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A COMPARATIVE ANALYSIS OF SUSTAINABILITY IN CROP AND DAIRY PRODUCTION SYSTEM IN TAMIL NADU, INDIA

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Abstract

Sustainability evaluation of crop and dairy production system was taken up in Tamil Nadu, India. Erode district was purposively selected for the present study. In the second stage, Erode, Modakkuruchi and Kodumudi blocks and four villages were selected purposively. From each production system, 40 farmers were selected at random and thus the total sample size was 160. Results indicated that both turmeric and sugarcane production systems were sustainable ecologically. Economically, turmeric cultivation was more sustainable by having higher stability and higher profitability. In social acceptability, turmeric was more sustainable in input self-sufficient index and while, sugarcane was more sustainable from equity criterion. Sustainable Rural Livelihood framework analyses revealed that foreign dairy production system was more sustainable. Livelihood security analyses showed that farmers of both the systems were sustainable. In integrated optimum plan, groundnut, tapioca, gingerly and green fodder was introduced as new enterprises and the gross cropped area was also increased. With respect to dairy enterprise, one foreign breed was introduced and at the same time, one local breed was reduced in the optimum plan. The policy advocacy suggested were credit policies, extension policies and future trading initiatives.

Keywords: Sustainability, Farm level indicators, Sustainable rural livelihood framework, Livelihood security and Optimum farm plans

I. INTRODUCTION

Sustainable agriculture may be regarded as the successful management of resources for agriculture to satisfy the changing human needs while maintaining or enhancing the quality of environment and conserving natural resources. (FAO, 1991). Sustainable development is the only way for rational utilization of resources and environmental protection without hampering economic growth. Integrated Farming Systems hold special position as in this system nothing is wasted, the by-product of one system becomes the input for other. India has a considerable livestock, poultry population and crop wastes.

The earlier studies focused mainly on development of sustainable farm plans, but, very little accessible information actually exists on the assessment of sustainability in India, especially

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in Tamil Nadu. Goswami (2002) made a study to develop optimum farm plan for a farming system in hills of Meghalaya and found that adoption of optimum farm plans will help in augmenting the income and employment of the tribal farmers, there by ecological and economic sustainability could be also achieved. Latinopoulos and Mytopowlos (2005) optimized allocation of land and water resources in irrigated agriculture by using the goal programming more specifically weighted lexicographic goal programme. The main objective of their study is to create, apply and evaluate a model that aimed at the simultaneous maximization of farmer's welfare and the minimization of the consequent environmental burden.

Shalendra and Tewari (2005) used lexicographic goal programming to develop optimum crop plan for sustainable crop production under alternative scenarios and measured their comparative sustainability status. They tried to minimize ecological and social problems associated with input intensive agriculture without adversely affecting the economic incentives of the farmers. Subrat (2006) used the linear and goal programming to optimize land use, water and nutrients in agricultural water shed area. The economics of various alternatives also were analyzed to arrive at a consensus solution that yielded an optimum cultivated area and net return, as well as permissible limits for agro chemicals in surface water. Umanath (2008) used lexicographic goal programming to develop optimum agricultural farm plans for different farming situations and block plan in a multi-objective frame-work for improving production and profit and other farming goals with the available resources.

There are only a few attempts of comparing sustainability between crop and dairy production system. In this juncture, this study focused on the issues of indicators of sustainability, sustainable rural livelihood framework and assessment of livelihood security of farmers which would apart from throwing light on differential evaluation of sustainability between these two systems and would be helpful to derive meaningful policy implications for welfare of the farmers. Keeping all these facets, this particular study was proposed in Erode district. Erode district ranked high in crop production and milk production. In crop production, turmeric and sugarcane covers the major area of the district and hence this study mainly concentrated on turmeric and sugarcane in crop production system. In dairy production system, it covered both the local and foreign breeds of Jersey and Holstien Freisian.

Objectives

The general objective of the study was to compare the sustainability in crop production system and dairy production system. The specific objectives were as follows:

1. To assess the sustainability status of crop production and dairy production system,
2. To assess the livelihood status of turmeric, sugarcane and dairy farmers,
3. To develop optimum farm plan for integrated farming system,
4. To identify constraints in production of turmeric, sugarcane and milk and suggesting suitable policy implications.

