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RESEARCH PAPER

Resource Use Efficiency of Farming Systems in Koramangala Challaghatta Valley Project Area, Karnataka

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ABSTRACT

The research empirically estimates the resource use efficiency and resource-saving target ratio of farmers in the Koramangala-Challaghatta Valley Project (KCVP) and Non-Koramangala -Challaghatta Valley Project (NKCVP) area using Data Envelopment Analysis (DEA). The study collected data from Kolar district in Karnataka, where 160 vegetable growers were selected using snowball sampling. Data were gathered through the utilization of pre-tested questionnaires and interview schedules. The study examined the efficiency of resource utilization among vegetable farmers, assessing both overall technical efficiency and pure technical efficiency through the application of a neoclassical non-parametric model called Data Envelopment Analysis. Furthermore, the study delved into resource overuse and estimated the resource-saving of various inputs used on the farm.

HIGHLIGHTS

- In the KCVP area, FS-I recorded the highest technical (0.74) and pure technical efficiency (0.90), followed by FS-II, FS-IV, and FS-III.
- In the NKCVP area, FS-I also showed the highest technical efficiency (0.86), followed by FS-IV, FS-II, and FS-III.
- FS-I consistently exhibited the most efficient resource utilization across both KCVP and NKCVP areas.
- Comparative analysis reveals that resource use was more efficient in the NKCVP area than in the KCVP area.
- FS-III showed the lowest efficiency scores in both regions, indicating potential for improvement in resource use.

Keywords: Technical efficiency, Non-parametric, Farming-system, Efficiency, and Resource-saving

Ensuring food security at the household level remains a significant concern for the majority of small and marginal farmers. These economically disadvantaged farmers operate in varied, location-specific, and risk-prone environments, underscoring the need for the development of interdisciplinary technologies for their enterprises (Dar *et al.* 2006). Over the past five decades, the predominant focus of agricultural research has largely centered on component and commodity-based studies. This encompassed the advancement of crop varieties, livestock breeds, agricultural tools and machinery, as well as the application of fertilizers, pesticides, and various production and protection technologies. However, these efforts were often conducted in isolation and at the institute level. While this approach enabled farmers to increase their yields, it concurrently led to the overexploitation of resources. Consequently, there has been a decline in factor productivity, in-efficiencies in

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resource utilization, and ultimately reduced farm productivity and profitability. This trend has also contributed to broader issues such as environmental degradation, groundwater contamination, the introduction of toxic substances into the food chain, and increased exposure of farmers to various forms of risk and uncertainty, particularly in terms of price fluctuations in agriculture.

Thus, a farming system is a resource management strategy to achieve economic and sustained production to meet the diverse requirements of households while a system preserves the resource base and maintains a high level of environmental quality (Gill *et al*. 2009). The goal of a farming system is sustainability, achieved by optimizing the production process through the efficient use of inputs while preserving quality. Sustainable agricultural systems depend on minimizing input usage and chemicals to attain long-term productivity and environmental compatibility (Sadiq *et al.* 2015). However, previous research indicates that farmers frequently either overuse or sub-optimally utilize their resources. The natural resource base of the country is under threat from modern farming methods and must be safeguarded to prevent irreversible degradation (Phuge *et al.* 2020). Sadiq and Isah argued that better and more informed management, and specifically management of ecological interactions and processes, are required to replace high inputs in sustainable systems. The crucial factor, as defined by Rahman and Lawal (2003), is the capacity to attain maximum output per unit of resource, which is essential for effectively addressing the challenges associated with achieving food security.

In this context, the study was conducted to assess the resource use efficiency of specific farming systems and determine the resource-saving target ratio. The aim was to understand how efficiently resources are utilized on farms in both the KCVP and NKCVP areas.

METHODOLOGY

The study was carried out in the Kolar district of Karnataka. The main objective of the study was to estimate the resource use efficiency along with the resource-saving target ratio in the study area. Therefore, the study primarily relies upon primary data collected from sample farmers. Insights from previous studies and discussions with field experts revealed that farming systems in the region are significantly influenced by the proximity of farmers to urban centers. The study used the data from two distinct categories of farmers from KCVP and areas other than KCVP area within the district. The region in which irrigation tanks are filled with treated sewage water, lifted from Bangalore city is considered as KCVP region, and other regions in which irrigation tanks are not filled with treated sewage water but use bore-wells to supplement the irrigation are considered as NKCVP region.

