Evaluation of Integrated Farming System Model for Resource Recycling and Livelihood Security of Small and Marginal Farmers of Telangana State, India

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors MG and CPK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GKR and SS managed the analyses of the study. MA, KC and MSK managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

Integrated farming system (IFS) model comprising the components like crop, horticulture, diary, sheep and poultry rearing was undertaken at All India Coordinated Project on Integrated farming system, PJTSAU, Rajendranagar, Hyderabad from 2010-11 onwards. Holistic integration of animals with crops in 1 ha area resulted in a total productivity of 36.4 t REY ha⁻¹ with the benefit cost ratio of 0.85 and net income of Rs.2,97,770/- with the total operational expenditure of Rs.3,48,796/- compared to that of an average farmers’ net income of Rs. 52,000 in Southern Telangana Zone of Telangana state in addition to generation of 602 man days of employment in the system. Out of this total net income, 54.02% returns from crop component including fodder, 10.43% returns from horticulture component and 31.9% from livestock unit, were recorded in the present model of Crop-Livestock-Horticulture along with production of diverse needs of farm family viz., cereals, pulses, oil

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seeds, fruits, vegetable, milk, meat and fodder for cattle. Through residue recycling and manure production 11.47 t of FYM, 70 kg of LPG equivalent gas and 1.81 t of biogas slurry were generated which is equal to 91-42-75 kg of N, P and K and saved worth of Rs 12133/-. Continuous use of crop residues and manures through residue recycling over these years helped improving the soil fertility of the unit with perceptible improvement in organic carbon from an initial status of 0.35% in ID block to 0.53%. Integrated farming system approach recorded 37.7 and 52.2 per cent higher productivity and profitability, respectively over conventional rice-groundnut system.

Keywords: Integrated farming system; productivity; employment generation; economics; livelihood; recycling.

1. INTRODUCTION

The research studies conducted in India and abroad had made it very clear that the efforts made towards single commodity based developmental activities could not achieve desired results and sustainability. Integrated farming system approach is not only a reliable way of obtaining a fairly high productivity with substantial fertilizer economy but also a concept of ecological soundness, leading to sustainable agriculture [1]. Indian economy is mainly governed by agriculture and allied operations. Majority of our farmers are marginal (<1 ha) and small (1-2 ha) landholders. Exploding population, urbanization and industrialization are leading to decline in per capita availability of vital agricultural resources and fragmentation of farm holdings, making them operationally uneconomic. Small and marginal farmers constituting 85% of the total farming community and possessing 44% of the total operational land control the core of Indian rural economy [2]. The process of marginalization of land holdings is likely to continue due to various demographic reasons. The per capita arable land has decreased from 0.34 ha in 1950-51 to 0.12 ha in 2011 and is expected to shrink further to 0.08 ha in 2025. The income from average farmers from cropping alone is hardly sufficient to sustain their family. The down trend of per capita land availability poses a serious challenge to the sustainability and profitability of farming [3], with hardly any scope for horizontal expansion of land for food production, vertical expansion by integrating appropriate farming components that require lesser space and time will pave the way to ensure reasonable periodic income to farm families [4]. Marginal (<1 ha), small (<1-2 ha size of holdings), and semi-medium (2-4 ha) farmers comprise about 80% of total operational farm holdings in India (134 million).

There are several basic needs including food (cereal, pulses, oilseeds, milk, fruit, honey, fish, meat, egg etc.) feed, fodder, fibre to be fulfilled besides employment, etc. for several generations. Proper understanding of interactions and linkages between the components would improve food production, employment generation as well as nutritional security. This multidisciplinary whole farm approach is very effective for solving the problems of small and marginal farmers [5]. This approach can be transformed into a farming system that integrates crops with enterprises such as agroforestry, horticulture, cow, sheep and goat rearing, fishery, poultry and pigeon rearing, mushroom production, sericulture and biogas production to increase the income levels. To have a systematic integration of multi-enterprise systems in a scientific manner, the present study was initiated during the year 2010-11 at Rajendranagar with an objective of developing a model under limited irrigation situation for efficient utilization of resources, in such a manner that product or by-product of one component becomes the input for other, becoming complementary and are organically well interlinked to each other without wastage and least disturbance to ecology.