II. METHODOLOGY

Selection of the Study Area

Erode district was purposively selected for the present study. Erode district is well known for turmeric production. Turmeric is grown in 14,533 ha., which occupies the first position in area under turmeric in the state of Tamil Nadu and second place in production next to Coimbatore district. (Season and crop report of Tamil Nadu, 2013-14). The total turmeric production in Erode district was 29,567.88 MT in 2013 -14 in which Kodumudi block ranks first in production with 8,050 MT followed by Erode block with 3,635.78 MT in 2013 -14. (Report of 'G' Returns, Joint Director of Agriculture, Erode district, 2013). Sugarcane, one of the major crop in Erode district next to turmeric. It is cultivated in 20,415 ha in 2013 – 2014. In sugarcane, Erode district occupied sixth place in area, third place in terms of cane production and molasses (Gur) production in Tamil Nadu. Sugarcane yield stands third place next to Salem and Namakkal Districts. (Season and crop report of Tamil Nadu, 2013-14). Erode and Kodumidi block was selected for turmeric and sugarcane production system and from each block, two villages having highest turmeric and sugarcane areas were selected for this study.

The total milk production in Erode district was 8, 4,359,940 liters in 2013 – 14. Erode and Modakkuruchi block ranks high in milk production with 33,441,176 liters and 4,376,130 liters respectively. (Report of Joint Director of Animal Husbandry, Erode district, 2013). Hence these two blocks were selected for dairy production system. From each block, two villages with highest milk production were purposively selected. Villages in crop production system included Thindal, Nanjaikolaneli, Kolathupalayam and Muthampalyam. Villages in dairy production system included Salaipudur, Gangapuram, Velampalyam and Kulavilaku. From each selected village, 20 farmers were selected at random and hence multi stage random sampling technique was adopted for the study. The sample farmers in crop and dairy production system included 80 each and thus the total sample size was160.

Indicators of sustainability for crop production system

The three basic features of sustainable agriculture are: (i) maintenance of environmental quality, (ii) stable crop and animal productivity, and (iii) social acceptability. (Yunlong and Smith, 1994). Consistent with this, agricultural sustainability was assessed from the perspectives of ecological soundness, social acceptability and economic viability. 'Ecological soundness' refers to the preservation and improvement of the natural environment. It was assessed based on four indicators of land use pattern, cropping pattern, soil fertility status and pest and disease management. Economic viability refers to the maintenance of yields and productivity of crops and livestock. It was assessed based on three indicators; land productivity, yield stability and profitability from stable crops. Social acceptability refers to self- reliance, equality and improved quality of life. It was assessed in terms of input self-sufficiency, equity and food security.

Sustainable rural livelihood framework for dairy production system

Sustainable Rural Livelihood framework consists of evaluating five capital assets namely natural capital, financial capital, physical capital, human capital and social capital. Premchand and Smitasirohi (2012) studied the sustainable livestock production index in Rajasthan. The authors worked out the mean value of component indices with 0.371, 0.442 and 0.237 for economic efficiency index (EEI), social equity index (SEI) and ecological security index (ESI) respectively. Emma Jane Dillon et. al. (2014) studied the sustainable intensification of the Irish dairy Sector with the indicators of productivity, profitability and viability. It showed that gross output per hectare (a proxy for the productivity of land) was found to be € 3,069.00 in 2012 and market based gross margin, an indicator of farm profitability was found to be € 1,440.00 per hectare in 2012. And the economic viability was found to be 69.00 percent.

Livelihood security for both crop and dairy production system

Livelihood security indices were developed using indicators given in the livelihood security model of CARE. The selected indicators for livelihood security are food security, economic security, health security, educational security, habitat security and social network security. One to five point scales was developed for the following selected indicators in crop and dairy production system. Scale one indicated serious threat to livelihood security and scale five indicated well protected livelihood security. Centre for Agriculture and Extension (CARE), Kenya (1996) for the first time made an attempt to empirically quantify the various issues impinging upon livelihood security by developing a comprehensive livelihood security index. The index developed by CARE is based on six different types of security indices like health, education, food, habitat, economic and social network. Shyamalie and Saini (2010) attempted to assess and compare different livelihood security outcomes impacting on the livelihood security of women in similar agro climatic tea growing areas of Kangra district of Himachal Pradesh (India) and the NuwaraEliya district of Sri Lanka. The study is based on a number of important indicators suggested in the model developed by CARE, Kenya (1996).

Lexicographic goal programming

LGP model based on Romero and Rehman (1989) was used to generate optimum crop plans under alternative scenarios to ensure sustainable crop production. Critical dimension of sustainable agriculture are economic, ecological and social. Income goal (Economic); nitrogen goal, phosphorous goal, potash goal, green fodder goal, dry fodder goal, concentrates goal (Ecological); and employment goal (Social) were considered to reflect the three different dimension of sustainable agriculture. The step wise procedure for the development of Lexicographic Goal programming Model specified in the study is explained below.