The villages surveyed to meet the primary data requirement of the study included Chowdadenahalli, Doddavallabbi, Singenahalli, Dinnehosalli, Uddapanahalli, Lakshmisagara and Narasapura in KCVP area, while Imarakunte, Dasarathimmanahalli, Baipanahalli, Nukkanahalli, Hoodali, Bangarpete, Mulbagal and Mallasandra villages in NKCVP area.

A snowball sampling was employed for the selection of respondents. The primary data were collected from 160 farm households, consisting of 80 farm households in KCVP area and 80 from NKCVP area, i.e., area outside the KCVP area. The distinction between two categories of respondents was on the basis of implementation of KC Valley Project (KCVP) i.e., number of village tanks filled with treated sewage water in the district. The data were collected from the respondents through personal interview methods using pre-tested, well-structured schedules. The villages were selected randomly based on the area in which tanks were filled under the project in the district. The required information regarding average land holdings, farming systems followed and resources used on the farm pertained to the agricultural year 2021-22 and farm income pertaining to previous year were collected.

Among the various farming systems followed in the district, it was decided to consider four major farming systems in each of the areas for detailed economic analysis. Detailed information on crops grown, inputs used, output obtained, input-output aspects of animal husbandry activities taken up by the sample farmers was elicited. The four major farming systems followed in the study area:

FS-I= $V + C + M + L$,

FS-II: $V + M + L$,

FS-III: V + C + L and

FS-IV: V + L,

where *FS*-Farming System, *V* = Vegetables, *C* = Crops other than vegetables (Ragi, fodder maize, pulse crops), *M* = Mulberry and *L* = Livestock (Dairy) in KCVP area.

In NKCVP area, *V* = Vegetables, *C* = Crops other than vegetables (Mango, Ragi, fodder maize, pulse crops), *M* = Mulberry and *L* = Livestock (Dairy).

Data Envelopment analysis

The Data Envelopment Analysis (DEA) is a nonparametric mathematical programming technique first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation. The DEA technique is used to estimate efficiency scores or levels of inputs or outputs from either an input or output orientation, either using constant returns to scale (CRS) or variable returns to scale (VRS) models. Following coelli *et al.* (1998) the linear programming models for the input-oriented measure of technical efficiency under the assumption of VRS, the envelopment form of the input-oriented VRS, DEA model can be specified as:

$$\mathrm{Min}_{\theta\,\lambda}\theta \quad \ldots(1)$$

Subject to;

$$Y_1 + Y_\lambda \geq 0,$$
$$\theta_{Xi} - X_\lambda \geq 0,$$
$$N^1\,\lambda = 1$$
$$\lambda \geq 0.$$

Where,

θ_1 is the i^{th} firm's Technical Efficiency (TE) score relative to the other firms in the sample ranging from zero to one. The θ value of 1 indicates a point on the frontier (100% efficiency) otherwise; the firm is operating below the frontier, with various degrees of in-efficiency, with zero indicating 100 percent in-efficiency. The analysis was done using R software.

In the analysis of efficient and in-efficient decision making units, the resource saving target ratio (RSTR) was calculated for farming system and is given as in (2). (Sadiq *et al.* 2015).

Resource Saving Target Ratio (%) =

$$\frac{\text{Resource saving target}}{\text{Actual resource input}} \times 100 \quad \ldots(2)$$

Where, resource saving target is the total amount of input that could be saved without decreasing output level. RSTR represents each in-efficiency level of resource usage. The value of RSTR is between zero and unity. A higher RSTR implies higher resource use inefficiency, and thus, a higher resource saving amount.

Here in the model, composite crop yield from all the enterprises are taken as dependent variable and inputs from all the enterprises (Seedlings/seed cost, cost on manures, cost on pesticides and fertilizers, cost on labour and other costs) were added together along with the technical efficiency of dairy and mulberry enterprises as one of the input variable, as output of dairy i.e., cow-dung acts as one of the input variable to ind the resource use efficiency of farming system. Technical efficiency (variable returns to scale) for dairy was found out separately because the input used in the dairy enterprise varies with crop production and even the output of dairy component cannot be taken in common terms.

