International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(8): 634-644
Received: 13-05-2024
Accepted: 16-06-2024

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Comparative performance of integrated farming system models in scarce rainfall zone under rainfed and irrigated conditions

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i8i.1341

Abstract
This study evaluates the comparative performance of Integrated Farming System (IFS) models under rainfed and irrigated conditions in Niluvurai village, Anantapuramu district, Andhra Pradesh. The objective is to enhance traditional IFS models for marginal and small farm holdings, focusing on improving productivity, economic returns, and employment generation. A total of 36 farmers were selected and categorized into rainfed and partially irrigated conditions. Various IFS models, including Crop + Small Ruminants (CSR), Crop + Large Ruminants (CLR), and Crop + Small + Large Ruminants (C + SR + LR), were implemented with and without modern interventions. Improved management practices, such as the use of high-yielding crop varieties, nutritional feeding for livestock, and drought mitigation techniques, were introduced. The results demonstrated that the IFS models with interventions significantly increased yields, economic returns, and employment opportunities compared to traditional farming systems. Specifically, net returns and productivity were markedly higher in the improved IFS models. The study concludes that integrating modern agricultural practices within traditional IFS frameworks can substantially improve the sustainability and economic viability of farming in scarce rainfall zones.

Keywords: Employment generation, integrated farming system, irrigated agriculture, rainfed agriculture, yield

Introduction
Agriculture in semi-arid regions faces numerous challenges, primarily due to erratic rainfall, poor soil fertility, and limited water resources. In such areas, integrated farming systems (IFS) can play a crucial role in enhancing farm productivity, ensuring food security, and improving the livelihoods of small and marginal farmers. The concept of IFS involves combining various agricultural enterprises such as crop cultivation, livestock rearing, and agroforestry in a holistic manner to optimize resource utilization and increase farm resilience. The Anantapuramu district in Andhra Pradesh, India, is characterized by its scarce rainfall and frequent droughts, making traditional farming practices often unsustainable and economically unviable. The village of Niluvurai, located within this district, presents a microcosm of these broader agricultural challenges. Farmers here primarily depend on rainfed agriculture, with some having access to partial irrigation. The traditional farming systems in the village include crop cultivation integrated with livestock, specifically small ruminants (goats and sheep) and large ruminants (cattle). This study aims to evaluate the performance of various IFS models under rainfed and partially irrigated conditions and also to strengthen the traditional IFS models for small and marginal farmers in Niluvurai village. By implementing improved management practices and modern agricultural interventions, the study seeks to compare the yield, economic returns, and employment generation potential of these IFS models against traditional farming systems. The ultimate goal is to develop sustainable farming models that can be replicated in similar agro-ecological zones.

Previous research has indicated that IFS can significantly enhance farm productivity and income by diversifying the sources of revenue and reducing the risk associated with single-crop failures.

However, the specific impacts of IFS in scarce rainfall zones, particularly under varying irrigation conditions, need further exploration. This study addresses this gap by systematically analyzing the performance of different IFS models, providing valuable insights into their potential for improving agricultural sustainability and economic viability in semi-arid regions. The findings from this study will not only contribute to the body of knowledge on IFS but also provide practical recommendations for policymakers, extension workers, and farmers in semi-arid regions. By demonstrating the benefits of integrated farming practices, this research aims to encourage wider adoption of IFS, ultimately leading to more resilient and sustainable agricultural systems

Materials and Methods

On-Farm Research on Integrated Farming System was carried out during 2023-24 in Niluvurai village, Anantapuramu dt. Marginal and small farmers were selected for this study equally under two farming situations (rainfed and partially irrigated conditions) and three farming systems (CSR, CLR, C + SR + LR based farming systems) (Table 2 and 3) involving natural resource management, crop production, horticulture, cattle, small ruminants, kitchen garden, fodder production and capacity building.

Niluvurai village is located in Narpala mandal, Anantapuramu district of Andhra Pradesh. It is situated in Latitude of 14.736394° N, Longitude of 77.797108° E. Mean elevation of this village is 372 m. It is located at 25 km from Anantapuramu and 17 km from Agricultural Research Station, Rekulakunta, Anantapuramu.

Soils of this village are shallow red sandy loams which are slightly acidic with pH of 6.63, low in Electrical Conductivity (0.02 dsm^{-1}), organic carbon (0.29%), available nitrogen (167 kg/ha); medium in available phosphorus (48 kg/ha) and potassium (294 kg/ha); deficient in micronutrients like copper (0.13 ppm), manganese (1.90 ppm), iron (0.70 ppm) and zinc (0.05 ppm).

