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Assessment of a sustainable rice based integrated farming system in rainfed conditions of Odisha

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ABSTRACT

The present investigation on economic viability and sustainability of crop-fish-poultry-mushroom integration against conventional farming in rainfed rice farms were carried out for three consecutive years from *kharif* 2010 to *rabi* 2013 at Khajuripada cluster villages of Kandhamal district, Dhenkanal Sadar and Odapada cluster villages of Dhenkanal district and Golamunda and Narla cluster villages of Kalahandi district of Odisha. The treatments of study consisted of two factors *viz.* sources of water i.e. P_0: without water harvesting structure (rainfed, no pond), P_1: with water harvesting structure (irrigated, with pond) and size of farm i.e. marginal: 0.8 ha, small: 1.6 ha. The treatments were in factorial randomized block design with five replications. The 1.6 ha integrated farming system (IFS) model gave rice equivalent yield (REY) of 44.93 t, net return of ₹ 2,27,521 and B: C of 1.83 as compared to REY of 6.70 t, net return of ₹ 15,235 and B:C of 1.26 in conventional rice-greengram cropping system. Sustainable yield and value index in 0.8 ha IFS model increased to 0.84 and 0.47 as compared to 0.10 and 0.03 in rice-greengram conventional pair cropping and in 1.6 ha IFS model increased to 0.82 and 0.44 over 0.13 and 0.03 in conventional cropping. The labour employment in both IFS models increased to 588 and 942 as compared to 204 and 400 in respective conventional rice farms. The land use efficiency had also increased over conventional system. Thus, this recommended model proved to be sustainable over the conventional practice in rainfed rice cropping situations of Odisha.

Key words : Land use efficiency, rainfed, rice equivalent yield, sustainable yield index

INTRODUCTION

Rice, the major crop of India, is cultivated in about 44 mha (Anon., 2019). Increasing production and productivity of rice is essential to feed the evergrowing population. However, considering its poor cost-benefit ratio and negative impact on the environment, alternatives options in rice farming need to be thought off (Theodore, 2004). Mamun et al. (2011) found that single crop production enterprises are vulnerable to high degree of risk and uncertainty due to seasonal, irregular and uncertain income and employment to the farmers. Jayanthi et al. (1997) in their studies also revealed that with a view to mitigate risks and uncertainties of income from crop enterprises and to reduce the time lag between investment and returns, it is essential that the farmers include such of those enterprises in their production programme that yield regularly and evenly distribute income throughout the year and are not subjected to vagaries of nature. Also, there is a need to produce more from these existing arable lands through proper management of basic agricultural resources such as soil, water and biological inputs (Saha et al., 2012).

Farming system is a complex inter-related set of elements containing crops, dairy, poultry, fish, sericulture, vermi-compost, sheep and goats etc. which interact among themselves. The judicious mix of the crops and animal enterprises must be based on the principle of minimizing the competition for resources and maximizing the complementarities of returns among the enterprises (Sachinkumar et al., 2012).

Babalad and Hundekar (1999) in their studies opined integrated farming system (IFS) model is not only the need of the time but also better alternative for optimization of resources available with small farmers. It is assumed to be the best possible solution to the continuous increase in demand for food production, stability of income and improvement of nutrition (Korikanthimath and Manjunath, 2009).

The practice of farming system varies from place to place depending on the agro-climatic condition, suitability of enterprise to the location, availability of inputs and marketing facilities (Chinnusamy, 1994; Veerabhadran, 1994; Basavaraja, 1999). Hence, IFS should include livestock, poultry, fishery, duckery, mushroom production, apiculture and sericulture along with crop components through which total biomass production per unit area can be increased. Backyard poultry and vermicomposting can be added to IFS to increase farm income and strengthen livelihoods of farmers (Nath and Barik, 2010). The farming system approach of land use through integration of agri-horti crops, fishery and livestock has been found most suitable for livelihood security (Rathore and Bhatt, 2008). Diversification of enterprises and especially inclusion of vegetables, livestock and other activities in the farming system not only helps to increase farm income but also generates employment (Sachinkumar et al., 2012). Integrated farming system provides an opportunity to increase the economic yield per unit area per unit time due to intensification and diversification of cropping and integration of allied enterprises, and thereby efficient use of resources (Singh et al*.,* 2007). Under the above circumstances, this research study was undertaken to find out a suitable rice based IFS model for the small and marginal farmers against their conventional rice-greengram cropping system which is economically viable and remains sustainable over the years.

