Evaluation of Integrated Farming System Model for Small and Marginal Farmers of Telangana State

M. Goverdhan¹, Ch. Pragathi Kumari²*, S. Sridevi³, M. V. Ramana⁴ and K. Suresh⁵

¹Department of Agronomy, AICRP on IFS, PJTSAU, Hyderabad-30 (Telangana), India.
²Department of Agronomy, AICRP on Integrated Farming Systems, PJTSAU, Hyderabad-30 (Telangana), India.
³Agricultural Polytechnic, Tornala, PJTSAU, Siddipet District, Hyderabad-30 (Telangana), India.
⁴Department of Agronomy, Rice Section, ARI, PJTSAU, Hyderabad-30 (Telangana), India.
⁵Department of Agronomy, Examination Cell, PJTSAU, Hyderabad-30 (Telangana), India.

Authors’ contributions

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

Article Information

DOI: 10.9734/CJAST/2020/v39i1030636

Editor(s):
(1) Dr. Orlando Manuel da Costa Gomes, Lisbon Accounting and Business School (ISCAL), Lisbon Polytechnic Institute, Portugal.

Reviewer(s):
(1) Qi Cheng, Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, China.
(2) M. Kiley, Worthington Centre of Eco Etho Research & Education Badgeworthy, Oare, UK.

Complete Peer review History: http://www.sdiarticle4.com/review-history/57044

Received 02 March 2020
Accepted 09 May 2020
Published 23 May 2020

ABSTRACT

The study was conducted to develop Integrated Farming Systems (IFS) model for limited irrigation situation. The land was earmarked for developing 1 ha. land for marginal/small farmers with crops, horticulture, fodders and animal components. This system resulted in total productivity of 41.4 t ha⁻¹ yr⁻¹ Rice Grain equivalent Yield (RGEY) along with employment generation of 830 man days. The net returns from 1 ha of crop + livestock (dairy and goat) + horticulture farming systems model was Rs. 2,17,336/-. Of this total net income, crop component including fodder comprised 27.74%, horticulture component comprised 4.41% and livestock unit shared 67.85%. Besides cash income, IFS generated employment for family labour. Recycling of bi-products from the livestock unit, sustains soil productivity.

*Corresponding author: E-mail: pragathi.agronomy@gmail.com;
Keywords: Integrated farming system; productivity; employment generation; economics; livelihood; recycling.

1. INTRODUCTION

Indian economy is mainly governed by agriculture and allied operations. 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 [1]. 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. Majority of our farmers are marginal (<1 ha) and small (1-2 ha) landholders. 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 down trend of per capita land availability poses a serious challenge to the sustainability and profitability of farming [2], 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 [3].

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). From the Green Revolution onwards, farmers have relied on single enterprise based agricultural systems particularly cereals based cropping systems that have over the years led to deterioration of soil health, increased risk of crop failure and downward trends in productivity [4]. 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. Judicious management of available resources, including optimal allocation of resources, is important to alleviate the risk related to land sustainability. Proper understanding of interactions and linkages between the components would improve food production, employment generation as well as nutritional security. Farming system research is considered as potential approach and powerful tool for management of vast natural and human resources in developing countries including India.

This multidisciplinary whole farm approach is very effective for solving the problems of small and marginal farmers [5]. This approach can be transformed in to 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. A farming family maintains multi-enterprise systems, depending upon his/her family requirements, knowledge base, socio-economic setup, agro-climatic conditions, farm resources and income opportunities. However, planning and implementation of different enterprises at farmers levels in our country lacks scientific and systemic approach. To have a systematic integration of multi-enterprise systems in a scientific manner, studies are required to evolve systems 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