Table 1: Selection of farmers at OFR village

Farming Situation	Farming system	Farmer category	No. farmers selected	
			With Interventions	Without Interventions
Rainfed situation	CSR based farming system	Marginal	3	3
		Small	3	3
Partially Irrigated situation	CLR based farming system	Marginal	3	3
		Small	3	3
	CSR + CLR based farming system	Marginal	3	3
		Small	3	3
Grand Total			18	18

Table 2: Details of farmers and their farming situation

S. No.	Name of the farmer	Farming Situation	Farming system	Farmer category	Cultivable area (ac)	No. of small ruminants	No. of Large ruminants
1.	B. Kumar	Rainfed Situation	Crop + Small Ruminants based farming system	Marginal Farmers	1.7	50	-
2.	P. Ramanna	Rainfed Situation	Crop + Small Ruminants based farming system	Marginal Farmers	2.5	400	-
3.	B. Saroja	Rainfed Situation	Crop + Small Ruminants based farming system	Marginal Farmers	1.5	100	-
4.	P. Bhulakshmi	Rainfed Situation	Crop + Small Ruminants based farming system	Small Farmers	5.0	300	-
5.	P. Adhinarayana	Rainfed Situation	Crop + Small Ruminants based farming system	Small Farmers	5.0	10	-
6.	P. Gopal	Rainfed Situation	Crop + Small Ruminants based farming system	Small Farmers	5.0	120	-
7.	Y. Sreeramulu	Partially irrigated situation	Crop + Large Ruminants based farming system	Marginal Farmers	1.5	-	4
8.	P. Uttanna	Partially irrigated .situation	Crop + Large Ruminants based farming system	Marginal Farmers	1.0	-	3
9.	Y. Kittaya	Parti.ally irrigated situation	Crop + Large Ruminants based farming system	Marginal Farmers	1.0	-	1
10.	M.Anand	Partially irrigated situation	Crop + Large Ruminants based farming system	Small Farmers	5.0	-	1
11.	P. Adinarayana	Partially irrigated situation	Crop + Large Ruminants based farming system	Small Farmers	3.0	-	1
12.	Y. Nagaraju	Partially irrigated situation	Crop + Large Ruminants based farming system	Small Farmers	3.0	-	6
13.	G. Ravi	Partially irrigated situation	Crop + Small Ruminants + Large Ruminants based farming system	Marginal Farmers	2.0	120	2
14.	P. Bhaskar	Partially irrigated situation	Crop + Small Ruminants + Large Ruminants based farming system	Marginal Farmers	2.0	80	6
15.	P. Pullamma	Partially irrigated situation	Crop + Small Ruminants + Large Ruminants based farming system	Marginal Farmers	2.0	180	2
16.	Y. Yerrinagappa	Partially irrigated situation	Crop + Small Ruminants + Large Ruminants based farming system	Small Farmers	5.0	100	10
17.	Y. Prabhakar	Partially irrigated situation	Crop + Small Ruminants + Large Ruminants based farming system	Small Farmers	5.0	21	6
18.	P. Srinivasulu	Partially irrigated situation	Crop + Small Ruminants + Large Ruminants based farming system	Small Farmers	3.0	60	3

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Actual and Normal rainfall during crop growth period is depicted in Fig. 1 which clearly indicates that actual rainfall is less compared to normal during all months except during July and August. Subsoiling was done during May and sowings were started during June and harvestings were done from September (Groundnut) to January (Redgram). Total rainfall of 480.5 mm was received from May to September against normal annual rainfall of 554.1 mm with an average of 96.1 mm with 26 rainy days. No rainfall was received from October. Normal mean crop seasonal rainfall during Kharif and Rabi are 383.2 and 117.1 mm and actual mean crop seasonal rainfall during Kharif and Rabi are 371.6 and 0.0 mm.

Crops and animals were raised by following improved management practices involving selection of improved varieties of seed of field crops, horticulture crops and fodder crops; feeding animals with highly nutritious feed required for weight gain in small ruminants and improving milk production in cattle; regular vaccination, deworming, animal health camps to protect animals from health problems; natural resource management to conserve rain water; drought mitigation technologies; growing of plantation crops and vegetables in space available at home etc., in improved Integrated Farming System. Whereas, in existing farming system regular management practices like growing of old and traditional varieties; grazing on open lands, feeding rice to animals were being followed. Yield of crops was calculated separately for each intervention, sheep by weight, cattle by milk. Employment generation was calculated as 8 hours per day as one day. For economics, cost of inputs and outputs prevailing in the market were considered and calculated.

