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# Resource use efficiency in rainfed integrated farming systems: A case study of Mahabubnagar district

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**Abstract**

Integrated Farming Systems is considered as a strategy to increase output and resource use efficiency, but the resources under IFS are interlinked, more in number and distributed among components unlike single crop. Hence, this paper aims at understanding resource use efficiency of Integrated Farming practices.

The study was undertaken in rainfed area of Southern Telangana Zone i.e., Mahbubnagar district using multi-stage sampling technique. The analysis proceeded with the major farming systems in the study area i.e., Crop, Crop -Cattle, Crop - Cattle - Goat, Crop - Cattle – Sheep designated as FS-I, FS-II, FS-III and FS-IV. Cobb-Douglas production function was employed to analyse resource use efficiencies of Integrated farming systems.

The highly adopted farming system (FS-II) shows constant returns to scale, FS-I & FS-III shows decreasing returns to scale and FS- IV shows increasing returns to scale. Livestock integrated farming systems (FS-II, FS-III and FS-IV) indicate optimal allocation of cattle, except for Crop - Cattle – Goat (over-allocated). The size of goat herd in FS-III and size of sheep flock in FS-IV, were over allocated indicating more scope for reorganisation to achieve highest resource use efficiency.

**Keywords:** Integrated farming systems (IFS), resource use efficiency (RUE), cobb-douglas (C-D) production function

## 1. Introduction

The advent of the Green Revolution in India in 1970's led to the growth process in the agricultural sector, routed farmers to focus on few crop enterprises instead of maintaining different complimentary and supplementary enterprises. Now, modern agriculture in India is facing multiple and complex changes in the production context, particularly the scarcity of natural resources accompanied by raising food demand, impact of climate change, volatility of input-output prices, decline in profitability due to the decline in farm size, etc., challenges the farming and its sustainability.

Prevailing situations calls for an integrated approach which provides better solutions to the farming problems and calls for higher diversity in cropping pattern because cropping alone cannot sustain the small farm holders and enhances productivity to ensure profitability in farming.

Intending to mitigate the risk and uncertainty in agriculture, IFS is a powerful tool (Panwar *et al.* 2018) [1] to improve productivity, enhance profitability and sustainability and is less risky when a well-designed (Sobhapati, 2018) [4] system is adopted. If it is implemented systematically, it will allow the saving of resources and improves farm income. As IFS is one of the strategies to increase output and makes judicious use of resources in this context, it is emphasised on the resource use efficiency of the integrated farming systems.

Resources which are used for the production process are considered as the inputs that run production activities. Resources utilised for the integrated farming system as a whole are more in number, interlinked and distributed among the components unlike, for single crop/component. Resources either for a single crop or a farming system, must be utilised efficiently. Efficient utilisation indicates the best way of utilising the resources in obtaining maximum output with minimum costs. At the farm level, some resources may be under-utilised or over utilised, but the optimum utilisation of all the resources determines and enhances the resource use efficiency of the system and improves sustainability. To understand this, the resource use efficiencies of major farming systems in the study area were analysed.

### 1.1 Objective

1. To analyse the resource use efficiency of identified major farming systems.

## 2. Materials and Methods

To understand the resource utilization of the integrated farming systems in rainfed, drought prone and poor resource endowment conditions, Mahbubnagar district was purposively selected. Multistage sampling technique was used. Hanwada and Gandeed mandals were selected as more and less diversified mandals respectively based on Herfindahl's index. Four villages from each mandal and 15 farmers from each village were selected randomly. The data was collected by personal interview with the aid of pre-tested schedule, from 120 farmers.

### 2.1 Cobb-Douglas(C-D)

Cobb-Douglas(C-D) production function Is fitted to the data to estimate the resource use coefficients and to explain the variability in the dependent variable i.e., gross farm income by the important resources of the farming systems.
Function of the following general form were fitted for different Farming Systems.

$$Y = a\, X_1^{b1}.\, X_2^{b2}.\, X_3^{b3} \ldots\ldots\ldots\ldots\ldots X_n^{bn} e_i \qquad (1)$$

On linearization it becomes,
$LogY= log\ a+ b_1 logX_1 + b_2 logX_2 + b_3 logX_3 + b_4 logX_4 + \ldots\ldots\ldots\ldots + b_n logX_n + e_i$

$X_1, X_2, X_3, X_4 \ldots\ldots, X_n$ are the parameters affecting the level of Y.

$b_1 b_2, b_3, b_4 \ldots\ldots, b_n$ are the elasticity coefficients and 'a' denotes a constant.