MATERIALS AND METHODS

Field experiments were carried out for three consecutive years from *kharif* 2010 to *rabi* 2013 in five clusters of villages belonging to Kandhamal, Dhenkanal and Kalahandi district of Odisha. The experiments were conducted at Khajuripada cluster of Kandhamal district, Dhenkanal Sadar and Odapada cluster of Dhenkanal district and Golamunda and Narla cluster of Kalahandi district. Khajuripada is situated at 84°24' E Longitude, 20°26' N Latitude and 476 m above mean sea level (msl), Dhenkanal Sadar is situated at 85° 38' E Longitude, 20°40' N Latitude and 56 m amsl, Odapada is situated at 85° 26' E Longitude, 20° 45' N Latitude and 56 m amsl, Golamunda situated at 83° 01' E Longitude, 19° 49' N Latitude and 254 m amsl and Narla is situated at 83°22' E Longitude, 20° 03' N Latitude and 254 m amsl. The soils of Khajuripada were well-drained, light textured with sandy clay loam texture and mostly acidic in reaction. In Dhenkanal Sadar and Odapada, soils were clay loam in texture with slightly acidic to slightly alkaline soil reaction. The soils of Golamunda and Narla were heavy textured with textural class of clay and slightly acidic to slightly alkaline in reaction. The normal annual rainfall of Kandhamal, Dhenkanal and Kalahandi districts are 1427.9 mm, 1428.8 mm and 1330.5 mm respectively. Of the total annual rainfall 1102.9 (77 %), 1109.0 mm (78%) and 1128.1 mm (85%) are received during rainy season (June to September).

The investigation was carried out with marginal and small land holding of 0.8 (S_1) and 1.6 ha (S_2) size, two sources of water i.e. no pond or rainfed (P_0) and pond or irrigated (P_1) and five replications(clusters) located in five different blocks, *viz.* Khajuripada (Kpd) of Kandhamal district (North Eastern Ghat Zone), Dhenkanal Sadar (Dsr) and Odapada (Opd) of Dhenkanal district (Mid Central Table Land Zone), Golamunda (Gld) and Narla (Nrl) of Kalahandi district (Western Undulating Zone) of Odisha with rainfed medium land situations. The experiment aimed at comparing performance of pond based IFS model comprising rice-onion sequence cropping system, pisciculture and on dyke plantation, poultry and mushroom with rainfed rice.

In all the IFS models, high yielding rice cv. '*Lalat*' was taken during *kharif* season and onion cv. 'N - 53' during *rabi* in all the years i.e. 2010-11, 2011-12 and 2012-13. Under rainfed condition without pond, rice (cv. *Lalat*) - greengram (cv. Local) cropping system was followed except Khajuripada cluster where rice- fallow system was followed. In IFS 0.8 ha models, cropping area was 7110 m^2 where as in control (no pond) the cropping area was 8,000 m^2. But in 1.6 ha IFS models, the cropping area was 14310 m^2 where as in control (no pond) the cropping area was 1.6 ha.

The components were selected basing on the popularity and suitability to rain-fed rice lands in Odisha. Pond was excavated to provide assured irrigation to rice crop in *kharif* season during dry spell as well as to take up a second profitable crop of onion during *rabi* season after the harvest of rice crop along with composite fish farming. Pond dyke was used for planting of papaya, banana and drumstick. Selection of profitable rice based cropping system and further their linkage with allied enterprises like fish, poultry and mushroom cultivation using the available by-products or wastes from cropping was envisaged.

From each block, two villages were selected randomly. The farmers were selected through the process of stratified random sampling. The farmers in each village were first grouped into small and marginal on the basis of size of land holdings and twenty farmers per cluster were selected from which 10 were marginal and 10 were small farmers. Thus, the total sample consisted of 100 farmers. All the sample farmers were interviewed with a structured questionnaire to get the necessary information. The data were collected from the farmers through the personal interviews. Data on different indicators *viz.* bio-physical indicators, economic indicators and land use indicators were collected. Economics of the farming was calculated and total information on labour use was recorded. Different statistical tools were used as per their suitability for better interpretation. The following computations were done to evaluate the sustainability of the proposed models.