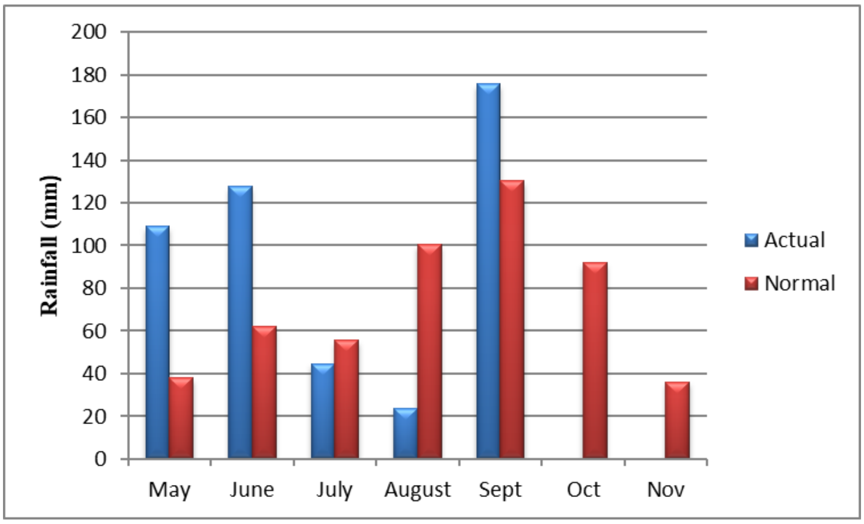

Fig 1: Rainfall during crop growth period in OFR village Niluvurai

Dryspells during crop growth period

Dryspell is the major problem in rainfed crops leading to poor productivity. Improved technologies like moisture and water conservation measures are very helpful and their impact can be visible when the crop will subject to moisture stress conditions due to prolonged dryspells. Crops were subjected to dry spells from vegetative stage to harvesting stage and details are presented in Table 3 and Fig. 2.

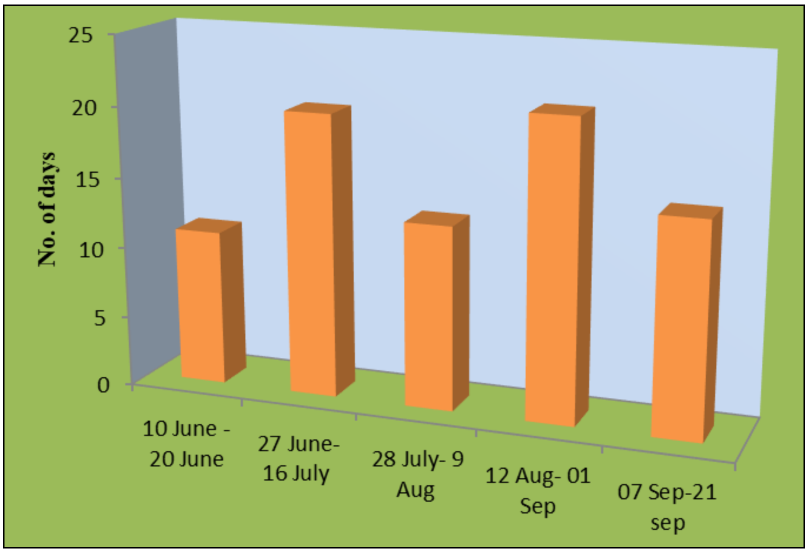

Fig 2: Dry spells during crop period

Table 3: Dry spells during crop growth period

S. No.	Period of dryspell	No. of days
1.	10.06.23-20.06.23	11
2.	27.06.23-16.07.23	20
3.	28.07.23-09.08.23	13
4.	12.08.23-01.09.23	21
5.	07.09.23-21.09.23	15
6.	After 30.09.23	No rainfall

Basic details of OFR village (Niluvurai)

Fig.3 clearly depicts that 69% of area is under rainfed situation followed by irrigated area (21%) ad 10% of the area is not under cultivation. Niluvurai village is mainly dominated with small ruminants with 64% population followed by buffaloes (21%) ad cows (15%) (Fig. 4). Fig. 5 shows that agriculture is the primary source of income to the farmers as 65% of the families are depending on agriculture alone, 23% of the families dependent on agriculture + livestock and 12% on other activities like jobs, business, auto driving etc. Major crops being cultivated are groundnut, Redgram and maize followed by rice, cotton and other crops (Table 4). Irrigation is being provided through borewells and far ponds.