In LGP, the goals are ranked according to their priority and goals with higher priority are satisfied first, before lower priority goals are considered in accordance with their order of ranking. The economic, ecological and social goals of sustainability were given first, second and third priority respectively. The model attempted to achieve these goals are subject to constraints on land use, area constraint on major crops of the region and capital use constraint.

Optimal farm plan for integrated farming system

The LGP model under pre emptive priority structure can be presented as

1) Minimize $Z = \sum P_i (W_i^+ d_i^- + W_i^- d_i^-)$ (achievement function) (W_i-Weights ; d_i— negative deviations from goals)

subject to constraints

2) $F_i(x) - d^+ + d_i^- - T_i$ (set of goals) (d^+- positive deviations from goals)

3) $x - b$ (set of linear constraints) (b- resource levels)

4) $x, d_i^+, d_i^- \geq 0$ (Non-negativity constraints)

5) $d_i^+, d_i^- = 0$ (for all goals)

The notion of pre emptive holds that the i^{th}priority. P_i is provided to the next priority P_{i+1} regardless of any multiplier associated with P_{i+1}. The relationship of priority factors can be written as

$P_1 >>> P_2 >>>.....>>>> Pi >>> .....>>>P_1$ which implies that the targeted goals at the highest priority before level P_1 are achieved to the extent possible before the set of goals at the next priority level P_2 is considered and so forth.

Formulation of lexicographic goal programming model

The parameters of the operational model are as follows:

r_j	=	Gross return from j^{th}crop/ milk activity (Rs. per ha).
R_j	=	Existing level of income (Rs)
n_j	=	Nitrogen consumption of j^{th}crop activity (kg per ha)
N	=	Total Nitrogen consumption for the whole farm (kg)
s_j	=	Phosphorous consumption of j^{th}crop activity (kg per ha)
S	=	Total Phosphorous consumption for the whole farm (kg)
k_j	=	Potash consumption of j^{th}crop activity (kg per ha)
K	=	Total Potash consumption for the whole farm (kg)
g_j	=	Green fodder consumption of j^{th}cow (kg/ cow/lactation)
G	=	Total green fodder consumption of dairy farm (kg)
d_j	=	Dry fodder consumption of j^{th}cow (kg/ cow/lactation)
D	=	Total dry fodder consumption of dairy farm (kg)
c_j	=	Concentrates consumption of j^{th}cow (kg/ cow/lactation)
C	=	Total concentrates consumption of dairy farm (kg)
e_j	=	Labor requirement for j^{th}crop / milk activity (man days per ha)
E	=	Total labor employment of farm (mandays)
X_{jc}	=	Area under of j^{th}crop grown in c^{th} season (ha)
L_c	=	Total area available in c-th season (ha)
X_t	=	Area under t^{th}major crop of the region (ha)
A	=	Aggregate area under the majorcrop (ha)
Cr	=	Capital requirement for j^{th}crop activity (Rs. per ha)
C	=	Total available capital (Rs.)

Then, the achievement function Z is minimized subject to the following operational goals and constraints.

1) $\sum rjxj\ d1- + d2+ = R$ Income goal

2) $\sum njxj\ d1- + d2+ = N$ Nitrogen consumption goal
3) $\sum sjxj\ d1- + d2+ = S$ Total Phosphorous consumption
4) $\sum kjxj\ d1- + d2+ = K$ Total Potash consumption
5) $\sum njxj\ d1- + d2+ = G$ Total green fodder consumption goal
6) $\sum sjxj\ d1- + d2+ = D$ Total dry fodder consumption
7) $\sum kjxj\ d1- + d2+ = C$ Total concentrates consumption
8) $\sum ejxj\ d1- + d2+ = E$ Total labor employment
9) $\sum Xjc <= Lc$ Land use constraint
10) $\sum Xt <= A$ Area use constraint
11) $\sum Xcr <= C$ Capital use constraint

Garrett's ranking technique

The problems in crop and dairy production system were analyzed using Garrett's ranking technique. The respondents were asked to rank the problems in crop and dairy production system. In the Garrett's ranking technique these ranks were converted into percent position by using the formula

$$\text{Percent position} = \frac{100 \text{ X } (R_{ij} - 0.5)}{N_j}$$

where,

R_{ij} = Ranking given to the i^{th} attribute by the j^{th} individual
N_j = Number of attributes ranked by the j^{th} individual.