Integrated Farming Systems research was initiated during the year 2010-11 at Rajendranagar with an objective of developing a model under limited irrigation situation. The one ha. model for marginal/small farmers comprised crops, horticulture and animal components. The horticulture component included a fruit crop guava and vegetables like tomato, bhendi during rainy season and cluster bean, beetroot in rabi season as intercrops. The crop component included arable cropping systems viz., rice-maize, rice-castor, maize-groundnut, 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 buffaloes (Murrah breed), (15 No. adults+18 No.kids) goats (Osmanabadi) and a unit of 50 backyard poultry birds (Vanaraja). 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 crops were irrigated by the drip irrigation system. The system was analysed by quantifying
Table 1. Different components of integrated farming system for ID situation of one hectare

| Enterprise          | Component                | Number | Net area (ha) allocated | Crop/Breed                                                                 |
|---------------------|--------------------------|--------|-------------------------|-----------------------------------------------------------------------------|
| Crop production     | Crops                    | 11     | 0.6                     | Rice-Maize                                                                 |
|                     |                          |        |                         | Rice-Castor                                                                |
|                     |                          |        |                         | BtCotton+Greengram – Fodder Sorghum                                        |
|                     |                          |        |                         | Maize-Groundnut                                                            |
|                     |                          |        |                         | Pigeonpea + Sweetcorn-Bajra                                                |
|                     |                          |        |                         | Pigeonpea + Maize – Sunhemp (green fodder)                                 |
|                     |                          |        |                         | Napier (perennial fodder)                                                  |
|                     |                          |        |                         | Lucerne (perennial fodder)                                                 |
| Fodder              |                          | 2      | 0.1                     | Napier (perennial fodder)                                                  |
|                     |                          |        |                         | Lucerne (perennial fodder)                                                 |
| Horticulture        | Fruits                   | 1      | 0.2                     | Guava (Main Tree)                                                          |
|                     | Vegetables               | 4      | 0.12                    | Tomato, Okra, Clusterbean, Beetroot                                        |
|                     | (under storey of fruit trees) |      |                         | Boundary plantation with Sesbaniasesban to meet fodder needs               |
| Dairy               | Buffaloes                | 2 adults+3 calves | 0.04                  | Graded Murrah breed                                                        |
| Goatery             | Goat                     | 15 adults +18 kids | 0.015                 | Osmanabadi                                                                 |
| Vermicomposting     | Vermi-Compost unit       | 1      | 0.015                   | -                                                                           |
| Backyard Poultry Fowls | Cocks & hens           | 10+40  | 0.03                    | Vanaraja breed                                                             |
| Area under supporting activities | Azolla production |        |                         |                                                                             |
the productivity, profitability 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 to 9.

3.1 Arable Crops Cropping Systems

During kharif, showed that rice grain yield was 1068 kg from 2000 sq m⁻¹ area from wet land block. From the upland block, maize produced 423 kg of grain yield from 1000 sq m⁻¹ area in maize-groundnut cropping system, while in maize + pigeonpea – sunhemp system, maize yield was 410 kg of grain and pigeonpea produced 69 kg from 1000 sq m⁻¹ area. From pigeonpea + sweet corn – bajra system, 78 kg of pigeonpea and 823 cobs of sweet corn and from

---

**Table 2. Gross cropped area under different crops**

| Farm produce | Gross area (m²) | % of total |
|--------------|----------------|------------|
| Crop production (Net area = 7000 m²) | 70.00 | |
| i) Cereals (Rice, maize) | 5000 | 38.46 |
| ii) Pulses (Green gram, Pigeonpea) | 1500 | 11.54 |
| iii) Oilseeds (Groundnut, Castor) | 2000 | 15.38 |
| iv) Commercial crops (Bt Cotton) | 500 | 3.85 |
| v) Millets (Bajra) | 1000 | 7.69 |
| vi) Green fodders : Napier & Lucerne(Perennial) | 1000 | 7.69 |
| vii) Dry fodders (rice straw, maize stover) | - | - |
| Total | 13000 m² | |

**Table 3. Gross cropped area under horticultural unit**

| Fruits | Number | Vegetables | Area |
|--------|--------|------------|------|
| i) Guava | 42 | i) Tomato | 600 m² |
| | | ii) Bhendi | 600 m² |
| | | iii) Cluster bean | 600 m² |
| | | iv) Beetroot | 600 m² |
| Total | | | 2400 m² |
Bt cotton + greengram – fodder Sorghum system, 52 kg of greengram and 215 kg of Bt cotton was recorded from 1000 sq m² area. From the fodder block, 12.13 t of green fodder was produced during the season (Table 4). It has been reported that highest maize equivalent yield (11803 kg ha⁻¹) with Rs 78,820 ha⁻¹ net returns recorded from cotton + green gram (1:2) – maize for green cobs cropping system compared to other cropping systems like maize-groundnut or maize-sunflower [6].