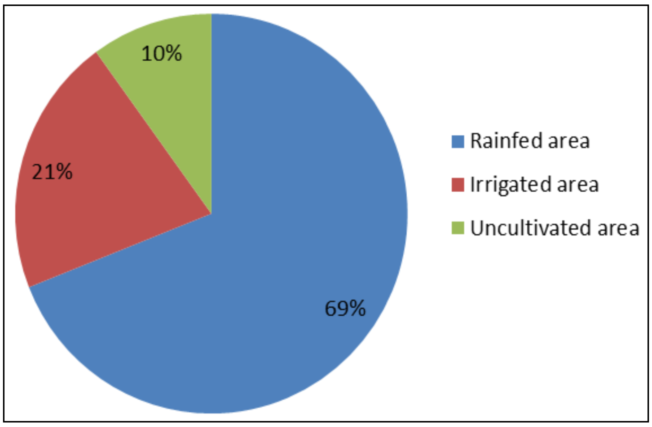

Fig 3: Type of land holding in OFR village Niluvurai

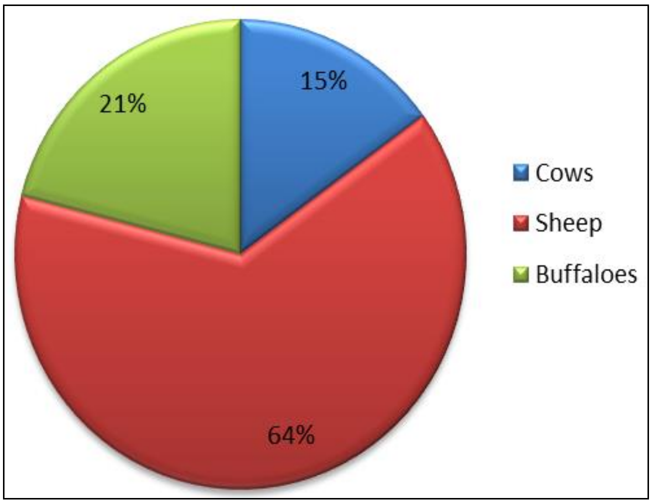

Fig 4: Livestock details of OFR village Niluvurai

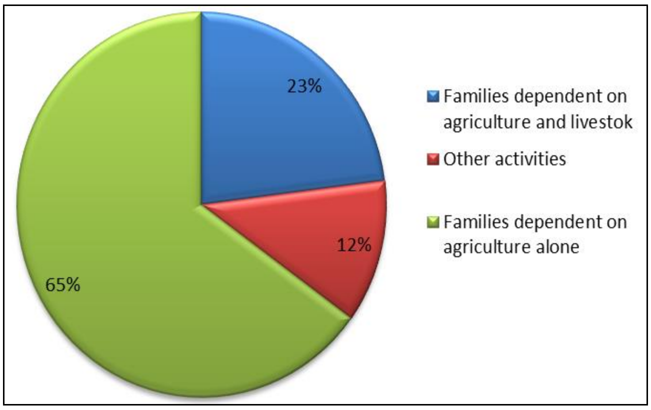

Fig 5: Family dependence for income in OFR village Niluvurai

Table 4: Details of crops, available resources and infrastructure in OFR village Niluvurai

Crops cultivated during *Kharif*	**Groundnut, redgram, castor, greengram, sorghum, korra, horsegram Cotton, maize**
Crops cultivated during *Rabi*	Groundnut, paddy, castor, field bean, cowpea, maize
No. of tractors	0
No. of bullock pairs	10
No. of borewells	56
No. of open wells	31 (all dried)
No. of farmponds	9

Problems identified in OFR village

Crops: Prolonged dryspells, Non adoption of soil & water conservation practices, Lack of improved varieties, Poor mechanization (No tractors), Poor soil health management

Cattle: Shortage of green fodder, Improper feeding of available green and dry fodder, No concentrate feeding to milch animals, No practice of legume feeding, Improper calf rearing

Sheep: Nellore brown with mixtures of Bellari breeds are predominant in the district, Shepherds / farmers mostly are illiterates and lack of awareness, Poor growth rate in ramlambs, Most of the flocks under migration

Table 5: Modules adopted for RIFS Research**:**

M1	NRM module	Insitu moisture conservation, rain water harvesting etc.
M2	Crop module	Improved varieties, inter cropping systems, improved agronomic practices etc.
M3	Livestock module	Vaccination, deworming, mineral mixtures etc.
M4	Perennial tree module	Growing of fodder trees, multipurpose trees etc.
M5	Fodder module	Improved fodder varieties and management practices etc.
M6	Specific/optional module	Interventions specific to individual farmer's needs
M7	Capacity building module	Trainings, field days, exposure visits etc.