By referring to the Garrett's table, the percent positions estimated were converted into scores. Thus for each factor the scores of the various respondents were added and the mean values were estimated. The mean values thus obtained for each of the attributes were arranged in descending order. The attributes with the highest mean value was considered as the most important one and the others followed in that order.

III. RESULTS AND DISCUSSION

Analysis of Agricultural sustainability using farm level indicators for crop production system

Agricultural sustainability was assessed by combining the three sustainability criteria of ecological soundness, economic viability and social acceptability.

Ecological sustainability

Ecological Sustainability was assessed based on cropping pattern, soil fertility management, use of chemical fertilizer and management of pests and diseases. Cropping pattern analyses revealed that turmeric and sugarcane were the major crops in crop production system. The cropping intensity in crop production system was 101.26. Crop diversification index for turmeric and sugarcane was 0.33 and 0.28 respectively. Table 1 reveals that Phosphorous content was low in both turmeric and sugarcane production. Potassium content was medium and nitrogen content was normal in both turmeric and sugarcane production.

The declining soil fertility has been a major concern for agricultural sustainability in the region. It is believed that declining land productivity, to a considerable extent, was due to lack of adequate amounts of organic matter in the soil. Use of chemical fertilizer was more in sugarcane with 469.08 kg/ha. (Table 2). Labor employment was higher in sugarcane cultivation with 261.67 man days than turmeric cultivation system. (Table 2).

The pest and disease management in both turmeric and sugarcane production was presented in Table 3. In both turmeric and sugarcane production, higher proportion of the farmers followed both chemical and biological control methods with 57 percent and 66 percent respectively for controlling pest and diseases. Forty three percent and 34 percent of the farmers applied pesticide alone in turmeric and sugarcane production. Thus both turmeric and sugarcane production systems are sustainable from ecological point of view.

Table 1. Soil-fertility status of sample farms

S.No.	Soil properties	Soil test value		Interpretation	
		Turmeric	Sugarcane	Turmeric	Sugarcane
1.	Nitrogen (kg/ha)	110.26	280.34	Normal	Normal
2.	Phosphorous (kg/ha)	18.06	28.66	Low	Low
3.	Potassium (kg/ha)	37.23	160.08	Slightly High	Slightly High

Table 2. Average input use in the sample farms

S. No	Input	Turmeric	Sugarcane
1.	FYM (t/ha)	4.20	4.80
2.	Fertilizer (kg/ha)	165.54	469.08
3.	Plant protection chemical (Rs/ha)	2900.00	12163.00
4.	Labour (in man days)	158.00	261.67

Table 3. Pest and disease management in the sample farms

S. No.	Particulars	Turmeric	Sugarcane
1.	Chemical alone	15 (43)	12 (34)
2.	Biological Control alone	-	-
3.	Both chemical and biological	20 (57)	23 (66)
4.	Total	**35** **(100)**	**35** **(100)**

Note: Figures in parentheses are percentages of the total

Economic viability

It was assessed based on three indicators; land productivity, yield stability and profitability of crops. The productivity analyses revealed that productivity of turmeric and sugarcane was

higher in crop production system. Fodder sorghum registered higher productivity in dairy production system. The stability of yield crop yield was examined by constructing an index based on farmer's subjective response to a question related to yield trend. In turmeric production, the index of yield stability was 0.17, whereas it was 0.14 in sugarcane production. The positive stability index in both the crops proved that those are stable.

The profitability of cropping system was analyzed based on financial and economic returns and value-addition per unit of land to understand the performance of an agricultural system. Profitability of turmeric and sugarcane was worked out for crop production system and the results are presented in Table 4. It has been found that the performance of turmeric cultivation was better than sugarcane cultivation as the output-input ratio was 2.27 in turmeric cultivation as compared to 1.87 in sugarcane cultivation. Net return was significantly higher in turmeric cultivation than sugarcane cultivation by 8.33 percent.

Table 4. Profitability of major principle crop in the sample farms

(in Rs. /ha)

S. No.	Particulars	Turmeric	Sugarcane
A.	**Financial**		
i.	Gross return	150000	162500
ii.	Total variable cost	58632	77858
iii.	Output-input ratio	2.27	1.87
B.	**Economic**		
i.	Net return	84186	75855
C.	**Value-addition**		
i.	Cost of chemical fertilizers	10280	15320
ii.	Cost of pesticides	2900	12163
iii.	Cost of fuel and charge of agricultural machinery use	5400	4350
iv.	Cost of intermediate goods (i+ii+iii)	18580	31833
v.	Value-addition*	131420	130667

*Value-addition = Gross return-Cost of intermediate goods

In order to determine the net contribution of agriculture to the economy, the value of chemical fertilizer, pesticide, fuels and other input services from outside the agricultural sector have to be deducted from the value of the agricultural output. The results indicated that the value-addition was almost similar with Rs.131420/ha in turmeric cultivation and 130667 in sugarcane cultivation. Thus the economic viability analyses showed that turmeric cultivation was more sustainable by having higher stability and higher profitability as compared to sugarcane cultivation.