Rice grain equivalent yield

Rice grain equivalent yield was worked out by converting the economic yield of onion and green gram on basis of marketable price ratio for each crop and rice and expressed in t ha^{-1}.

Rice grain equivalent yield (t ha^{-1}) =

$$\frac{\text{Productivity of component (t)} \times \text{Price of component (₹/t)}}{\text{Price of rice (₹/t)}}$$

Land use efficiency

Land use efficiency (LUE) computed by using formula (Usadadiya and Patel, 2013), expressed as %.

$$\text{LUE} = \frac{\text{Total duration of crops in individual crop sequence (Rice-onion or rice-green gram or rice-fallow)}}{365} \times 100$$

Sustainable yield index

The sustainable yield index (SYI) was computed by using the formula (Vittal et al., 2002)

$$\text{SYI} = \frac{Y_{mean} - \sigma}{Y_{max}}$$

Y_{mean} = mean yield, σ = Standard deviation

Y_{max} = maximum yield from all treatment

Sustainable value index

Sustainable value index (SVI) was calculated like SYI in terms of monetary value.

$$\text{SVI} = \frac{Y_{mean} - \sigma}{Y_{max}}$$

Y_{mean} = mean net return, σ = Standard deviation

Y_{max} = maximum net return from all treatments

RESULTS AND DISCUSSION

Rice crop was taken up in all the twenty units. In five marginal rainfed units rice was taken up in 0.8 ha of land, whereas in five small rainfed units rice was taken up in 1.6 ha of land. In case of marginal IFS units, the rice crop was taken up in an area of 0.711 ha and in small IFS unit, the crop was grown in 1.431 ha.

Table 1. Rice equivalent yield (t ha^{-1}) from conventional rice- greengram cropping system

Size of farm (ha)	Kpd	Dsr	Opd	Gmd	Nrl	Mean
2010-11						
0.8	2.52	4.2	4.12	4.07	4.37	3.86
1.6	4.45	7.86	7.38	7.06	7.49	6.85
2011-12						
0.8	2.44	3.97	3.74	3.85	4.24	3.65
1.6	4.30	7.55	6.68	6.63	6.96	6.42
2012-13						
0.8	2.54	4.27	4.01	3.93	4.42	3.83
1.6	4.36	8.09	7.35	6.86	7.51	6.83
Pooled						
0.8	2.50	4.15	3.96	3.95	4.34	3.78
1.6	4.37	7.83	7.14	6.85	7.32	6.70

The conventional rice-greengram cropping system was followed in four out of five cluster villages. It was observed from the above table that the highest rice equivalent yield (REY) was recorded 4.34 t ha^{-1} (Narla), whereas the lowest was 2.50 t ha^{-1} (Khajuriapada) in 0.8 ha marginal farming category. Among the 1.6 ha category, the highest REY was obtained 7.83 t $ha^{-1}$and the lowest was 4.37 t ha^{-1}. In both the cases Khajuriapada remained at the lowest REY because rice-fallow cropping system was followed in those cluster villages. Rice-pulses (greengram) gave more REY, increased cropping intensity and also affected other factors. Table 2 indicates that the factors related to sustainability of farming is better in both the cases of small and marginal category in case of the recommended IFS model than the conventional practice. In economical terms, the BC ratio increased from 1.38 to 1.83 in 0.8 ha farm and in 1.6 ha it increased from 1.26 to 1.83. In 1.6 ha category of farms, the mean cost of cultivation in all clusters, increased from ₹ 59194 to ₹ 27400 but the gross return increased to ₹ 501523 from ₹ 74429.