2. MATERIALS AND METHODS

The one ha. model for marginal / small farmers comprised crops, horticulture and animal components. The horticulture component included a fruit crop guava and pasture components like hedge lucern and stylo santhes were taken as intercrops. The crop component included arable cropping systems viz., rice-groundnut, Bt Cotton+Greengram – Fodder Sorghum, maize-groundnut-sunhemp, maize+pigeonpea-sunhemp and sweetcorn+ pigeonpea-bajra crops, horticulture, fodder block were enclosed by boundary plantation of Sesbania sesban (Table 1). The livestock component of 2 dairy cows (Gir breed), (20 No. female adults + 1 No. male adult), sheeps (Nellore Judipi) and a unit of 200 Aseel breed.
poultry birds (Desi birds). Crops including horticulture and animals were raised by applying recommended package of practices utilizing the resources available within the farm to the maximum extent. The system was analysed by quantifying the productivity, profitability, resource recycling and employment generation. The productivity of different enterprises was converted in to rice grain equivalent yield based on farm gate price. Area allotted to each enterprise, cropping programme followed in crop production and horticulture component have been shown in Tables 1-3.

3. RESULTS AND DISCUSSION

The annual yields from the different components are presented in Tables 4.1 to 4.8.

Table 1. Different components of integrated farming system model in one hectare

| Enterprise             | Component    | Number | Net area (ha) allocated | Crop/Breed                                                                 |
|------------------------|--------------|--------|-------------------------|-----------------------------------------------------------------------------|
| Crop production        | Crops        | 11     | 0.60                    | Rice - Ground nut                                                           |
|                        |              |        |                         | Bt Cotton + Greengram - Fodder                                             |
|                        |              |        |                         | Sorghum                                                                    |
|                        |              |        |                         | Maize - Groundnut + Sunhemp                                                 |
|                        |              |        |                         | Pigeonpea + Sweetcorn - Bajra                                               |
|                        |              |        |                         | Pigeonpea + Maize - Sunhemp                                                 |
|                        | Fodder       | 2      | 0.1                     | Napier (perennial fodder)                                                   |
|                        |              |        |                         | Hedge Lucerne (perennial fodder)                                            |
| Horticulture           | Fruits       | 1      | 0.2                     | Guava (Main Tree)                                                          |
|                        |              |        |                         | (under storey pasture and fodders)                                          |
|                        |              | 4      | 0.12                    | Stylosouthes and hedge lucerne                                             |
|                        | Boundary     |        |                         | plantation with Sesbania sesban to meet fodder needs                       |
| Dairy                  | Gir cows     | 2      | 0.04                    | Gir breed                                                                  |
|                        |              |        |                         | 2 adults + 3 calves                                                        |
| Sheep Unit             | Sheep        | 20     | 0.015                   | Nellore Judipi                                                             |
|                        |              |        |                         | 20 adults + 1 kids                                                         |
| Backyard Poultry Fowls| Aseel Breed  | 200    |                         | Desi birds                                                                 |
| Area under supporting activities | Azolla production | 0.03 | Azolla production |
|                        |              |        |                         | Kitchen Garden                                                             |
|                        |              |        |                         | Biogas unit                                                                |