Social acceptability

The high dependency on external inputs, such as chemical fertilizers, pesticides, and diesel and irrigation water increases farmer's vulnerability and reduces profit. The sustainability should seek to minimize dependency on external inputs. Hence, input self-sufficiency in the study area was analysed and presented in Table 5. Table 5 shows that in turmeric cultivation, the proportion of dependency on local inputs was higher with a proportion of 90.88 percent with comparative higher usage of local inputs, such as labour, seed, organic fertilizers and pesticides as compared to sugarcane cultivation with 84.42 percent. These were reflected in the input self-sufficiency ratios. It was 0.91 in turmeric cultivation and 0.84 in sugarcane cultivation. It clearly showed that turmeric cultivation was relatively more self-sufficiency in terms of input dependency than sugarcane cultivation.

Table 5. Input self-sufficiency

(In Rs. /ha)

S. No.	Particular	Turmeric	Sugarcane
1.	Cost of all variable inputs	146580 (100)	195020 (100)
2.	Cost of local inputs	133205 (90.88)	164645 (84.42)
3.	Cost of external inputs	13375 (9.12)	30375 (15.58)
4.	Input self-sufficiency ratio*	0.91	0.84

* Input self-sufficiency ratio = Cost of inputs / Cost of all variable inputs

Equity

The details of equity and food security are given in Table 6. It shows that labour requirement to produce one tonne of sugarcane was 1.61 man days and to produce one quintal of turmeric was 0.25 man days. Thus the labour usage was higher in sugarcane cultivation than turmeric which confirmed the sustainability of the sugarcane from the equity point of view.

Food security

Food security was measured in terms of household's food expenditure on food items following Yunlong and Smith (1994) methodology and the said analysis was limited to this framework. The expenditure on food items was Rs. 68714 and Rs. 70800 in turmeric and sugarcane production respectively. Thus for social acceptability point of view, turmeric is more sustainable from input self-sufficient index and sugarcane is more sustainable from equity point of view. Thus both turmeric and sugarcane production systems are sustainable from ecological point of view. Economic viability analyses showed that turmeric cultivation was more sustainable by having higher stability and higher profitability as compared to sugarcane cultivation. Turmeric is more sustainable from input self-sufficient index and sugarcane is more sustainable from equity point of view with the context of social acceptability.

Table 6. Equity and Food security

S. No.	Particulars	Turmeric	Sugarcane
1.	**Equity**		
i.	Labour requirement to produce one unit of output	0.25	1.61
ii.	Labour cost per unit of output (Rs.)	75.84	483.08
2.	**Food security**		
i.	Expenditure on food items	68714	70800

Sustainable rural livelihood framework for dairy production system

The selected indicators under Sustainable Rural Livelihood framework (SRL) were natural capital, financial capital, physical capital, human capital and social capital assets. These indicators were analysed for dairy production system and furnished in the Table 7. Natural assets were measured in terms of value of cow and cow shed value. Table 7 shows that cow value of local breed and foreign breed was Rs.18128 and Rs.201457 respectively. The cow value of foreign breed was higher over local breed by Rs. 183229. The cow shed value of local breed and foreign breed was Rs.7211 and Rs.12526 respectively. The Table 7 clearly depicts the financial assets such as income and saving were higher in foreign breed than local breed. Income and saving of foreign breed was higher by 184.20 percent and 37.82 percent respectively over local breed.

The value of durable assets in local and foreign breed was Rs. 114611 and Rs. 145095 respectively. The physical assets of foreign breed were higher by 26.60 percent over local breed. Human assets such as health and education were measured on the basis of expenditure. Expenditure on education was Rs.34419 and Rs.40568 in local breed and foreign breed respectively. Expenditure on health was higher with Rs.6500 in foreign breed than local breed (Rs.5750). The expenditure on education and health of foreign breed was higher by 17.87 percent and 13.04 percent respectively over local breed.