Labour requirement for IFS model crop - pisciculture - mushroom - poultry enterprises remained more or less same over years. Among the clusters, labour requirement varied from 585 in Khajuripada and Narla to 594 in Odapada in 0.8 ha IFS model and 927 in Khajuripada to 948 in Narla in 1.6 ha IFS models (Table 2). The IFS model with 0.8 ha size required a total labour of 588 human days per annum constituting 54.4, 24.0, 11.7 and 9.9 per cent in crop, mushroom, fish and poultry, respectively. In case of 1.6 ha model, the total labour was 942 with share of 67.2, 15.0, 11.7 and 6.1 per cent for respective enterprises.

Table 2. Rice equivalent yield (t ha^{-1}), economics and labour employment (man days) in IFS models

Particulars	Khajuripada	Dhenkanal Sadar	Odapada	Golamunda	Narla	Mean
IFS models- 0.8 ha						
Rice equivalent yield	28.60	33.37	32.12	32.29	33.23	31.92
Cost of cultivation(₹)	194668	194879	195698	195211	194786	195048
Gross return(₹)	319188	372468	358455	360239	370630	356196
Net return(₹)	124520	177589	162757	165028	175844	161148
B: C	1.64	1.91	1.83	1.85	1.90	1.83
Labour employment	585	587	594	590	585	588
Conventional cropping system- 0.8 ha						
Rice equivalent yield	2.50	4.15	3.96	3.95	4.34	3.78
Cost of cultivation(₹)	22128	32790	32512	31955	32218	30321
Gross return(₹)	27754	46046	43881	43847	48231	41952
Net return(₹)	5626	13256	11369	11891	16013	11631
B: C	1.25	1.40	1.35	1.37	1.50	1.38
Labour employment	146	209	206	201	203	204
IFS models- 1.6 ha						
Rice equivalent yield	39.75	46.68	45.17	45.58	47.45	44.93
Cost of cultivation(₹)	272409	274586	274191	275018	273798	274000
Gross return(₹)	443705	521340	504494	508692	529381	501523
Net return(₹)	171295	246754	230303	233674	255583	227521
B: C	1.63	1.90	1.84	1.85	1.93	1.83
Labour employment	927	942	946	952	948	942
Conventional cropping system- 1.6 ha						
Rice equivalent yield	4.37	7.83	7.14	6.85	7.32	6.70
Cost of cultivation(₹)	43243	63924	63748	62227	62827	59194
Gross return(₹)	48481	87112	79227	75971	81354	74429
Net return(₹)	5238	23188	15478	13743	18527	15235
B: C	1.12	1.36	1.24	1.22	1.29	1.26
Labour employment	283	412	406	389	400	400

During all the years of experimentation, LUE was not influenced significantly by sizes of farm and clusters. Both 0.8 and 1.6 ha farm gave nearly equal LUE. The mean LUE varied from the lowest of 56.52 % in Khajuripada to the highest of 65.63% in Odapada cluster .Sources of water influences LUE significantly. Creation of pond increased LUE significantly compared to no pond. In absence of pond, the LUE was 51.48, 51.45 and 51.35 per cent during 2010-11, 2011-12 and 2012-13, respectively with mean of 51.43 %. Construction of pond enhanced LUE to 75.58, 75.44 and 75.73 per cent, respectively with mean of 75.66 %. Averaged over years, the construction of pond enhanced LUE by 47.11%.

