* (0.0261)	1	66.26
8	X_7 – Transportation cost(Rs /ha)	b_7	0.1042 (0.0688)	1	10.20
		R^2	0.51		
		Returns to scale	0.48		

Figures in parentheses indicate standard error
*** Significant at 1% level of significance
* Significant at 10% level of significance

Resources use Efficiency Estimates and MVP/MFC Ratios for FS-IV

The regression coefficients of the resources were shown in [Table-6] which revealed that, the regression coefficients for all resources used by the farmers were positive except fertilizer + FYM. It is inferred that among the explanatory variables, value of feed cost (X_5) was positive and significant at 5 per cent level of significance, whereas the chick cost (X_6) was significant at 10 per cent level of significance. Elasticity of feed cost (X_5) and chick cost (X_6) indicates that one per cent increase in these variables would bring 0.3258 per cent and 0.1871 per cent increase in the gross income. The elasticity of land (X_1), human labour (X_3) and bullock labour (X_4) did not contribute to the gross income as they were statistically non-significant and found positive. The positive value of production elasticity implies that these inputs were applied at the optimum level. The fertilizer + FYM (X_2) showed negative elasticity (-0.0497) however it was non-significant indicating excess uses of these resources. The value of R^2 was 0.84. The sum of regression coefficient was 1.17 indicating increasing return to scale. It means the gross value increases proportionately with an increase in the variable factors. Thus, it can be concluded from the foregoing results that among prevailing farming systems, FS-IV was operating in first zone while FS-I, FS-II and FS-III were operating in second zone. So, there is a scope to increase the gross return by increasing the investment on factors included in the analysis of efficiency of re-

sources in FS-IV. MVP/FC ratio was the highest in case of chick cost (80.60) followed by bullock labour cost (14.16), feed cost (3.18), human labour cost (2.71) and rental value of land (1.35). This indicates that an addition of one rupee in chick cost per bird, bullock labour cost, feed cost, human labour cost and rental value of land would yield return of Rs 80.60, Rs 14.16, Rs 3.18, Rs 2.71 and Rs 1.35, respectively. The MVP/FC ratio found negative value in fertilizer + FYM. It indicated that an additional expenditure of one rupee on fertilizer + FYM cost would reduce revenue by Rs -3.42, means over investment for these resources which need to invest optimally.

Table 6- Resources use efficiency estimates and MVP/MFC ratios for FS-IV

Sr. No	Particulars	Coefficients	Estimated Values	Factor Cost	MVP : MFC Ratios
1	Intercept	a	3.3238 (3.0123)	-	-
2	X_1 - Land (ha)	b_1	0.1532 (0.1425)	1	1.35
3	X_2 - Fertilizer + FYM cost (Rs /ha)		-0.0497 (0.0781)	1	-3.42
4	X_3 - Human labour cost (Rs /ha)	b_3	0.3070 (0.4423)	1	2.71
5	X_4 - Bullock labour cost (Rs /ha)	b_4	0.2435 (0.1905)	1	14.16
6	X_5 - Feed cost (Rs / animal)	b_5	0.3258** (0.1470)	1	80.60
7	X_6 - Chick cost (Rs / bird)	b_6	0.1871* (0.0995)		
		R^2	0.84		
		Returns to scale	1.17		

Figures in parentheses indicate standard error
** Significant at 5% level of significance
* Significant at 10% level of significance

Conclusion

Level of diversification was found varied from system to system, however CEI was found higher in FS-IV it means that under this system diversification was observed higher and less risky compare to other farming system. As far as resources use efficiency was concerned, it was observed that return to scale in FS-I was found 0.24 but it can be optimize by reducing all the factors involved in the model. In Cob Douglas production function sum of bi directly gives the return to scale which determine the zone in which production activities carried out. FS-II was operated in IInd zone of production function because the sum of regression coefficient was 0.59. Gross income can be increased by increasing the cost on human labour and feed and by decreasing the cost of bullock labour, fertilizer and rental value of land. In case of FS-III, it operated in IInd zone of production function and sum of regression coefficient was 0.48. The resource use efficiency can be optimize by reducing the cost on bullock labour, fertilizer, human labour and rental value of land and by increasing the cost on feed, chicks and transportation. FS-IV was observed in Ist zone that refers increasing return to scale and the optimum level can be achieved by decreasing the cost of fertilizer with increasing the cost on bullock labour, feed, human labour, chick and rental value of land. Hence, efficiency of resources is found not equally utilized in maize based farming systems which showed rejection of earlier hypothesis.

Conflicts of Interest: None declared.

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