Where, Y= Gross farm income (in Rs), $X_1$ = Land in acres, $X_2$ = Cost of seeds, $X_3$= Cost of fertilizers, $X_4$= Cost of FYM, $X_5$= Human labour cost, $X_6$= Animal labour cost, $X_7$ = Machine labour cost, $X_8$ = No. of cattle, $X_9$ = No. of goat, $X_{10}$ = No. of sheep, $b_i$ = Elasticities of production (i =1 to n), $e_i$= error term.

### 2.2 Returns to Scale

The returns to scale was estimated directly by the sum of "$b_i$" coefficients. The returns will be increasing ($b_i$ >1), constant ($b_i$ =1) or decreasing ($b_i$ <1) based on value of summation respectively.

### 2.3 Resource Use Efficiency

The ratio of the Marginal Value Product (MVP) and Marginal Factor Cost (MFC) of individual resources were used to judge the allocative efficiencies. The computed MVP was compared with the MFC or opportunity cost of the resource to draw inferences. A resource is said to be optimally allocated when its MVP = MFC. In Cobb-Douglas production function, Marginal Value Product (MVP) of $X_i$, the $i^{th}$ input factor is given by the following formula

$$\text{MVP of } X_i = b_i.\, (\bar{Y}/\bar{X}_i) \qquad (2)$$

Where,
$\bar{Y}$ = Geometric mean of gross farm income of respective farming systems, $\bar{X}_i$= Geometric mean of input $\bar{X}_I$, $b_i$. = Production elasticity of $X_i$

In imputing the marginal cost of the selected inputs like land and no. of animals, the average per acre value of land, average per head value of an animal, were taken as its marginal cost. The marginal cost of all other inputs was considered as one, since those are measured in value terms in regression analysis.

## 3. Results and Discussion

**3.1 Major farming systems and details of the components**: Based on the percentage of adoption, four were identified as major farming systems, those are Crop (FS-I), Crop – Cattle (FS-II), Crop - Cattle – Goat (FS-III), Crop - Cattle – Sheep (FS-IV). The most followed integrated farming system was Crop – Cattle (FS-II), adopted by 36.67 per cent. The second major farming system was Crop (FS-I) adopted by 20.83 per cent. The Crop - Cattle - Goat (FS-III) and Crop - Cattle – Sheep (FS-IV) were third and fourth major farming systems adopted by 19.2 and 9.17 per cent of the respondents respectively.
The average cropping acreage was 4.35, 5.91, 4.6 and 5.96 acres for FS-I, FS-II, FS-III and FS-IV respectively. The cropping pattern includes all the major crops paddy, red gram, jowar and maize, the other crops grown were groundnut, castor, cotton, vegetable, fodder, millets and onion.
Livestock possession of the integrated farming systems, cattle was the largely integrated livestock enterprise in all integrated farming systems. The average cattle size includes 4.84, 5.43 and 3.66 for FS-II, FS-III and FS-IV respectively. The average herd size of goat includes 25.56 for FS-III and average flock size of sheep include 88.33 for FS-IV given in Table 1.

**Table 1:** The average cropping acreage, average size of the cattle, goat, sheep of the major integrated farming systems.

| S. No | Major Farming Systems | % of adoption | Crop in ac. | Avg. (in no.) | | |
|---|---|---|---|---|---|---|
| | | | | Cattle size | Goat size | Sheep size |
| 1 | Crop (FS-I) | 20.83 | 4.35 | - | - | - |
| 2 | Crop -Cattle (FS-II) | 36.67 | 5.91 | 4.84 | - | - |
| 3 | Crop-Cattle-Goat (FS-III) | 19.2 | 4.6 | 5.43 | 25.56 | - |
| 4 | Crop-Cattle-Sheep (FS-IV) | 9.17 | 5.96 | 3.66 | - | 88.33 |

**3.2 Resource Use Efficiency of the FS-I (Crop):** The results of C-D production function model of the FS-I are presented in the Table 2. The coefficient of multiple determination ($R^2$) indicates variability in the gross income (Y) by independent variables is 95%.
The regression coefficients ($b_i$) for land, human labour, machine labour were observed positive and significant except, seed (NS) indicating that every one per cent increase of these resources would increase the gross income by 0.39, 0.52, 0.42 per cent respectively.
Whereas, $b_i$ for fertilizer, FYM and animal labour were negative and significant except for fertilizer and FYM. Every one per cent increase in the animal labour would decrease the gross income by 0.32 per cent.
The sum of the elasticities (0.95) indicates decreasing returns to scale i.e., there is still scope for the reorganization of the resources by reducing the costs incurred. Similar kind of results were obtained for crop-based farming systems by Phuge *et al.* (2020) [2]. The MVP to MFC ratio is greater than unity for land (5.11), human labour (2.89), machine labour

(3.78) indicating their under-utilization. The MVP to MFC ratios found to be negative and less than unity for animal labour (-10.86) indicating their over utilization.