RESULTS AND DISCUSSION

Resource use efficiency of sample farms in KCVP area

The efficiency analysis of the farming systems in the KCVP area using Data Envelopment Analysis (DEA) revealed significant variations in resource use efficiency scores across different farming systems. The estimated technical efficiency (TE) and pure technical efficiency (PTE) under both constant returns to scale (CRS) and variable returns to scale (VRS) are discussed below.

Farming System I (V + C + M + L)

The mean technical efficiency score for Farming System I was 0.74, while the pure technical efficiency score was found to be 0.90, indicating that a reduction in input use could enhance efficiency without affecting output levels. The distribution of technical efficiency scores revealed that 29.41 percent (5 farmers) had efficiency scores below 0.49, whereas 11.76 percent of respondents were in the efficiency range of 0.5-0.69 and 0.7-0.89. Additionally, 17.65 percent (3 farmers) had efficiency scores between 0.9-0.99, and an equal proportion (29.41%) of farmers operated at the most efficient level (efficiency score of 1.00) under CRS. Under VRS, a larger proportion (64.71%) of farmers achieved an efficiency score of 1, demonstrating improved efficiency in input utilization. This suggests that farmers practicing this system are effectively utilizing resources, but minor improvements in input allocation could enhance overall productivity.

Farming System II (V + M + L)

For Farming System II, the mean technical efficiency was 0.70, while the pure technical efficiency was 0.80. A relatively higher proportion of farmers (46.67%) achieved an efficiency score of 1, indicating a significant number of efficient farms. However, 26.67 percent (4 farmers) had scores below 0.49, 20 percent (3 farmers) fell in the range of 0.5-0.69, and 6.67 percent (1 farmer) were in the 0.7-0.89 category. Under VRS, a larger percentage (66.67% or 10 farmers) achieved an efficiency score of 1, followed by 20 percent (3 farmers) in the range of 0.5-0.69, with 13.33 percent of farmers falling below 0.49. These findings indicate that farmers adopting this system benefit from livestock and mulberry integration but could further enhance efficiency through better input allocation.

Farming System III (V + C + L)

Farming System III recorded a relatively lower technical efficiency (0.65), while the pure technical efficiency was 0.80. The efficiency distribution showed that 38.10 percent (8 farmers) had scores below 0.49, indicating substantial inefficiency. Meanwhile, 23.81 percent (5 farmers) were technically efficient with a score of 1, 19.05 percent (4 farmers) fell in the range of 0.5-0.69, 14.29 percent (3 farmers) were in the 0.7-0.89 range, and 4.71 percent (1 farmer) had an efficiency score between 0.9-1.0. Under VRS, more than half (57.14%) of the farmers attained an efficiency score of 1, with 23.80 percent (5 farmers) scoring below 0.49 and 9.52 percent (2 farmers) in the 0.5-0.69 and 0.9-1.0 efficiency range. This suggests that farmers in this system face significant resource allocation in-efficiencies, particularly in managing vegetables and crop production, and require targeted interventions to optimize input use.

Farming System IV (V + L)

In Farming System IV, the mean technical efficiency score was 0.68, while the pure technical efficiency was 0.83. Approximately one-third (7 farmers, 35%) had efficiency scores below 0.49, while 25 percent (5 farmers) achieved the most efficient level (score of 1.00). Meanwhile, 20 percent (4 farmers) fell in the 0.7-0.89 category, 15percent (3 farmers) in the 0.5-0.69 range, and one farmer in the 0.9-1.0 range. Under VRS, two-thirds (13 farmers, 65%) achieved full efficiency, while 20 percent operated below 0.49, 10percent in the 0.5-0.69 range, and 5percent (1 farmer) in the 0.9-1.0 efficiency category. These findings indicate that livestock-based systems require better feed management and optimized resource allocation to enhance efficiency.

The analysis of farming systems in the KCVP area reveals significant variations in resource use efficiency. Farming System I (V + C + M + L) exhibited the highest pure technical efficiency (0.90), indicating that integrating vegetables, cereal crops, mulberry, and livestock enhances resource utilization, though its technical efficiency (0.74) suggests input inefficiencies. Conversely, Farming System III (V + C + L) had the lowest technical efficiency (0.65), highlighting the need for better input management and resource allocation. The higher proportion of farmers achieving efficiency scores of 1 under variable returns to scale (VRS) suggests that scale inefficiencies play a key role, emphasizing the need for optimized farm sizes and resource strategies. The superior efficiency in Farming Systems I and II underscores the benefits of integrated farming systems, reinforcing the importance of diversification in enhancing farm productivity and sustainability, which policymakers and extension services should actively promote.