Table 3. Land use efficiency (%) of different IFS during 2010-11 to 2012-13

Treatments	Kpd	Dsr	Opd	Gmd	Nrl	Mean
2010-11						
0.8 ha	55.92	64.67	66.10	65.04	65.83	63.51
1.6 ha	56.56	64.88	65.54	64.99	65.79	63.55
Mean	56.24	64.78	65.82	65.01	65.81	63.53
S R	NS NS					
No pond	36.40	54.54	55.77	55.22	55.49	51.48
Pond	76.08	75.02	75.87	74.81	76.12	75.58
SE(m)± for P 1.59 CD (P=0.05) for P 4.91			P × S NS			
2011-12						
0.8 ha	56.46	64.71	65.39	65.38	65.53	63.49
1.6 ha	56.69	64.42	65.09	65.33	65.49	63.40
Mean	56.57	64.56	65.24	65.35	65.51	63.45
S R	NS NS					
No pond	37.13	54.25	55.48	55.34	55.07	51.45
Pond	76.02	74.87	75.00	75.37	75.95	75.44
SE(m)± for P 1.53 CD (P=0.05) for P 4.70			P × S NS			
2012-13						
0.8 ha	56.69	64.48	65.47	65.91	65.45	63.60
1.6 ha	56.80	64.19	65.03	65.86	65.53	63.48
Mean	56.74	64.33	65.25	65.88	65.49	63.54
S R	NS NS					
No pond	36.68	53.85	55.50	55.49	55.22	51.35
Pond	76.81	74.81	75.00	76.28	75.76	75.73
SE(m)± for P 1.61 CD (P=0.05) for P 4.97			P × S NS			
Pooled for 3 years						
0.8 ha	56.36	64.62	65.89	65.44	65.60	63.58
1.6 ha	56.68	64.50	65.37	65.40	65.60	63.51
Mean	56.52	64.56	65.63	65.42	65.60	63.55
S R	NS NS					
No pond	36.74	54.22	55.58	55.35	55.26	51.43
Pond	76.30	74.90	75.67	75.49	75.94	75.66
SE(m)± for P 0.91 CD (P=0.05) for P 2.61			P × S NS			

The productivity of the farming system in absence of on-farm water harvesting pond was very unsustainable as indicated by SYI values ranging from 0.07 in Khajuripada 0.12 in Narla cluster with 0.8 ha model and 0.08 in Khajuripada to 0.15 in Dhenkanal Sadar cluster in 1.6 ha model (Table 4). The trend was more or less similar for SVI values also. The construction of on-farm water harvesting pond enhanced both SYI and SVI values. The SYI values increased to 0.75 in Khajuripada and 0.88 in Narla cluster in 0.8 ha IFS model and 0.73 in Khajuripada to 0.87 in Narla cluster with 1.6 ha IFS model. Similarly, the SVI values increased from 0.03 to 0.47 in 0.8 ha model and 0.03 to 0.44 in 1.6 ha IFS model.

Table 4. Sustainable yield index (SYI) and Sustainable value index (SVI) of different models

Clusters	Sustainable yield index		Sustainable value index	
	No pond	Pond	No pond	Pond
0.8 ha IFS model				
Kpd	0.07	0.75	0.01	0.34
Dsr	0.11	0.88	0.04	0.52
Opd	0.11	0.84	0.03	0.47
Gmd	0.11	0.85	0.04	0.48
Nrl	0.12	0.88	0.05	0.52
Mean	0.10	0.84	0.03	0.47
1.6 ha IFS model				
Kpd	0.08	0.73	0.01	0.31
Dsr	0.15	0.85	0.04	0.48
Opd	0.13	0.82	0.02	0.44
Gmd	0.13	0.83	0.03	0.46
Nrl	0.14	0.87	0.03	0.52
Mean	0.13	0.82	0.03	0.44

SYI and SVI values were lower in rainfed systems as compared to pond based systems. In rainfed systems, the SYI values varied from 0.07 to 0.12 in 0.8 ha and 0.08 to 0.15 in 1.6 ha model (Table 4). The SYI values in 0.8 ha pond based model varied from 0.75 to 0.88 and 0.73 to 0.87 in 1.6 ha pond based model. Solaiappan et al. (2007) reported higher sustainability index for combination of enterprises compared to cropping alone for net returns. The SVI values varied from 0.01 to 0.05 in 0.8 ha rainfed farm and 0.01 to 0.04 in 1.6 ha rainfed farm. The SVI values in 0.8 ha pond based model varied from 0.34 to 0.52 and in 1.6 ha model from 0.31 to 0.52. Thus, on-farm water harvesting pond converted unsustainable rainfed farm to sustainable IFS model. In aberrant weather years, pond provided life saving irrigation during the period of partial dry spell and helped in growing of the second crop of onion during *rabi* and ancillary enterprises throughout the year. This study corroborates the findings of Nath et al. (2016).

The study indicates that instead of traditional cropping practices, adoption of water harvesting based IFS by the resource-poor farmers could be of immense helpful in creating jobs and enhancing farm income if easy credit arrangement can be made. It would also help to conserve soil erosion and ground water recharge through deep percolation by reducing runoff during heavy shower.