During *rabi*, 552 kg of maize grain yield was recorded from 1000 m² area with 1027 kgs stover yield from rice-maize cropping system. Castor recorded 128 kg of bean yield with 184 kg of stalks in rice-castor system. From 1000 sq.m area of maize - groundnut cropping system, 173 kg pod yield of groundnut was recorded with 212 kg haulm yield. In maize + pigeon pea – sunhemp cropping system, 2335 kg of green fodder and from Bt cotton + greengram – fodder sorghum system 2045 kg of green fodder was obtained. From pigeonpea + sweet corn – bajra, system 158 kg of grain yield with 302 kg of stalk yield was realized. From fodder block, 27537 kg of green fodder was obtained during the current year. From 0.7 ha area of cropping unit a net return of Rs 1,17,076 with a cost of cultivation of Rs 52,587 (Table 5) having 53.83% share in net income and 27.85% in gross income. This agrees with the findings of other workers [7-9].

3.2 Horticulture

Guava fruits (2000 m²) resulted in net returns of Rs. 1102/-. Intercropping of tomato and bhendi in guava orchard during *kharif* resulted in 268 kg of tomato yield and 115 kg of bhendi (Table 6).

### Table 4. Productivity (kg unit area⁻¹) and prices of field crops in cropping unit

| Cropping System | Area (m²) | Grain | Stover | Grain | Stover |
|-----------------|----------|-------|--------|-------|--------|
| Rice – Maize (M)| 1000     | 517   | 559    | 552   | 1027   |
| Rice – Castor   | 1000     | 551   | 603    | 128   | 184    |
| Pigeonpea (PP) + Sweet corn (SC) - Bajra | 1000 | 78 kg PP + 823 cobs | 89 PP +1128 kg SC | 158 | 302 |
| Maize + pigeon pea – Sunhemp (green fodder) | 1000 | 410(M) & 69 (PP) | 893 kg(M) & 93kg(PP) | 0 | 2335 |
| Bt cotton + Green gram (GG) - Fodder sorghum | 1000 | 215 kg (Bt) & 52kg (GG) | 487kg(Bt)&102kg(GG) | 0 | 2045 |
| Maize-groundnut | 1000 | 423   | 997    | 173   | 212    |
| Green Fodder    | 1000     | 27537 |        |       |        |
| **Total**       | **7000** |       |        |       |        |

| Crop            | Yield and price |
|-----------------|-----------------|
| Paddy | Rs 14.70 kg⁻¹, Rs 1.00/kg stover     |
| Castor | Rs 35.00 kg⁻¹, Rs 0.25/kg stover     |
| Greengram | Rs 52.25 kg⁻¹, Rs 2.00/kg stover     |
| Sunhemp | Rs 2.00 kg⁻¹, Rs 2.00/kg stover     |
| Bajra | Rs 13.3 kg⁻¹, Rs 2.00/kg stover     |
| Maize | Rs 13.65 kg⁻¹, Rs 1.00/kg stover     |
| Pigeonpea | Rs 50.50 kg⁻¹, Rs 0.25/kg stover     |
| Groundnut | Rs 42.20 kg⁻¹, Rs 3.00/kg stover     |
| Sweet corn | Rs 4 per cob Rs 1.50/kg stover     |
| Bt Cotton | Rs 41.60 kg⁻¹, Rs 0.25/kg residue |

### Table 5. Profitability (Rs/unit area⁻¹) of different cropping systems in cropping unit of IFS

| Cropping system | Area (m²) | Kharif | Rabi |
|-----------------|----------|--------|------|
| Rice – Maize    | 1000     | 8159   | 2519 |
| Rice – Castor   | 1000     | 8703   | 3063 |
| Pigeonpea + Sweet corn - Bajra | 1000 | 8945 | 4000 |
| Maize + pigeon pea – Sunhemp (green fodder) | 1000 | 9997 | 5167 |
| Bt cotton + Green gram - Fodder sorghum | 1000 | 11987 | 6030 |
| Maize-groundnut | 1000 | 6771 | 1881 |
| Green Fodder    | 1000     | 82611  | 80563 |
| **Total**       | **7000** | 54562  | 22659 |
Table 6. Productivity and returns from horticulture unit