Resource use efficiency of sample farms in NKCVP area (n=80)

The estimated technical and pure efficiency at constant returns to scale and variable returns to scale for sample farms is presented in Table 2. The mean technical efficiency scores were 0.860, 0.77, 0.695 and 0.830 and that of pure technical efficiency levels were 0.907, 0.780, 0.8 and 0.69, for the Farming System I, Farming System II, Farming System III and Farming System IV, respectively.

The distribution of farmers according to technical efficiency scores revealed that in farming system I, 52.38 percent (11) of respondents were in the efficiency score range of 0.70-0.89 followed by 23.81 percent (5) of respondents were technically efficient with an efficiency score of 1.00, 19.05 percent (4) were in the range of 0.90-1.00 and one farmer (4.76%) was in the range of 0.5-0.69 efficiency score. Whereas, on the other hand at variable returns to scale, 47.61 percent (10) were purely efficient with an efficiency score of one followed by 33.33 percent (7) in the range of 0.90-1.00 and 19.04 percent (4) in the range below 0.49 (Table 2).

The majority of respondents in farming system II are technically efficient with 36.36 percent (4) with an efficiency score of one and in the range of 0.7-0.89 and 27.27 percent each (3) and even at constant returns to scale, four farmers technically efficient with score of one, three farmers were in the range of 0.7-0.89 and 0.9-0.99.

In Farming System III, 37.50 percent (6) of respondents were in the range of 0.50-0.69 followed by 31.25 percent (5) were technically efficient with an efficiency score of 1.00,18.75 percent (3) were below 0.49 efficiency score, 12.50 percent (2) were in the range of 0.7-0.89 efficiency score. And assuming variable returns to scale, 62.5 percent (10) of respondents were purely technical efficient at variable returns to scale with an efficiency score of 1.00 followed by 18.8 percent (6) were in the range of 0.5-0.69, 12.5 percent (2) were below 0.49, one farmer (6.25%) was in the range of 0.7-0.89(2).

Farmers who were practicing farming system-IV in NKCVP area, among them majority of farmers

Table 1: Resource use efficiency of Selected Farming systems in KCVP (n=80)

	FS-I (n=25)				FS-II (n=18)				FS-III (n=23)				FS-IV (n=15)			
	TE@CRS		PE@VRS		TE@ CRS		PE@VRS		TE@CRS		PE@VRS		TE@CRS		PE @VRS	
Range	No.	% to total	No.	% total	No.	% to total	No.	% to total	No.	% to total	No.	% to total	No.	% to total	No.	% to total
0-0.49	5	29.41	3	17.65	4	26.67	2	13.33	8	38.10	5	23.80	7	35	4	20
0.5-0.69	2	11.76	1	5.88	3	20.00	3	20.00	4	19.05	2	9.52	3	15	2	10
0.7-0.89	2	11.76	1	5.88	1	6.67	0	0.00	3	14.29	0	0	4	20	0	0
0.9-1	3	17.65	1	5.88	0	0.00	0	0.00	1	4.76	2	9.52	1	5	1	5
1	5	29.41	11	64.71	7	46.67	10	66.67	5	23.81	12	57.14	5	25	13	65
	17	100	17	100	15	100	15	100	21	100	21	100	20	100	20	100
Mean	0.745		0.9		0.7		0.8		0.65		0.8		0.68		0.83	

Note: *FS-I= V+C+M+L. FS-II: V+M+L, FS-III: V+C+L and FS-IV: V+L, where FS-Farming System, V= Vegetables, C=Crops other than vegetables (Ragi, fodder maize, pulse crops), M= Mulberry and L=Livestock (Dairy), CRS- Constant returns to scale, VRS- Variable returns to scale, TE-Technical Efficiency, PE-Pure Efficiency.*

Table 2: Resource use efficiency of Selected Farming systems in NKCVP (n=80)