Table 7. Sustainable rural livelihood assets for dairy production system

S. No.	Assets	Local breed	Foreign breed
I	**Natural assets**		
	Cow (in Rs.)	18128	201457
	Cow shed value (in Rs.)	7211	12526
II	**Financial assets**		
	Income (in Rs.)	1,36,260	3,87,257
	Saving (in Rs.)	45643	62907
III	**Physical assets**		
	Durable assets (in Rs.)	114611	145095
IV	**Human assets**		
	Expenditure on education (in Rs.)	34419	40568
	Expenditure on health (in Rs.)	5750	6500
V	**Social assets**		
	Gender ratio	68	77
	Equity	0.41	0.16

It could be observed from the Table 7 that the gender ratio of males per thousand females was also high in foreign breed (77) than local breed (68). The Gini co-efficient value of income for the local and foreign breed was 0.41 and 0.16 respectively. The lower Gini coefficient ratio of 0.16 reflects that equity was higher in foreign breed as compared to foreign breed system. Thus in all the five assets, foreign breed production system showed superior results as compared to local breed production system indicating its more sustainability.

Livelihood status of crop and dairy farmers

After having analysed the sustainability of two production systems by the two approaches of farm level indicators and SRL framework, to give impetus to their livelihood security, the livelihood security of sample farmers in both crop and dairy production system were assessed by constructing five point scales and presented in Table 8. In particular, the table presents the comparative livelihood index scores for food security, economic security, education security, habitat security and social network security for both crop and dairy production system

Food security has been studied in terms of two indicators namely expenditure spends on food items and diet diversity. It could be observed from the Table 8 that the aggregate score of food security was almost similar in crop production system with aggregate mean score of 3.11 and dairy production system with aggregate mean score 3.03 . Further, the composite index of food security with a value slightly above the mid-point index score in the scale of one to five indicated that both production system enjoyed food security. Economic security index developed based on the score in the scale of one to five points. It could be observed from the Table 8 that aggregate mean score of economic security was almost similar with 3.31in crop production system and in dairy production system with 3.07. Further, the composite index of economic security with a value slightly above the mid-point index score in the scale of one to five indicated that both production system enjoyed food security.

The health security was measured by the accessibility to health services in the selected villages of both crop and dairy production system. The results showed that health security of both the systems were higher with mean score of 4.12 and 4.07.The educational security has been captured by indicators like literacy level and availability of schools. The index score of the overall educational security of both production systems was similar with 3.79 and 3.69. Also, these values were more than the mid values and hence both the system is sustainable. Habitat security was measured by quality of house, accessibility to drinking water and quality of drinking water and the analyses revealed the similar results for both the systems with 4.89 and 4.82. The index scores of the overall habitat security of farmers in both the production systems were more than the mid values, both the systems are sustainable.

Table 8. Livelihood security indices of crop production and dairy production system

S. No.	Assets	Crop production system	Dairy production system
1.	**Food security**		
	Food expenditure	3.08	3.16
	Diet diversity	3.14	2.89
	Aggregate mean score	3.11	3.03
2.	**Economic security**		
	Income	3.18	2.99
	Value of land/Cow	3.44	3.07
	Aggregate mean score	3.31	3.07
3.	**Health security**		
	Accessibility to health services	4.12	4.07
4.	**Educational security**		
	Literacy level	4.01	3.96
	Availability of schools	3.57	3.42
	Aggregate mean score	3.79	3.69
5.	**Habitat security**		
	Quality of house	3.82	3.75
	Accessibility to drinking water	4.95	4.88
	Quality of drinking water	4.69	4.71
	Aggregate mean score	4.89	4.82
6.	**Social network security**		
	Level of support(government and other agencies)	3.93	4.66
	Level of active participation in community organization	2.84	3.47
	Aggregate mean score	3.39	4.07

The overall score of the social network security and also in the individual criterion of level of support (government and other agencies) and level of active participation in community organization, dairy production system showed the superior results with an aggregate mean score of 4.09 than crop production system with a score of 3.39. The overall score of the social network security was higher than the mid-value in both the systems and hence both are sustainable. Thus it could be concluded from the livelihood security analyses that farmers of both the systems are having more livelihood security and especially in the social network criterion, dairy production system is more secure which indicated the support received by the dairy sector from Government and community.

Optimum Plan for Integrated Farming Systems

The Lexicographic objective Goal Programming model was constructed to develop integrated optimum farm plans for sustainable crop and milk production and the results of both existing and optimum plan are furnished in Table 9.The existing plan had a gross cropped area of 1.58 ha with 0.50 ha of turmeric, 0.60 ha of sugarcane and 0.40 ha of paddy and with a local breed of 2 numbers. The existing plan utilized 696 kg of nitrogen, 400 kg of phosphorus, 160 kg of

potash, 26.21 tonne of green fodder, 13.18 tonne of dry fodder and 1.11 tonne of concentrates, and earned an income of Rs. 577500.