| Orchard and Vegetables | Area (m²) | Kharif (Rs plot⁻¹) | Rabi (Rs plot⁻¹) | System (Rs plot⁻¹) |
|------------------------|-----------|---------------------|------------------|-------------------|
|                        |           | Yield (kg plot⁻¹)   | GR | NR | Yield (kg plot⁻¹) | GR | NR | GR | NR |
| **Base Orchard**       |           | Fruit | Residue | Fruit | Residue |          |     |     |     |     |
| Guava                  | 2000      |       |        |       |        | 6350 | 1102 |
| **Under storey vegetables** |         |       |        |       |        |       |     |
| Tomato- Clusterbean    | 600       | 268   | 54.2   | 4034  | 829    | 132  | 68  | 2647 | 653  | 6681 | 1482 |
| Bhendi- Beetroot       | 600       | 115   | 25.8   | 2881  | 173    | 726  | 27  | 10907 | 8636 | 13788 | 8809 |
| **Total**              |           |       |        |       |        | 1002 | 9289 | 26819 | 11393 |     |     |

Tomato: Rs 15.00 kg⁻¹, Cluster bean: Rs 20.00 kg⁻¹, Bhendi stover: Rs 0.25 kg⁻¹
Bhendi: Rs 25.00 kg⁻¹, Guava: Rs 25kg⁻¹, Beetroot stover: Rs 0.25 kg⁻¹
Beetroot: Rs 15.00 kg⁻¹, Tomato stalk: Rs 0.25kg⁻¹, Cluster bean stover: Rs 0.25 kg⁻¹

Table 7. Performance and returns of livestock unit

| Particulars (01-6-2016 to 31-5-2017) | Size                        | No. of days | Production (Milk/Meat/Fodder) | Dung (kg) | Shed waste (kg) | Claves/ kids/chicks (No) | Production cost (Rs.) | Gross returns (Rs.) | Net returns (Rs.) |
|-------------------------------------|-----------------------------|-------------|-------------------------------|-----------|-----------------|--------------------------|-----------------------|---------------------|-------------------|
| Buffalo (Murrah 2+2)                | 2 Adults + 2 calves         | 365         | (lit/kg)                      | 1629 (81429) | 2111 (528) | 2 avail + 2 sold (49500) | 244299              | 135529             | -108770           |
| VC                                  | Year round                  | 2241        |                               |           |                 |                          |                       | 7843               | 2342              |
| FYM                                 |                             | 16503       |                               |           |                 |                          |                       | 7203               | 9301              |
| Goats (Osmanabadi)                  | 16 Adults + 26 kids         | 365         | (lit/kg)                      | 819 (147490) | 6705 (1676) | 7 + 13 (374 kg) (66150) | 46645               | 215316             | 168671            |
| Poultry (40+10)                     | 50 chicks + 2 birds         | 365         | (lit/kg)                      | 55 (4235) (32842.5) | 139.15 (35) | 5.7 (438.9) | 19349 | 37551 | 18203 |
| Total                               |                             | 322996      |                               | 412743 | 89746           |                           |                       |                     |                   |

*Figures in parenthesis are value of the products
Milk @ Rs 50.00/l, goat meat @ Rs 180/ kg live, poultry meat @ Rs 77/ kg live, cattle dung @ Rs 0.25/kg, goat dung @ Rs 0.25/kg, shed waste @ Rs 0.25/kg, FYM @ Rs 1.00/kg and Vermicompost @ Rs 3.50/kg, poultry litter @ Rs 0.25/kg
From horticulture unit a net return of Rs 1002/- was realized during kharif. The yield of understorey vegetables decreased as the guava orchard was in active bearing stage during this year. The intercropping of understorey vegetables during rabi viz., cluster bean (132 kg) and beetroot (726 kg) resulted in net returns of Rs. 9,289/-. The total net returns from the horticulture unit was Rs.11,393/-. 