**Table 2:** Results of Cobb-Douglas production of FS -I (Crop)

| Inputs | Particulars | $b_i$ | S E | MVP: MFC |
|---|---|---|---|---|
| | Intercept | 5.25 | | - |
| $X_1$ | Land (acres) | 0.3967 * | (0.0950) | 5.11 |
| $X_2$ | Seed (Rs) | 0.0566 NS | (0.0540) | 3.02 |
| $X_3$ | Fertiliser (Rs) | -0.0109 NS | (0.1659) | -0.20 |
| $X_4$ | FYM (Rs) | -0.1173 NS | (0.1425) | -9.28 |
| $X_5$ | Human labour (Rs) | 0.5191** | (0.0244) | 2.89 |
| $X_6$ | Animal labour (Rs) | -0.3151* | (0.0841) | -10.86 |
| $X_7$ | Machine labour (Rs) | 0.4248* | (0.0990) | 3.78 |
| | Coefficient of determination ($R^2$) | 0.93 | | |
| | Returns to scale ($\sum b_i$) | 0.95 | | |

Figures in parentheses indicates standard errors (SE).
***significance at 1per cent level, ** significance at 5per cent level, *significance at 10per cent level.

**3.2.1 Resource Use Efficiency of FS-II (Crop-Cattle):** From Table 3, The variability explained by the independent variables on (Y) is 88 per cent with ($R^2$) value 0.88.

The $b_i$ for all the resources were positive and significant for land (0.201), seed (0.078), fertilizer (0.223), FYM (0.165), No. of cattle (0.333). Every one per cent increase of these resources would increase the (Y) by their respective magnitudes.

FS-II indicates constant returns to scale (1.07). Similar kind of results were obtained for livestock integrated farming systems by Phuge *et al.* (2020) [2]. From MVP to MFC ratios, under-utilized resources were land (4.51), seed (8.05), fertilizer (10.08) and FYM (10.70). The ratio was (1.1) for the number of cattle, indicating its optimum allocation. None of the resources were over utilized.

**Table 3:** Results of Cobb-Douglas production of FS-II (Crop-Cattle)

| S.no | Particulars | $b_i$ | S E | MVP: MFC |
|---|---|---|---|---|
| 1 | Intercept | 7.1041 | | |
| 2 | Land (acres) | 0.2006* | (0.0856) | 4.5 |
| 3 | Seed (Rs) | 0.0783** | (0.0362) | 8.05 |
| 4 | Fertiliser (Rs) | 0.2226* | (0.1042) | 10.08 |
| 5 | FYM (Rs) | 0.1654 * | (0.0611) | 10.70 |
| 6 | Human labour (Rs) | 0.0329 NS | (0.0675) | 0.43 |
| 7 | Machine labour (Rs) | 0.0463 NS | (0.0788) | 7.01 |
| 8 | Cattle (in no.) | 0.3328* | (0.1059) | 1.10 |
| | Coefficient of determination | | 0.88 | |
| | Returns to scale | | 1.07 | |

Figures in parentheses indicates standard errors.
***significance at 1per cent level, ** significance at 5per cent level, *significance at 10per cent level

**3.3 Resource Use Efficiency of the FS-III (Crop-Cattle-Goat):** Table 4 shows 0.86 ($R^2$), with $X_i$'s of FS-III explaining 86 per cent of the variability in (Y).

The positively significant resources include seed, FYM, machine labour where unit additional expenditure would increase (Y) accounting for 0.155, 0.014, 0.046 per cent respectively. The negatively significant factors, cattle and goat indicates that every one per cent increase, would decrease (Y) by 0.14 and 0.06 per cent respectively.

The sum of elasticities (0.61), indicates decreasing returns to scale for the system. Seed (24.64), FYM (17.58) and machine labour (1.85) were under-utilized resources (MVP/ MFC >1); hence, there is scope for the reorganization. The cattle (-0.15) and goat (0.07) were over allocated.