It could be observed in the optimum plan that there was decrease in the area under sugarcane, turmeric, and paddy by 0.05 ha, 0.10 ha and 0.05 ha respectively. Groundnut, tapioca, gingelly and green fodder were introduced as a new enterprises into the optimum plan with an area of 0.15 ha, 0.10 ha, 0.08 ha and 0.05 ha respectively. The gross cropped area was1.50 ha in the existing plan which had increased to 1.78 ha in the optimal plan which showed an increase of 18.67 percent. With respect to dairy enterprise, one foreign breed was introduced and at the same time, one local breed was reduced.

Table 9. Optimum plan for sustainable crop and milk production

S.No.	Particulars	Existing Plan	Optimal Plan	Change in area and resource allocation
I	**Area under different crops (in ha)**			
1.	Turmeric	0.50	0.40	-0.10
2.	Sugarcane	0.60	0.55	-0.05
3.	Paddy	0.40	0.45	-0.05
4.	Groundnut	-	0.15	0.15
5.	Tapioca	-	0.10	0.10
6.	Gingelly	-	0.08	0.08
7.	Green fodder	-	0.05	0.05
	Gross cropped area	1.50	1.78	0.28 (0.19)
II	**Livestock no.**			
8.	Local breed	2.00	1.00	-1.00
9.	Foreign breed	-	1.00	1.00
II	**Goal**			
1.	Income goal (in Rs.)	577500	622500	45000 (7.79)
2.	Nitrogen (in kg)	696.00	683.75	-12.25 (-1.76)
3.	Phosphorus (in kg)	400.00	365.22	-34.78 (-8.70)
4.	Potash (in kg)	160.00	155.50	-4.50 (-2.81)
5.	FYM (tonne)	15.65	15.65	0.00 (0.00)
6.	Employment (man days)	824.52	863.78	39.26 (4.76)
7.	Green fodder (tonne)	26.21	25.86	-0.35 (-1.34)
8.	Dry fodder (tonne)	13.18	13.18	0.00 (0.00)
9.	Concentrates (tonne)	1.11	1.01	-0.10 (-9.01)

Note: Figures within parentheses indicate percent increase or decrease over existing plan

The optimum plan achieved the targeted income goal and increased the income by Rs.45000 with an increase of 7.79 percent over the existing plan. In contrast, the optimum plan reduced the existing level of nitrogen by 12.25 kg/ha, phosphorous by 34.78 kg/ha and potash by 4.50 kg/ha. This plan also reduced the existing level of green fodder by 0.35 tonne/lactation and concentrates by 0.10 tonne/lactation. The optimum plan increased the labour employment by 39.26 man days.

The goals namely income goal, nitrogen consumption goal, phosphorous consumption goal, potash consumption goal, green fodder consumption goal, concentrates consumption goal and employment generation goal were achieved in the integrated optimum farm plan. Thus the optimal plan achieved the economic goal along with ecological goal and social goal which is *prima facie* for the development of integrated sustainable farm plans in the region. The optimal plan included additional cropping enterprises of groundnut, tapioca, gingelly and green fodder and also the dairy enterprise of foreign breed which would lead to sustainability in the region through crop diversification and adoption of integrated farming system. Thus the preceding Lexicographic Goal Programming analyses demonstrated that integrated sustainable farming system plan could be developed with economic, ecological and social goals comprehensively in the real world situations without any conflict among the goals and could be adopted by farmers of the region.

Constraints in crop and dairy production system- Garrett's ranking

The farmers in the study area faced several problems in the crop and milk production. Hence it was decided to study the major constraints in the study area. The constraints identified by the sample crop and dairy farmers were ranked using Garrett's ranking technique and the details are furnished below.