Total 7 modules were adopted for RIFS approach involving crop, livestock and capacity building

Table 6: Details of constraints in existing system and interventions implemented in diversified system

Module	Existing system	Constraints in Existing system	Diversified system
M1 - NRM module	Sole Redgram and castor	Not adopting insitu moisture conservation practices	Deep tillage with chisel plough *Insitu* moisture conservation through conservation furrows at 35 DAS Supplemental irrigation through farm pond
M2 - Crop module	Sole Redgram and castor Groundnut + redgram intercropping system	Old varieties Prolonged dryspells	RG improved varieties – LRG 52, LRG 105 and PRG176 GN improved varieties K-1812 and TCGS 1694 Spraying of KNO_3 Castor improved varieties-ICH 5 and ICH 66
M3 - Livestock module	Rearing of ramlambs cow, buffaloes	Grazing on open lands Avoiding mineral feeding	Total Mixed Ration Animal health camp, deworming, vaccination
M4 - Fodder module	Horsegram after kharif groundnut	Cultivating local horsegram variety	Introduced improved fodder sorghum Co FS 31
M5 - Perennial tree module	Barren field bunds Tamarind	No boundary plantation Oldest trees with less fruit bearing	Planting tamarind grafts i.e., Thettu Amalika and Ananta Rudhira in backyard and on field bunds
M6 - Optional module	Limited vegetable production	Purchasing vegetables from local shops	Introduced nutri kitchen garden kits (NHRDF)
M7 - Capacity building module	Traditional cultivation	Lack of knowledge on improved crop management practices	Need based trainings and awareness programmes to farmers

Results and Discussion

The data presented in Tables 7 through 11 illustrates the performance of various components under different interventions for both marginal and small farmers.

Yield and Groundnut Equivalent Yield (GEY)

For marginal farmers and small farmers under the crop + small ruminants (CSR), Crop + Large Ruminants and C + SR + LR based farming system in both rainfed and partially irrigated conditions (Table 7 to 12), the interventions resulted in a significant increase in yields The interventions, including improved crop and fodder varieties, moisture conservation techniques, supplemental irrigation, feeding of nutritious feed, kitchen gardening led to a marked increase in crop yields and Groundnut Equivalent Yield (GEY). The productivity of the existing systems on marginal farmers and small farmers was lower compared to the IFS with interventions. The additional benefits through IFS interventions were substantial, with Groundnut Equivalent Yield advantage ranging from 297 to 411 kg for marginal farmers and 372 to 437 kg for small farmers.

These findings align with literature suggesting that integrated farming systems, which combine multiple agricultural activities, optimize resource use and enhance productivity (Singh *et al.*, 2011; Hegde, 2012) [8, 4]. Deep Tillage has been documented to improve soil structure, reduce compaction, and enhance root growth, leading to higher crop yields (Aikins & Afuakwa, 2012) [1]. Improved Crop Varieties are known to be more resilient to pests and diseases and have higher productivity, which aligns with the increased yields observed (Ortiz *et al*., 2007). Drought Mitigation Techniques such as KNO3 sprays help in managing water stress, thus improving crop performance (Ashraf, 2010).

Cost of Production and Returns

The cost of production increased slightly due to the interventions but was offset by the significant increase in gross and net returns (Table 7 to 12). While the cost of production increased with the interventions, the net returns were significantly higher, indicating that the investments in better farming practices and inputs are economically viable. For marginal farmers additional monitory benefit of R.11277 to Rs.12474 and for small farmers Rs. 10199 to Rs. 14335 was obtained with interventions. This is consistent with findings by Soni *et al.* (2014), who reported that integrated farming systems improve farm income and sustainability in rainfed areas. Livestock Integration into cropping systems provides multiple benefits, including manure for soil fertility, additional income from animal products, and efficient use of farm resources (Thornton & Herrero, 2010).

Employment Generation (man days)

Employment generation saw a marked increase in marginal farmers with interventions. Small farmers also benefited significantly, with EG increasing. Additional advantage of 40 to 71 man days were recorded in marginal farmers and 44 to 64 man days in small farmers. The increase in employment generation is particularly noteworthy. The introduction of diverse farming activities within the IFS framework requires more labor, thus creating more employment opportunities. This is crucial for rural development and poverty alleviation, as noted by Reddy and Reddy (2017) [7].

Sustainability

Integrated Farming Systems promote sustainability by enhancing soil fertility, reducing dependency on external inputs, and improving biodiversity. The adoption of practices such as deep tillage, moisture conservation, and the introduction of perennial trees further support sustainable farming, as highlighted in studies by Gill *et al.* (2011) [3] and Prasad *et al.* (2018) [6].