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REFERENCES

Anonymous, 2019. A statistical report on area of cultivation for rice in India 2014-19; https://www.statista.com/statistics/765691/india-area-of-cultivation-for-rice.

Babalad, H.B. and Hundekar, S.T. 1999. Organic recycling of farm wastes in integrated farming systems for sustainable production. In: *Lecture notes of summer short course on Farming Systems for Sustainable Production*, 24 May- 2 June, 1999, University of Agricultural Sciences, Dharwad, pp. 150-165.

Basavaraja, H. 1999. Economic assessment of integrated farming systems. In: *Lecture notes of summer short course on Farming Systems for Sustainable Production,* 24 May- 2 June, 1999, University of Agricultural Sciences, Dharwad, pp. 270-274.

Chinnusamy, K.N. 1994. Farming system research and development in Cauvery delta and North Western Zone in Tamil Nadu. In: *Lecture notes on summer institute on Integrated Farming Systems Research and Management for Sustainable Agriculture,* 6-15 June, 1994, Tamil Nadu Agricultural University, Coimbatore, pp. 252-257.

Jayanthi, C., Rangasamy, A. and Chinnusamy, C. 1997. Component productivity in lowland integrated farming systems. *Madras Agric. J.* **84**(4): 208-213.

Korikanthimath, V.S. and Manjunath, B.L. 2009. Integrated farming systems for sustainability in agricultural production. *Indian J. Agron.* **54** (2): 140-148.

Mamun, S.A., Nusrat, F. and Debi, M.R. 2011. Integrated farming system: Prospects in Bangladesh. *J. Environ. Sci. Nat. Resour.* **4**(2): 127-136.

Nath, S.K., De, H.K. and Mahapatra, B.K. 2016. Integrated farming system, is it a panacea for the resource poor farm families of rainfed ecosystem. *Curr. Sci*. **110**: 969-971.

Nath, S.K. and Barik, K.C. 2010. Increasing incomes of resource poor farm families trough integrated farming system in CDR eco-system. *Int. J. Rural Stud.* **20**: 11–16.

Rathore, S.S. and Bhatt, B.P. 2008. Productivity improvement in *jhum* fields through integrated farming system. *Indian J. Agron.* **53**: 167-171.

Sachinkumar, T.N., Basavaraja, H., Kunnal, I.B., Kulkarni, G.N., Mahajanashetty, S.B., Hunshal, C.S. and Hosamani, S.V. 2012. Economics of farming systems in northern transitional zone of Karnataka. *Karnataka J. Agric. Sci.* **25**: 350-358.

Saha, R. Mishra, V.K. and Ghosh, P.K. 2012. Zero tillage- A resource conserving technology for rice cultivation in hilly ecosystems of India. *e-planet* **10(1)**: 47-52

Singh, K., Bohra, J.S., Singh, T.K., Singh, J.P., Singh, Y. and Singh, C.S. 2007. Productivity and economics of integrated farming system in irrigated agroecosystem of eastern Uttar Pradesh. *Indian J. Agron.* **52**: 11-15.

Solaiappan, U., Subramanian, V. and Maruthi Sankar, G.R. 2007. Selection of suitable integrated farming system model for rainfed semi-arid vertic inceptisols in Tamil Nadu. *Indian J. Agron.* **52**: 194-197.

Theodore, R.K. 2004. Sustainability of rice based farming systems in the Tambiraparani river command area. *Madras Agric. J.* **91**: 489-495.

Usadadiya, V.P. and Patel, R.H. 2013. Influence of preceding crops and nutrient management on productivity of wheat based cropping system. *Indian J. Agron.* **58**: 15-18.

Veerabhadran, V. 1994. Farming system research and development in Southern zone of Tamil Nadu. In: *Lecture notes on summer institute on integrated farming systems research and management for sustainable agriculture*, 6-15 June, 1994, Tamil Nadu Agricultural University, Coimbatore, pp. 258-269.

Vittal, K. P. R., Maruthi Sankar, G. R., Singh, H. P. and Samra, J. S. 2002. Sustainability index. In: *Sustainability of practices of dry land agriculture : Methodology and assessment*, CRIDA, Hyderabad, pp. 4-9.