Table 2. Gross cropped area under different crops

| Farm produce                          | Gross area (m²) | % of total |
|---------------------------------------|-----------------|------------|
| i) Cereals (Rice, maize)              | 4000            | 25.00      |
| ii) Pulses (Green gram, Pigeonpea)    | 3000            | 18.75      |
| iii) Oilseeds (Groundnut)             | 3000            | 18.75      |
| iv) Commercial crops (Bt Cotton)      | 1000            | 6.25       |
| v) Millets (Bajra)                    | 1000            | 6.25       |
| vi) Green fodders: Napier & Hegde Lucerne (Perennial) | 1000 | 6.25 |
| vii) Sorghum, Sunhemp (Seasonal)      | 3000            | 18.75      |
| viii) Dry fodders (rice straw, maize stover) | -              | -          |
| Total                                 | 16000 m²        | -          |
Table 3. Gross cropped area under horticultural unit

| Fruits          | Number | Pasteures                      | Area   |
|-----------------|--------|--------------------------------|--------|
| i) Guava        | 42     | i) Hedge lucerne                | 800 m² |
|                 |        | ii) Stylosanthes hamata         | 400 m² |
| Total           |        |                                | 1200 m²|

3.1 Arable Crops Cropping Systems

During *kharif*, showed that rice grain yield was 1134 kg from 2000 sq m area from wet land block. From the upland block, maize produced 511 kg of grain yield from 1000 sq m area in maize-groundnut-Sunhemp cropping system, while in maize + pigeonpea – sunhemp system, maize yield was 485 kg of grain and pigeonpea produced 70.4 kg from 1000 sq m area. From pigeonpea + sweet corn – bajra system, 63.6 kg of pigeonpea and 1149 cobs of sweet corn and from Bt cotton + Greengram – Fodder Sorghum system, 46.4 kg of greengram and 184 kg of Bt cotton was recorded from 1000 sq m area. From the fodder block, 27.9 t of green fodder was produced during the season (Table 4.1). Pragathi Kumari et al. [6] reported, highest maize equivalent yield (11803 kg ha⁻¹) with Rs 78,820 ha⁻¹ net returns from cotton + green gram (1:2) – maize for green cobs cropping system compared to other cropping systems like maize-groundnut or maize-sunflower.

During *rabi*, 710 kg of groundnut pod yield was recorded from 3000 m² area with 1027 kg stover yield from Rice-groundnut and Maize-groundnut-sunhemp cropping system. From 1000 sq.m area of maize-groundnut-sunhemp cropping system, 1430 kg pod yield of sunhemp was recorded. In maize + pigeon pea – sunhemp cropping system, 1643 kg of green fodder and from Bt cotton + greengram – fodder sorghum system 4150 kg of green fodder was obtained. From pigeonpea + sweet corn – bajra, system 168 kg of grain yield with 319 kg of stalk yield was realized. From fodder block, 27958 kg of green fodder was obtained during the current year. From 0.7 ha area of cropping unit a net return of Rs 1,60,869 with a cost of cultivation of Rs 57,174 (Table 4.2) having 54.02% share in net income and 27.85% in gross income. This agrees with the findings of Radhamani [7], Esther et al. [8] and Kathirvelan et al. [9].

Table 4.1. Productivity (kg unit area⁻¹) and prices of field crops in cropping unit

| Cropping system                     | Area (m²) | Yield | Price          |
|-------------------------------------|-----------|-------|----------------|
|                                     |           | Kharif| Rabi           |                |
|                                     |           | Grain | Stover         | Grain | Stover |
| Rice – Groundnut                     | 2000      | 1134  | 1320           | 480   | 696    |
| Pigeonpea (PP)+Sweet corn (SC) -Bajra| 1000      | 63.6 kg PP + 1149 kg cobs | 173 PP + 1462 kg SC | 168 | 319 |
| Maize + pigeon pea – Sunhemp (green fodder) | 1000 | 485 (M) & 70.4 (PP) | 595 kg (M) & 210 kg (PP) | 0 | 1643 |
| Bt cotton + Green gram (GG) -Fodder sorghum | 1000 | 184 kg (Bt) & 46.4 kg (GG) | 426 kg (Bt) & 98.5 kg (GG) | 0 | 4150 |
| Maize-groundnut-Sunhemp              | 1000      | 511   | 684            | (G.nut) 230 | (G. nut)-331 sunhemp 1430 |
| Green Fodder                        | 1000      | 0     | 27958          |        |
| Total                               | 7000      |       |                |        |