Table 7: Yield and Economics of Integrated Farming System with and without interventions for marginal farm holdings under crop + small ruminants (CSR) based farming system in rainfed situation (Mean of 3 farmers)

Module	Components of farming system	Area (ha)	Details of interventions	Yield (kg)	GEY (kg)	Cost of production (Rs)	Gross returns (Rs.)	Net returns (Rs)	EG (man days)
NRM	Sole Pigeonpea	0.4	Deep tillage with chisel plough	227	342	9200	21565	12365	57
			Insitu moisture conservation through conservation furrows at 35 DAS						
			Supplemental irrigation through farm pond						
Crop	Groundnut + Redgram (15:1)	0.4	Groundnut improved varieties - K 1812 and TCGS 1694	399	399	14000	25137	11137	61
			Drought mitigation through KNO_3 spray @ 5 ml/lit twice at 1 week interval	279	312	14210	19497	5287	
			Redgram improved varieties - PRG 176 and LRG 105	213	321	8600	20235	11635	
Fodder	Fodder Sorghum	0.1	Improved variety – Co FS 31	1875	59.5	1825	3750	1925	17
Livestock	Ramlambs – 10 no.		Feeding of ramlambs with grazing + GN haulm 300 g + Total Mixed Ration 300-400 g/day for 4 months	206	1210	34000	76220	42220	120
Perennial tree	No boundary plantation/very old tamarind trees		Planting of Tamarind, Jamun and Guava grafts in backyard and on field bunds @ each species 2 no.	Fruit setting initiated					1
Optional	No vegetable production	40m^2	NHRDF nutri kitchen garden kits	35	44	150	2800	2650	18
RIFS productivity		0.9		3234	2688	81985	169204	87219	274
Existing system productivity		0.9	Sowing of groundnut + pigeonpea (15:1) (0.8 ha), fodder sorghum (0.1 ha) and rearing of ramlambs (10 no.)	2760	2294	68462	144404	75942	234
Additional Benefit					394			11277	40
Benchmark data 2018					987	33753	58878	25125	239
Additional benefit through RIFS in 2023								62094	35

Table 8: Yield and Economics of Integrated Farming System with and without interventions for small farm holdings under crop + small ruminants (CSR) based farming system in rainfed situation (Mean of 3 farmers)

Module	Components of farming system	Area (ha)	Details of interventions	Yield (kg)	GEY (kg)	Cost of production (Rs)	Gross returns (Rs.)	Net returns (Rs)	EG (man days)
NRM	Sole Pigeonpea	0.4	Deep tillage with chisel plough	239	360	9200	22705	13505	59
			Insitu moisture conservation through conservation furrows at 35 DAS						
			Supplemental irrigation through farm pond						
Crop	Groundnut + Redgram (15:1) Castor	0.6	Groundnut improved varieties - K 1812 and TCGS 1694	599	599	21000	37690	16690	97
			Drought mitigation through KNO_3 spray @ 5 ml/lit twice at 1 week interval	409	432	21315	29142	7827	
			Redgram improved varieties - PRG 176 and LRG 105	304	458	12900	28857	15957	
		0.2	Castor improved varieties-ICH 5 and ICH 66	197	166	3370	10441	7071	
Fodder	Fodder Sorghum	0.2	Improved variety – Co FS 31	3780	120	3650	7560	3910	28
Livestock	Ramlambs – 8 no.		Feeding of ramlambs with grazing + GN haulm 300 g + Total Mixed Ration 300-400 g/day for 4 months	178	1045	27200	65860	38660	120
Perennial tree	No boundary plantation/very old tamarind trees		Planting of Tamarind, Jamun and Guava grafts in backyard and on field bunds @ each species 2 no.	Fruit setting initiated					1
Optional	No vegetable production	40m^2	NHRDF nutri kitchen garden kits	37	47	150	2960	2810	17
RIFS productivity		1.4		5743	3227	98785	205215	106430	322
Existing system productivity		1.4	Sowing of groundnut + pigeonpea (15:1) (1.2 ha), fodder sorghum (0.2 ha) and rearing of ramlambs (8 no.)	4965	2790	85320	177415	92095	278
Additional Benefit					437			14335	44
Benchmark data 2018					987	33753	58878	25125	239
Additional benefit through RIFS in 2023								81305	83

Table 9: Yield and Economics of Integrated Farming System with and without interventions for marginal farm holdings under crop + large ruminants (CLR) based farming system in partially irrigated situation (Mean of 3 farmers)