3.3 Livestock Unit

From dairy unit, a total of 1629 litres of milk was produced in 12 months period. The dairy unit gave negative returns due to low milk yield as only one buffalo was in milching stage throughout the year. In goat unit, body weight increase of 512 kg was recorded over initial body weight of 681 kg from 42 goats during 12 months period. Three goats weighing around 36 kg died. Around 16.28 t of dung and 2.11 t shed waste were produced in 12 months period. 29 goats weighing around 819 kg were sold and 25 kids were produced during this period. Three goats weighing around 36 kg died. 25 kids were produced during this period. Three goats weighing around 36 kg died. Around 16.28 t of dung and 2.11 t shed waste 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].

3.4 Residue Recycling

Through residue recycling and manure production generated 16.50 t of FYM and 2.24 t of vermicompost which is equal to 149-70-102 kg of N, P and K and saved fertilizer worth of Rs 8500/-. 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].

Table 8. Residue recycling in IFS model

| Compost/Manure      | N (kg) | P (kg) | K (kg) |
|---------------------|--------|--------|--------|
| FYM – 16503 kg (N-0.69%, P- 0.35%, K- 0.55%) | 113.87 | 57.76  | 90.77  |
| Vermicompost – 2241 kg (N–1.56%, P-0.56%, K – 0.48%) | 34.96  | 12.55  | 10.76  |
| Total               | 148.83 | 70.31  | 101.53 |

Table 9. Productivity and profitability of IFS unit

| Item                          | Cropping Unit | Livestock unit | Horticulture unit | Recyling unit of wastes/by product | Total IFS |
|-------------------------------|---------------|----------------|-------------------|-----------------------------------|-----------|
|                               |               | Dairy          | Goatery & Poultry |                                    |           |
| Productivity (t RGEY ha⁻¹ yr⁻¹) | 11.54         | 9.22           | 17.20             | 1.82                              | 1.66      | 41.44   |
| COC (Rs ha⁻¹ yr⁻¹)           | 52587         | 245020         | 65994             | 15427                             | 12704     | 391732  |
| Gross Returns (Rs ha⁻¹ yr⁻¹) | 169663        | 135529         | 252867            | 26819                             | 24346     | 609224  |
| Net returns (Rs ha⁻¹ yr⁻¹)   | 117076        | (-) 109491     | 186874            | 11392                             | 11643     | 217493  |
| B:C ratio                    | 2.23          | (-) 0.45       | 2.83              | 0.73                              | 0.91      | 0.56    |
| Employment                   | 116           | 509            | 153               | 27                                | 24        | 829.5   |
3.5 Economics of IFS Unit

The proposed system resulted in total productivity of 41.44 t ha\(^{-1}\) yr\(^{-1}\) RGEY along with employment generation of 630 man days. On the whole, the one ha of crop + livestock (dairy & goat) + horticulture farming systems (IFS) model was found profitable with a net returns of Rs. 2,17,493/- after incurring production cost of Rs. 391,732/-. This total net income comprised 27.85% returns from crop component including fodder, 4.40% returns from horticulture component and 67.75% from livestock unit (Table 9). Month wise productivity, net returns and employment generation possible in IFS unit (Fig. 1).

4. CONCLUSION

Integrated farming system would help in doubling the farmer’s income in addition to sustaining productivity. A sustainable integrated farming system comprising of crop (0.7 ha) + livestock (0.1 ha) + horticulture (0.2 ha), suggested to improve the farm family income. Adoption of improved cultivars, better performing breeds/strains and good management practices under integrated farming system gave more production, higher income generation and employment opportunities throughout the year. More net farm income was realized by farmers who maintained crop-livestock-horticulture integration on their fields. The IFS approach is better than traditional system in its contribution to productivity, profitability, economics and employment generation for small and marginal farmers of Telangana state.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. GOI. Agricultural statistics at a glance, Directorate of Economics and Statistics, Govt. of India, New Delhi; 2014. Available:https://data.gov.in
2. Siddeswaran K, Sangetha 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 at New Delhi. 2012;3:992-993.
3. Gill MS, Singh JP, Gangwar KS. Integrated farming System and agriculture sustainability. Indian Journal of Agronomy. 2009;54(2):128–39.
4. Rahman FH, Sarkar S. Efficient resource utilization through integrated farming system approach in the farmers’ field at Burdwan district of West Bengal. Extended Summaries: 3rd International Agronomy Congress, New Delhi. 2012;3:997-998.
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, Vennila 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.