Paddy : Rs 17.5 kg⁻¹ Rs.1.00/kg stover  
Bt Cotton : Rs 54.5 kg⁻¹ Rs.0.25/kg residue  
Greengram : Rs 69.75 kg⁻¹ Rs.2.00/kg stover  
Sunhemp: Rs 2.00 kg⁻¹ Rs.2.00/kg stover  
Green fodder (APBN-I): Rs 3.00 kg⁻¹  
Maize : Rs 17.00 kg⁻¹ Rs.1.00/kg stover  
Pigeonpea : Rs 56.75 kg⁻¹ Rs.0.25/kg stover  
Groundnut : Rs 48.9 kg⁻¹ Rs.3.00/kg stover  
Sweet corn : Rs 9 per kg cobs Rs.1.50/kg stover  
Fodder sorghum: Rs.2.00/kg stover
Table 4.2. Profitability (Rs unit area\(^{-1}\)) of different cropping systems in cropping unit of IFS

| Cropping system                      | Area (m\(^2\)) | Kharif COC | Kharif GR | Kharif NR | Rabi COC | Rabi GR | Rabi NR | System (Rs) |
|--------------------------------------|----------------|------------|-----------|-----------|----------|---------|---------|-------------|
| Rice – Groundnut                     | 2000           | 9973       | 21165     | 11192     | 7015     | 26952   | 19937   | 31129       |
| Pigeonpea + Sweet corn-Bajra         | 1000           | 6917       | 17336     | 10419     | 2949     | 3595    | 646     | 20931       |
| Maize + pigeon pea – Sunhemp         | 1000           | 5295       | 13011     | 7716      | 1664     | 3286    | 1622    | 16297       |
| Bt cotton + Green gram -Fodder sorghum| 1000           | 6499       | 15392     | 8893      | 2628     | 8300    | 5672    | 23692       |
| Maize-groundnut                      | 1000           | 4654       | 9371      | 4717      | 5478     | 15762   | 10284   | 15001       |
| Green Fodder                         | 1000           |            |           |           | 4103     | 83874   | 79771   |             |
| Total                                | 7000           | 33337      | 76275     | 42937     | 18031    | 55035   | 37004   | 160869      |

*Abbreviations in table: Cost of cultivation (COC), Gross returns (GR), Net returns (NR)

Table 4.3. Productivity and returns from horticulture unit

| Orchard & fodders                  | Area (m\(^2\)) | Fruit/ fodder Yield (kg plot\(^{-1}\)) | System (Rs plot\(^{-1}\)) |
|-----------------------------------|----------------|----------------------------------------|---------------------------|
| Base Orchard                      |                |                                        |                           |
| Guava                            | 2000           | 216                                    | 3172                      |
| Under storey fodders              |                |                                        |                           |
| Hedge lucerne                     | 800            | 10272                                  | 3503                      |
| Stylo                             | 400            | 1235                                   | 2176                      |
| Total                             |                |                                        | 8851                      |