Module	Components of farming system	Area (ha)	Details of interventions	Yield (kg)	GEY (kg)	Cost of production (Rs)	Gross returns (Rs.)	Net returns (Rs)	EG (man days)
NRM	Sole Pigeonpea	0.4	Deep tillage with chisel plough Insitu moisture conservation through conservation furrows at 35 DAS	220	332	9200	20900	11700	61
Crop	Groundnut + pigeonpea (15:1)	0.4	Groundnut improved varieties - K 1812 and TCGS 1694	397	397	14000	25011	11011	58
			Drought mitigation through KNO_3 spray @ 5 ml/lit twice at 1 week interval	280	315	14210	19540	5330	
			Redgram improved varieties - PRG 176 and LRG 105	217	327	8600	20615	12015	
Fodder	Fodder Sorghum	0.2	Improved variety – Co FS 31	3750	119	3650	7500	3850	32
Livestock	Jersy cow – 1 no.		Feeding of cow/day @ GN haulm 5 kg + fodder sorghum 15 kg + Total Mixed ration 6 kg/day for 4 months	1159	552	8568	34770	26202	262
Perennial tree	No boundary plantation/very old tamarind trees		Planting of Tamarind, Jamun and Guava grafts in backyard and on field bunds @ each species 2 no.	Fruit setting initiated					1
Optional	No vegetable production	40m^2	NHRDF nutri kitchen garden kits	30	38	150	2400	2250	15
RIFS productivity		1.0		6053	2080	58378	130736	72358	429
Existing system productivity		1.0	Sowing of groundnut + pigeonpea (15:1) (0.8 ha), fodder sorghum (0.2 ha) and rearing of jersy cow (1 no.)	5190	1783	46057	106096	60039	368
Additional Benefit					297			12319	61
Benchmark data 2018					987	33753	58878	25125	239
Additional benefit through RIFS in 2023								47233	190

Table 10: Yield and Economics of Integrated Farming System with and without interventions for small farm holdings under crop + large ruminants (CLR) based farming system in partially irrigated situation (Mean of 3 farmers)

Module	Components of farming system	Area (ha)	Details of interventions	Yield (kg)	GEY (kg)	Cost of production (Rs)	Gross returns (Rs.)	Net returns (Rs)	EG (man days)
NRM	Sole Pigeonpea	0.4	Deep tillage with chisel plough Insitu moisture conservation through conservation furrows at 35 DAS	232	350	9200	22040	12840	54
Crop	Groundnut + pigeonpea (15:1)	0.6	Groundnut improved varieties - K 1812 and TCGS 1694	595	595	21000	37485	16485	83
			Drought mitigation through KNO_3 spray @ 5 ml/lit twice at 1 week interval	400	429	21315	29102	7787	
			Redgram improved varieties - PRG 176 and LRG 105	294	443	12900	27930	15030	
Fodder	Fodder Sorghum	0.4	Improved variety – Co FS 31	7560	240	7300	15120	7820	42
Livestock	Jersy cow – 1 no.		Feeding of cow/day @ GN haulm 5 kg + fodder sorghum 15 kg + Total Mixed ration 6 kg/day for 4 months	1123	535	8568	33690	25122	260
Perennial tree	No boundary plantation/very old tamarind trees		Planting of Tamarind, Jamun and Guava grafts in backyard and on field bunds @ each species 2 no.	Fruit setting initiated					1
Optional	No vegetable production	40m^2	NHRDF nutri kitchen garden kits	32	41	150	2560	2410	16
RIFS productivity		1.4		10236	2633	80433	167927	87494	456
Existing system productivity		1.4	Sowing of groundnut + pigeonpea (15:1) (1.0 ha), fodder sorghum (0.4 ha) and rearing of jersycow (1 no.)	8790	2261	66910	144205	77295	392
Additional Benefit					372			10199	64
Benchmark data 2018					987	33753	58878	25125	239
Additional benefit through RIFS in 2023								62369	217

Table 11: Yield and Economics of Integrated Farming System with and without interventions for marginal farm holdings under crop + small ruminants + large ruminants (C + SR + LR) based farming system in partially irrigated situation (Mean of 3 farmers)