	FS-I (n=21)				FS-II (n=11)				FS-III (n=16)				FS-IV (n=32)			
	TE@CRS		PE@VRS		TE@CRS		PE@VRS		TE@CRS		PE@VRS		TE@CRS		PE@VRS	
Range	No.	% to total	No.	% total	No.	% to total	No.	% to total	No.	% to total	No.	% to total	No.	% to total	No.	% to total
0-0.49	0	0.00	4	19.04	0	0.00	1	9.09	3	18.75	2	12.5	2	6.25	0	0
0.5-0.69	1	4.76	0	0.00	0	0.00	0	0.00	6	37.50	3	18.8	3	9.38	1	3.12
0.7-0.89	11	52.38	0	0.00	4	36.36	3	27.27	2	12.50	1	6.25	17	53.10	5	15.63
0.9-1	4	19.05	7	33.33	3	27.27	3	27.27	0	0.00	0	0	1	3.13	6	18.75
1	5	23.81	10	47.61	4	36.36	4	36.36	5	31.25	10	62.5	9	28.10	20	62.50
Total	21	100	21	100	11	100	11	100	16	100	16	100	32	100	32	100
Mean	0.860		0.907		0.77		0.780		0.695		0.800		0.83		0.69	

Note: *FS-I= V+C+M+L. FS-II: V+M+L, FS-III: V+C+L and FS-IV: V+L, where FS-Farming System, V= Vegetables, C=Crops other than vegetables (Ragi, fodder maize, pulse crops), M= Mulberry and L=Livestock (Dairy), CRS- Constant returns to scale, VRS- Variable returns to scale, TE-Technical Efficiency, PE-Pure efficiency.*

(53.10%) were in the efficiency score range of 0.7-0.89 followed by 28.1 percent (9) were technically efficient with an efficiency score of 1.00, 9.38 percent (3) were in the range of 0.50-0.69, 6.25 percent (2%) were below 0.49 efficiency score range and one farmer was in the efficiency range of 0.9-1.00. Efficiency scores for variable returns to scale i.e., pure technical efficiency was one for 62.5 percent (20) of sample respondents followed by 18.75 percent (6) in the range of 0.90-1.00, 15.63 percent (5) were in the range of 0.70-0.89 and one farmer (3.12%) was in the efficiency score range of 0.5-0.69 (Table 2).

The findings highlight that resource use efficiency varies across different farming systems, with higher efficiency observed under variable returns to scale (VRS), suggesting that scale inefficiencies are a key factor. Farming systems integrating multiple enterprises, such as vegetables, crops, livestock, and mulberry, demonstrated better efficiency, reinforcing the importance of diversification in optimizing resource utilization. The lower efficiency scores in some systems indicate the need for improved input management and resource allocation strategies. Since a significant number of farmers achieved full efficiency under VRS, policy interventions should focus on optimizing farm sizes, promoting precision agriculture, and enhancing access to better farming technologies to improve overall productivity and sustainability.

Resource-saving from different sources in Farming System-I in KCVP area

The results in Table 3 present the actual and optimal resource use in Farming System I (FS-I), estimated using Data Envelopment Analysis (DEA). The results indicate that input quantities can be reduced through better operational practices without affecting output. Farmers spent Rs. 34,122 on planting material, while the optimal usage was Rs. 30,250. FYM application was 16.84 TL, but the optimal level was 14.85 TL, suggesting an 11.81% saving. Fertilizer use could be reduced by 13.60% (132.89 kg), plant protection chemicals by 12.87%, and human labor by 13.83% (283.24 man-days instead of 328.72). Similar findings were reported by Pahlavan (2011) in tomato production in Iran, where a 25.15% resource saving was observed.

Resource-saving from different sources in Farming System-II in the KCVP area

The information on the actual use and optimal usage of resources in farming system II in the KCVP area are presented in Table 4. It was observed from the table that resource-saving percentage with the

Table 3: Resource-saving from different sources in Farming System-I in the KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource-saving	
				Quantity	Percent
1	Planting material(Rs.)	34122.80	30250.00	3872.80	11.35
2	FYM(TL)	16.84	14.85	1.99	11.81
3	FERT(Kg)	977.20	844.31	132.89	13.60
4	PPC(litres)	6.91	6.02	0.89	12.87
5	Labor(No.)	328.72	283.24	45.48	13.83

Note: *FYM- Farm Yard Manure, FERT- Fertilizers, PPC-Plant Protection Chemicals, TL-Tractor Load.*