*Abbreviations in table: Cost of cultivation (COC), Gross returns (GR), Net returns (NR)
| Particulars                  | Size                                      | No. of days | Production (Milk/ meat/ fodder) | Dung | Shed waste | Claves/ kids/ chicks | Production cost | Gross returns | Net returns |                |
|-----------------------------|-------------------------------------------|-------------|--------------------------------|------|------------|---------------------|----------------|---------------|-------------|----------------|
| Cows (Gir) (2+3) (01-6-2018 to 31-5-2019) | 2 Adults + 3 calves (Period) | 365         | (lit/kg) | (kg) | (kg) | (No) | (Rs.) | (Rs.) | (Rs.) |                |
|                             |                                           |             |                                          |      |            |                     |                |               |             |                |
|                             |                                           |             | 1254                                      | 20679 | 5095       | 3 calves           | 166534         | 176772        | 10238       |                |
|                             |                                           |             | (100328)                                  | (5170) | (1274)     | (70000)            |                |               |             |                |
|                             | FYM                                       | 100 sq.m    | Year round                                | 11470 |            |                     | 5430           | 11470         | 6040        |                |
|                             | Biogas unit                               | 2 Cu.m capacity | 70 kg (5 No LPG gas cylinders) (6750)  | Slurry 1815 kg |            |                     | 6354           | 8565         | 2211        |                |
| Sheep (Nellore jodipi) (01-6-2018 to 31-5-2019) | 36 Adults | 365         | 105                                       | 2640  |            | 441                 | (28215)        | (660)         | (119070)    | 75908          | 147945        | 72037        |
|                             |                                           |             | (28215)                                  | (660) |            |                     |                |               |             |                |
|                             | Poultry (200)                             | 200         | 365                                       | 90    | 225        | 82.5                | 25385          | 38101         | 12716       |                |
|                             | (01-6-2018 to 31-5-2019)                  |             |                                           |       |            |                     |                |               |             |                |
|                             | 103 live birds                            |             |                                           | 19895 | (56)       |                     | (18150)        |               |             |                |
| Total                       |                                           |             |                                           |       |            |                     | 279611         | 382853        | 103242      |                |

*Figures in parenthesis are value of the products
Table 4.5. Production and returns from kitchen garden of IFS unit

| Vegetables     | Production (kg) | Cost (Rs/kg) | Returns (Rs) |
|----------------|-----------------|--------------|--------------|
| Leafy vegetables | 227.5           | 10           | 2275         |
| Bhendi         | 7.5             | 20           | 150          |
| Beans          | 55.5            | 20           | 1050         |
| Tomato         | 86              | 10           | 860          |
| Brinjal        | 8.25            | 25           | 206          |
| Green chilli   | 14.75           | 40           | 590          |
| Coccinia       | 37              | 20           | 398          |
| Papaya         | 11              | 20           | 220          |
| Total          | 447.5           |              | 5749         |

3.2 Horticulture

Guava fruits (2000 m²) resulted in net returns of Rs. 31,070/-. Under storey pastures and fodder crops, hedge lucern and *Stylosanthes hamata* were raised in between guava rows. Intercropping of hedge lucerne in Guava orchard resulted in 10272 kg of fodder in five cuttings (Table 4.3). From horticulture unit a total net return of Rs 31,070/- was realized during current year.

3.3 Livestock Unit

From dairy unit, a total of 1254 l of milk was produced in 12 months period. The dairy unit given positive net returns of Rs 10732/-. In sheep unit, body weight increase of 441 kg was recorded from 36 sheeps during 12 months period and sheeps weighing around 105 kg were sold. Two goats weighing around 18 kg were dead. Around 20.67 t of dung and 5.09 t shed waste and 2.64 t of sheep manure was available for composting (Table – 4.4). Total net returns of Rs. 1,03,242/- was obtained from livestock unit. IFS would help in enhancing the productivity to satisfy the ever-increasing population of the country, and create confidence among farmers through higher profitability [10].

Milk @ Rs 50.00/l, shep meat @ Rs 270/ kg live, poultry meat @ Rs 220/ kg live, cattle dung @ Rs 0.25/kg, sheep dung @ Rs 0.25/kg, Shed waste @ Rs 0.25/kg, FYM @ Rs 1.00/kg and Vermicompost @ Rs 5/kg, Poultry litter @ Rs 0.25/kg

3.4 Kitchen Garden

In 250 sq.m area a kitchen garden with all seasonal vegetables was maintained to meet the vegetable requirement of farm family. From this unit a total 447.5 kg of vegetable were produced over a period of one year with a cost of production of Rs 3453/- and net returns of Rs 2296/-.  