**Table 4:** Results of Cobb-Douglas production of FS -III (Crop-Cattle-Goat)

| S.no | Particulars | $b_i$ | S E | MVP: MFC |
|---|---|---|---|---|
| 1 | Intercept | 0.0143 | | |
| 2 | Land (acres) | 0.0988 NS | (0.1332) | 0.35 |
| 3 | Seed (Rs) | 0.1548** | (0.0514) | 24.65 |
| 4 | Fertiliser (Rs) | 0.3974 NS | (0.2331) | 9.79 |
| 5 | FYM Cost (Rs) | 0.0138*** | (0.0013) | 17.58 |
| 6 | Human labour cost (Rs) | 0.0149 NS | (0.1915) | 0.22 |
| 7 | Animal labour cost (Rs) | 0.0795 NS | (0.0839) | 1.42 |
| 8 | Machine labour cost (Rs) | 0.0459* | (0.0195) | 1.86 |
| 9 | Cattle (in no.) | -0.136** | (0.0151) | -0.15 |
| 10 | Goat (in no.) | -0.0612** | (0.0260) | 0.07 |
| | Coefficient of determination ($R^2$) | | 0.8641 | 0 |
| | Returns to scale ($\sum b_i$) | | 0.6079 | |

Figures in parentheses indicates standard errors
*** significance at 1per cent level, ** significance at 5per cent level, *significance at 10per cent level

**3.4 Resource Use Efficiency of FS-IV (Crop-Cattle-Sheep):** Table 5; reveal $R^2$ value (0.93), indicating 93 per cent of the variability in the (Y) by $X_i$'s of FS-IV. The positively significant factors were human labour and cattle; unit additional expenditure would increase (Y) accounting for 1.87 and 0.31 per cent respectively.

Animal labour and sheep were found negatively significant indicating, one per cent increase of each would decrease the gross income by 1.16 and 0.38 per cent respectively.

The sum of elasticities (1.25) indicates increasing returns to scale for FS-IV. The human labour (1.34) was under-utilized resource (MVP / MFC >1). The ratio for no. of sheep (-0.51) and animal labour (-25.23) indicates over utilization/over allocation. No. of cattle (1.08) indicate optimum allocation.

The analysis indicates that variables like land, seed, FYM (Singh, H. *et.al* 2018) [3], machine labour, human labour, wherever found significant in the four farming systems, were under-utilized/under-allocated based on their MVP to MFC ratios, but animal labour was over-utilized. Similar results were obtained in the research work of Verma (2002) [5] where seed, manures & fertilizers, human labour and machine labour factors under-utilized by the small farmers.

**Table 5:** Results of Cobb-Douglas production of FS-IV (Crop-Cattle-Sheep).

| S. No | Particulars | $b_i$ | S E | MVP: MFC |
|---|---|---|---|---|
| 1 | Intercept | -3.01138 | (6.07237) | |
| 2 | Land (acres) | -0.0278 NS | (0.3251) | -0.93 |
| 3 | Seed (Rs) | -0.2090 NS | 0.1892) | -20.29 |
| 4 | Fertiliser (Rs) | 0.5172 NS | (0.7795) | 2.43 |
| 5 | Human labour (Rs) | 1.8704* | (0.8841) | 1.34 |
| 6 | Machine labour (Rs) | 0.3451 NS | (0.2452) | 38.04 |
| 7 | Animal labour (Rs) | -1.1652* | (0.7941) | -25.23 |
| 8 | Cattle (in no.) | 0.3130* | (0.095) | 1.08 |
| 9 | Sheep (in no.) | - 0.3843* | (0.1055) | -0.51 |
| | Coefficient of determination ($R^2$) | | 0.93 | |
| | Returns to scale ($\sum b_i$) | | 1.25 | |

Figures in parentheses indicates standard errors

*** significance at 1per cent level, ** significance at 5per cent level, *significance at 10per cent level,

## 4. Conclusion

The analysis of four major farming systems, concludes that (FS-II) shows almost constant returns to scale and hence highly adopted. FS-I & FS-III shows decreasing returns to scale and FS- IV shows increasing returns to scale. Land, Seed, FYM, machine labour, human labour, animal labour were the resources wherever found significant, were under-utilized/under-allocated based on their MVP to MFC ratios, but animal labour was over-utilized. Livestock integrated farming systems (FS-II, FS-III and FS-IV) indicate optimum allocation of cattle except for FS-III (over-allocated). The size of goat herd in FS-III and size of sheep flock in FS-IV were over allocated. Hence, the optimal allocation of cattle, decrease in size of over-allocated resources (goat and sheep) and increased use of significantly contributing under-utilised resources bring overall optimality of farming systems and renders higher income to the farmers.

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