Constraints faced by turmeric and sugarcane farmers

The five constraints identified by the sample turmeric and sugarcane farmers were ranked and the details are furnished in Table 10 and 11 respectively. The turmeric farmers expressed that the non-availability of labour was the most important constraint (62.42) as most of the labour in the area were more willing to work under Mahatma Gandhi National Rural Employment Guarantee Scheme. The second major constraint in the turmeric production was low price (55.34). It was evident that the famers received Rs.10000 per tonne in yester years but now it was reduced to Rs.2800 per ton. The next important constraint was high wage rate (44.64) and it was Rs. 350 for men and Rs. 280 for women respectively. Water scarcity and pest and disease incidence was the fourth and fifth constraints in turmeric cultivation with a score of 40.24 and 36.11 respectively

Table 10. Constraints faced by turmeric farmers

S.No.	Constraints	Mean Score	Rank
1	Non-availability of labour	62.42	I
2	Low price	55.34	II
3	High wage rate	44.64	III
4	Water scarcity	40.24	IV
5	Pest and disease attack	36.11	V

The sugarcane farmers expressed that the non-availability of labour was the most important constraint (64.44) as most of the labour in the area were more willing to work under Mahatma Gandhi National Rural Employment Guarantee Scheme[3]. The Second major constraint in the sugarcane production was high wage rate (56.71) and it was Rs. 350.00 for men and Rs. 280.00 for women respectively. The next important constraint was pest and disease incidence with a score of 48.35. Water scarcity and pest and high cost of fertilizer and plant protection chemicals was the fourth and fifth constraints in sugarcane cultivation with a score of 40.21 and 34.53 respectively.

Table 11. Constraints faced by sugarcane farmers

S. No.	Constraints	Mean Score	Rank
1	Non-availability of labour	64.44	I
2	High wage rate	56.71	II
3	Pest and disease attack	48.35	III
4	Water scarcity	40.21	IV
5	High cost of fertilizer and plant protection chemicals	34.53	V

Constraints faced by dairy farmers

The constraints faced by dairy farmers are presented in Table 12. The dairy farmers expressed that the lack of grazing land was the most important constraint (62.57) as the pastures and other grazing lands formed only 0.02 percent of total geographical area in Erode district. The second major constraint in the milk production was disease occurrence of Foot and Mouth disease and milk fever disease (54.82) which results in reduction of milk yield as evident from table 12. High price of concentrates and price fluctuation was the third and fourth constraints in milk production with a score of 43.41 and 39.16 respectively.

Table 12. Constraints faced by dairy farmers

S.No.	Constraints	Mean Score	Rank
1	Lack of grazing land	62.57	I
2	Disease occurrence	54.82	II
3	High price of concentrates	43.41	III
4	Price fluctuation	39.16	IV

IV. CONCLUSION

The sustainability analyses reveal that there are enhanced returns on the fronts of economic viability, ecology and social acceptability for developing turmeric and sugarcane production

[3] Mahatma Gandhi National Rural Employment Guarantee Act" (or, MGNREGA), is an Indian labour law and social security measure that aims to guarantee the 'right to work'. It aims to enhance livelihood security in rural areas by providing at least 100 days of wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work.

system. With respect to sustainable rural livelihood framework in dairy production system, with the five capital assets revealed that both the production systems are sustainable and hence government should devise suitable credit and extension policies for further all round development of both crop and dairy production system. Livelihood security analyses revealed that the livelihood security of farmers in both production systems is sustainable at present. So government should initiate agricultural development and welfare programmes for further continued sustainable development of farmers in the region.

The sustainable integrated optimum plan suggests from multi objective goal programming should be popularized in Erode district by agriculture department as it achieved all the conflicting economic, ecological and social goals which is a pre-requisite for the sustainable agricultural development of the region. The second major constraint in the turmeric production was low price and famers were receiving Rs.10000 per tonne in yester years but now it was reduced to Rs.2800 per ton. Hence the farmers in the region should follow future trading either by adopting warehouse receipt method[4] or practicing Demat account to eliminate price risk. The farmers felt that non availability of labour and high wage rate were the most important problems in cultivation of both turmeric and sugarcane. Hence, the introduction of labour - saving machineries in the study area would increase further the area of cultivation of both turmeric and sugarcane and finally to sustainable agricultural development.

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[4] A **warehouse receipt** is a document that provides proof of ownership of commodities that are stored in a warehouse, vault, or depository for safekeeping. Warehouse receipts may be negotiable or non-negotiable. Negotiable warehouse receipts allow transfer of ownership of that commodity without having to deliver the physical commodity. Most warehouse receipts are issued in negotiable form, making them eligible as collateral for loans. Non-negotiable receipts must be endorsed upon transfer. Warehouse receipts also guarantee existence and availability of a commodity of a particular quantity, type, and quality in a named storage facility. It may also show transfer of ownership for immediate delivery or for delivery at a future date. Rather than delivering the actual commodity, negotiable warehouse receipts are used to settle expiring futures contracts. Warehouse receipts may also indicate ownership of inventory goods and/or unfinished goods stored in a warehouse by a manufacturer or distributor.

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