3.5 Residue Recycling

Through residue recycling and manure production 11.47 t of FYM, 70 kg of LPG equivalent gas and 1.81 t of biogas slurry were generated which is equal to 91.42-75 kg of N, P and K and saved worth of Rs 12133/-. Continuous use of crop residues and manures through residue recycling over these years helped improving the soil fertility of the unit with perceptible improvement in organic carbon from an initial status of 0.35% in ID block to 0.53% (Table 4.6). Improvement in status of available phosphorus and potassium was also evident in IFS unit, with increased available phosphorus from an initial status of 14.8 to 38.81 in fodder block and above 30.0 kg under other cropping systems except for Maize-Groundnut and potassium from an initial of 170 kg ha⁻¹ to 266.2 kg ha⁻¹ (191.2 - 266.2 kg ha⁻¹).

Crop residues are used for animal feed, while manure from livestock enhance agricultural productivity by improving soil fertility as well as reducing the use of chemical fertilizers [11].

Holistic integration of animals with crops in 1 ha area resulted in a total productivity of 36.42 t rice grain equivalent yield (RGEY) ha⁻¹ and net income of Rs. 2,97,770/- and 0.85 Rs Re⁻¹ with the total operational expenditure of Rs. 348796/- (Table 4.8) compared to that of an average farmer’s net income of Rs. 52,000 in Southern Telangana Zone of Telangana state in addition to generation of 602 man days of employment in the system. This corroborates the findings of [12].
Table 4.6. Soil fertility status of IFS unit at the end of Rabi, 2018-19

| Soil parameter | Initial Maize + Bt cotton + greengram - F. sorghum | ID cropping systems & horticultural unit | Fodder | Guava orchard | Wetland systems |
|----------------|-----------------------------------------------|----------------------------------------|--------|---------------|----------------|
| pH             | 7.86                                         | 7.72                                   | 7.41   | 7.01          | 8.07           |
| EC (dSm⁻¹)     | 0.34                                         | 0.30                                   | 0.36   | 0.25          | 0.41           |
| OC (%)         | 0.43                                         | 0.42                                   | 0.40   | 0.45          | 0.53           |
| Avail. N (kg ha⁻¹) | 158                                        | 125.4                                  | 125.4  | 138.0         | 138.0          |
| Avail. P (kg ha⁻¹) | 14.8                                        | 27.1                                   | 31.7   | 31.3          | 38.8           |
| Avail. K (kg ha⁻¹) | 170.0                                       | 191.2                                  | 233.2  | 266.2         | 255.2          |

Table 4.7. Residue recycling in IFS model

| Compost / manure | N (kg) | P (kg) | K (kg) |
|------------------|--------|--------|--------|
| FYM – 11470 kg (N-0.57%, P- 0.25%, K– 0.48%) | 65.39   | 28.68  | 55.06  |
| Biogas slurry – 1.81t (N–1.47%, P-0.74%, K – 1.10%) | 26.62   | 13.32  | 19.94  |
| Total            | 91.0   | 42.0   | 75.0   |

*Abbreviations in table: Nitrogen (N), Phosphorous (P), Potassium (K)

Table 4.8. Productivity and profitability of IFS unit

| Item                             | Cropping unit | Livestock unit | Horticulture unit | Recycling unit | Kitchen garden | Total IFS | Conventional rice – groundnut system |
|----------------------------------|---------------|----------------|-------------------|----------------|----------------|-----------|-------------------------------------|
| Productivity RGEY (t ha⁻¹ yr⁻¹)  | 12.28         | 10.10          | 10.63             | 1.98           | 1.14           | 0.29      | 36.42                               |
| COC (Rs ha⁻¹ yr⁻¹)               | 57174         | 166534         | 101107            | 8851           | 11784          | 3159      | 348796                              |
| Gross Returns (Rs ha⁻¹ yr⁻¹)     | 218044        | 176772         | 186046            | 39921          | 20035          | 5749      | 646566                              |
| Net returns (Rs ha⁻¹ yr⁻¹)       | 160869        | 10237          | 84753             | 31070          | 8251           | 2590      | 297770                              |
| B: C ratio                       | 2.81           | 0.06           | 0.84              | 3.51           | 0.70           | 0.82      | 0.85                                |
| Employment                       | 114           | 255            | 189.5             | 15.7           | 18.5           | 9        | 602                                 |

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Employment generation in cropping alone (180) is limited to the key operations of sowing, intercultural operations and harvest and labour is not required during the rest of the year. Contrary to this, employment generation in a multi-enterprise farming system is spread uniformly throughout the year (602). The results corroborate this, and the finding is supported also by Devendra [13]. Sivamurugan [14] stated that integration of cropping with dairy + biogas + mushroom generated the highest employment of 875 mandays.