Table 4: Resource use saving from different sources in FS-II in KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material(Rs.)	11583.77	10968.62	615.14	5.31
2	FYM(TL)	9.54	8.188	1.35	14.18
3	FERT(kg)	592.79	519.70	73.08	12.33
4	PPC(liters/kg)	2.62	2.44	0.18	6.87
5	LC(man-days)	164.74	141.41	23.33	14.16

Note: *FYM(TL)-Farm Yard Manure in tractor loads, FERT(kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals, LC-Labour cost.*

adoption of optimal usage of planting material was 5.31 percent, 14.18 percent of FYM, 12.33 percent (fertilizer), 6.87 percent (PPC),14.16 percent of cost on Human labor would be saved by following the optimal levels to obtain the actual output on the farm. And Similar kind of results were found by Sapkota and Bajracharya (2018) who made a study on resource use efficiency analysis for potato production in Nepal.

Resource-saving from different sources in FS-III in the KCVP area

The actual and optimal resource usage in Farming System III of the KCVP area are presented in Table 5. The results suggest that farmers can reduce resource use without affecting output levels. The resource-saving target ratio indicates potential savings of ₹ 4,447 on planting material, 3.84 TL of FYM, 193 kg of fertilizers, 1 liter of PPCs, and 81 man-days of human labor. Similar findings were reported by Tu, V.H. (2017) in Vietnam, highlighting resource use efficiency and economic gains in sustainable rice production.

Resource-saving from different sources in FS-IV in the KCVP area

The resource-saving target ratio in Farming System IV indicates that all considered inputs were over-utilized. By adopting optimal usage, farmers can achieve the same output while reducing input costs. The potential savings include 13 percent on planting material and FYM, 17 percent on fertilizers, 15 percent on PPC, and 16 percent on human labor costs. These findings align with Lokapur *et al.* (2014), who reported similar resource use efficiency improvements in vegetable farming in Belgaum district, Karnataka.

The resource-saving target ratio across all farming systems indicates that farmers are over-utilizing key inputs, leading to in-efficiencies. By adopting optimal resource use, significant cost savings can be achieved without compromising output. The highest savings were observed in fertilizers, FYM, plant protection chemicals, and human labor, emphasizing the need for better input management strategies. These findings highlight the importance of precision farming, improved agronomic practices, and policy interventions to enhance resource use efficiency. Aligning with previous studies, the results suggest that optimizing resource allocation can improve farm profitability and sustainability in the study area.

In the NKCVP area, results for FS-I (as shown in Table 7) reveal that resource savings across most inputs were minimal, indicating efficient resource utilization by farmers. Specifically, the potential

Table 5: Resource-saving from different sources in FS-III in the KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material (Rs.)	31660.91	27213.48	4447.43	14.05
2	FYM(TL)	21.09	17.25	3.84	18.21
3	FERT (kg)	945.13	751.93	193.20	20.44
4	PPC (litres/kg)	6.43	5.36	1.07	16.64
5	LC (man-days)	385.12	303.98	81.13	21.07

Note: *FYM(TL)-Farm Yard Manure in tractor loads, FERT (kg)-Fertilizer in Kilograms, PPC-Plant Protection Chemicals, LC-Labour cost.*

Table 6: Resource-saving from different sources in FS-IV in the KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource-saving	
				Quantity	Percent
1	Planting material(Rs.)	32708.12	28445.70	4262.43	13.03
2	FYM(TL)	16.05	13.85	2.20	13.68
3	FERT(kg)	951.59	790.71	160.88	16.91
4	PPC(litres)	6.71	5.67	1.04	15.55
5	HL(man-days)	311.16	260.02	51.14	16.44

Note: *FYM(TL)-Farm Yard Manure in tractor loads, FERT(kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals, LC-Labour cost.*

Table 7: Resource-saving from different sources in FS-I in the NKCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource-saving	
				Quantity	Percent
1	Planting material (₹)	14638.25	14553.35	84.90	0.58
2	FYM (TL)	8.09	7.03	1.06	13.10
3	FERT (kg)	502.97	489.32	13.65	2.71
4	PPC (litres)	2.17	2.15	0.01	0.55
5	LC(man-days)	139.15	122.09	17.06	12.26

FYM(TL)-Farm Yard Manure in tractor loads, FERT(Kg)-Fertilizer in Kg's, PPC-Plant Protection Chemicals, LC-Labor cost.