This total net income comprised 33.72% returns from crop component including fodder, 6.17% returns from horticulture component and 56.11% from livestock unit (Table 4.8).

4. CONCLUSION

Crop + Hortipasture + livestock Integrated farming system model resulted in the best integration of all the resources and would help in doubling the farmer’s income in addition to sustaining productivity. A sustainable integrated farming system provided maximum return and employment. It is clear that small and marginal farmers thrive by adopting Integrated farming system concept through efficient recycling of residues and sustain nutritional security, fodder security, economic security and finally social security.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh JP, Gangwar SA, Kochewadi SA, Pandey DK. Integrated farming system for improving livelihood of small farmers of western plain zone of Uttar Pradesh, India. SAARC Journal of Agriculture. 2012;10(1): 45-53.

2. GOI. Agricultural statistics at a glance, Directorate of Economics and Statistics, Govt. of India, New Delhi; 2014.

3. Siddeswaran K, Sangeetha SP, Shanmugam PM. Integrated farming system for the small irrigated upland farmers of Tamil Nadu. Extended Summaries: 3rd International Agronomy Congress, held during 26-30 November 2012 at New Delhi. 2012;3:992-993.

4. Gill MS, Singh JP, Gangwar KS. Integrated farming System and agriculture sustainability. Indian Journal of Agronomy. 2009;54(2):128–39.

5. Gangwar B. Farming systems research for accelerating agricultural development in less developed countries – a review. Agricultural Reviews. 1993;14(3):149-159.

6. Pragathi Kumari CH, Sridevi S, Goverdhan M. Profitable cropping systems for southern telangana zone of Telangana State, India. International Journal of Current Microbiology and Applied Sciences. 2018;7(01):2518-2525.

7. Radhamani S. Sustainable integrated farming system for dryland vertisol areas of Western Zone of Tamil Nadu. Ph.D. dissertation, submitted to Tamil Nadu Agricultural University, Coimbatore, India; 2001.

8. Esther D, Jayanthi C, Sankaran N. Physical indicators of sustainability – A farming systems approach for the small farmer in rainfed vertisols of the Western zone of Tamil Nadu. Journal of Sustainable Agriculture. 2005;25(3):43-65.

9. Kathirvelan P, Manickam S, Venkatachalam SR, Arutchenthil P, Deivamani M. Crop diversification with castor (Ricinus communis L.) for enhancing the productivity, profitability and resource conservation under rice based cropping system. Journal of oilseeds research. 2017;20.

10. Jayanthi C, Venilla C, Nalini K, Vivek G. Physical indicators on farm farming system for irrigated lands of Western zone of Tamil Nadu. Journal of Farming Systems Research and Development. 2007;13(1): 17-25.

11. Gupta V, Rai PK, Risam KS. Integrated crop-livestock farming systems: A strategy for resource conservation and environmental sustainability. Indian Research Journal of Extension Education, Special Issue. 2012;2:49-54.
12. Rangasamy A, Venkitasamy R, Jayanthi C, Purshothaman S, Palaniappan SP. Rice-based farming system: A viable approach. Indian Farming. 1995;44(11):27-29.

13. Devendra C. Goats: Challenges for increased productivity and improved livelihoods. Outlook on Agriculture. 1999;28:215-226.

14. Sivamurugan AP. Sustainable farming system under irrigated upland situation. Ph.D., Thesis, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu; 2001.

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