Table 8: Resource-saving from different sources in Farming System-II in the NKCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource-saving	
				Quantity	Percent
1	Planting material (₹)	16608.25	13535.35	3072.9	18.50
2	FYM (TL)	7.12	7.03	0.09	1.26
3	FERT (kg)	567.07	413.52	153.55	27.07
4	PPC (litres)	2.70	2.53	0.17	6.29
5	Labor (man-days)	169.50	138.09	31.41	18.53

FYM(TL)-Farm Yard Manure in tractor loads, FERT(Kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals.

Table 9: Resource-saving from different sources in Farming System -III in NKCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource Saving	
				Quantity	Percent
1	Planting material (₹)	34390.19	29245.60	5144.59	14.96
2	FYM (TL)	5.06	4.27	0.79	15.61
3	FERT (kg)	296.00	216.00	80.00	27.03
4	PPC (litres)	2.99	2.53	0.46	15.38
5	Labor (man-days)	108.00	94.00	14.00	12.96

Note: *FYM(TL)-Farm Yard Manure in tractor loads, FERT(Kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals.*

Table 10: Resource-saving from different sources in Farming system-IV in the NKCVP area

Inputs	Actual use	Optimum use	Resource Saving	Resource-saving
Planting material (₹)	19599.48	16680.44	2919.04	14.89
FYM (TL)	3.55	3.05	0.5	14.08
FERT (kg)	283	221	62	21.91
PPC (litres/kg)	2.01	1.72	0.29	14.43
Labor (man-days)	318.01	272.44	45.57	14.33

FYM (TL)-Farm Yard Manure in tractor loads, FERT (Kg)-Fertilizer(Kg's), PPC-Plant Protection Chemicals.

savings were only 0.58% for planting material, 2% for fertilizers, and 0.55% for plant protection chemicals (PPC). Slightly higher savings were observed for farmyard manure (FYM) and human labor at 13% and 12%, respectively. These low input-saving ratios suggest that farmers in FS-I are already using resources judiciously, which is consistent with the findings of Paled and Guledagudda (2018) in the context of hybrid seed production in Northern Karnataka.

In contrast, FS-II in the NKCVP area exhibited a higher potential for resource savings, particularly for fertilizers, where 27% could be saved—pointing to overuse. Human labor and planting material each showed an 18% saving potential, while PPC had a modest 6% savings margin. FYM, with just a 1% saving potential, was found to be the most efficiently utilized input in this system.

Resource-saving target ratio was found higher for fertilizer used on the farm (27%) followed by FYM and PPC (15%), cost on planting material (14%) and 13 percent of the cost on human labor can be saved by following the optimal usage to obtain the same level of output by the farmers in the Farming system III of NKCVP area. Similar kind of results were found by Naik *et al.* in 2018 while studying the resource use efficiency of Soybean in Belagavi District of Karnataka, India.

To obtain the same level of output by following the optimal usage of resources, the cost on planting material saved was 14.89 percent, FYM (14%), PPC (14%), human labor (14%), and the highest resource saving was found in the usage of fertilizers (22%) indicating farmers have overused the fertilizers in their farm fields by the farmers in farming system IV of NKCVP area.

In NKCVP area, resources were efficiently used in farming system I (Table 2), followed by Farming system IV, II and III respectively which is not only economical to farmers but also sustainable.

CONCLUSION

The study highlights variations in resource use efficiency among farms practicing four major farming systems in the study area. While some farmers in both KCVP and NKCVP areas operate at optimal efficiency levels, others demonstrate inefficiencies, indicating potential for improvement. Among the farming systems, FS-I emerged as the most efficient under constant returns to scale, followed by FS-II, FS-IV, and FS-III in both regions. The higher efficiency of FS-I is attributed to its diversified components, including vegetables, other crops (ragi, pulses, and fodder maize), mulberry, and milch animals, which contribute to better resource utilization. Notably, farms in the NKCVP area exhibited relatively better efficiency than those in KCVP. The resource-saving target ratio analysis indicates excessive use of key inputs, underscoring the need for improved input management. Promoting the adoption of recommended agronomic practices and encouraging farmers to seek expert guidance from extension agents and Raitha Samparka Kendras can enhance efficiency, ensuring sustainability and optimal resource utilization in the region.

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