Module	Components of farming system	Area (ha)	Details of interventions	Yield (kg)	GEY (kg)	Cost of production (Rs)	Gross returns (Rs.)	Net returns (Rs)	EG (man days)
NRM	Sole Pigeonpea	0.4	Deep tillage with chisel plough Insitu moisture conservation through conservation furrows at 35 DAS	230	347	9200	21850	12650	60
Crop	Groundnut and Redgram	0.4	Groundnut improved varieties - K 1812 and TCGS 1694	401	401	14000	25263	11263	62
			Drought mitigation through KNO_3 spray @ 5 ml/lit twice at 1 week interval	278	309	14210	19454	5244	
			Redgram improved varieties - PRG 176 and LRG 105	209	315	8600	19855	11255	
Fodder	Fodder Sorghum	0.2	Improved variety – Co FS 31	3750	119	3650	7500	3850	34
Livestock	Ramlambs – 8 no.		Feeding of ramlambs with grazing + GN haulm 300 g + Total Mixed Ration 300-400 g/day for 4 months	193	1133	27200	71410	44210	120
	Jersy cow – 1 no.		Feeding of cow/day @ GN haulm 5 kg + fodder sorghum 15 kg + Total Mixed ration 6 kg/day for 4 months	1098	523	8568	32940	24372	256
Perennial tree	No boundary plantation/very old tamarind trees		Planting of Tamarind, Jamun and Guava grafts in backyard and on field bunds @ each species 2 no.	Fruit setting initiated					1
Optional	No vegetable production	$40m^2$	NHRDF nutri kitchen garden kits	28	36	150	2240	2225	17
RIFS productivity		1.0		6187	3183	85578	200512	115069	550
Existing system productivity		1.0	Sowing of groundnut + pigeonpea (15:1) (0.8 ha), fodder sorghum (0.2 ha) and rearing of ramlambs (8 no.), jersey cow (1 no.)	5389	2772	72055	174650	102595	479
Additional Benefit					411			12474	71
Benchmark data 2018					987	33753	58878	25125	239
Additional benefit through RIFS in 2023								89944	240

Table 12: Yield and Economics of Integrated Farming System with and without interventions for small farm holdings under crop + small ruminants + large ruminants (C + SR + LR) based farming system in partially irrigated situation (Mean of 3 farmers)

Module	Components of farming system	Area (ha)	Details of interventions	Yield (kg)	GEY (kg)	Cost of production (Rs)	Gross returns (Rs.)	Net returns (Rs)	EG (man days)
NRM	Sole Pigeonpea	0.4	Deep tillage with chisel plough Insitu moisture conservation through conservation furrows at 35 DAS	247	372	9200	23465	14265	59
Crop	Groundnut and Redgram	0.6	Groundnut improved varieties - K 1812 and TCGS 1694	602	602	21000	37895	16895	89
			Drought mitigation through KNO_3 spray @ 5 ml/lit twice at 1 week interval	417	464	21315	29181	7866	
			Redgram improved varieties - PRG 176 and LRG 105	314	473	12900	29783	16883	
Fodder	Fodder Sorghum	0.4	Improved variety – Co FS 31	7500	238	7300	15000	7700	45
Livestock	Ramlambs – 8 no.		Feeding of ramlambs with grazing + GN haulm 300 g + Total Mixed Ration 300-400 g/day for 4 months	189	1110	27200	69930	42730	120
	Jersy cow – 1 no.		Feeding of cow/day @ GN haulm 5 kg + fodder sorghum 15 kg + Total Mixed ration 6 kg/day for 4 months	1135	540	8568	34050	25482	256
Perennial tree	No boundary plantation/very old tamarind trees		Planting of Tamarind, Jamun and Guava grafts in backyard and on field bunds @ each species 2 no.	Fruit setting initiated					1
Optional	No vegetable production	$40m^2$	NHRDF nutri kitchen garden kits	31	39	150	2480	2330	15
RIFS productivity		1.4		10435	3838	107633	241784	134151	585
Existing system productivity		1.4	Sowing of groundnut + pigeonpea (15:1) (1.0 ha), fodder sorghum (0.4 ha) and rearing of ramlambs (8 no.), jersey cow (1 no.)	9372	3447	94110	217154	123044	525
Additional Benefit					391			11107	60
Benchmark data 2018					987	33753	58878	25125	239
Additional benefit through RIFS in 2023								97919	286

Comparative Performance of Yield and Economics: Benchmark Data 2018 vs. RIFS Productivity in 2023:

The provided Table 13, Fig. 6 to 8 compares the performance of various farming systems in terms of yield, net returns, and employment generation between the benchmark data of 2018 and the results after interventions in 2023.

Yield Improvement

Across all farming systems, there is a significant increase in Groundnut Equivalent Yield (GEY) compared to the benchmark data from 2018. For instance, GEY rise from 987 kg in 2018 to 2080-3828 kg in 2023. Literature supports that integrated farming systems, which combine crops, livestock, and other components, enhance resource use efficiency and productivity (Singh *et al*., 2011) [8].

Economic Gains

The net returns have seen substantial increases across all systems. Farmers experienced a rise in net returns from Rs. 25,125 in 2018 to Rs. 87219- Rs. 134, 151 in 2023. This economic gain is corroborated by studies indicating that integrated farming systems improve farm profitability by diversifying income sources and optimizing input use (Hegde, 2012; Soni *et al*., 2014) [4, 9].

Employment Generation

Employment generation has also increased markedly. Farmers saw an increase of employment generation from 239 man-days in 2018 to 274-585 man-days in 2023. The increase in labor demand aligns with findings that integrated farming systems can generate more employment by integrating multiple activities that require diverse labor inputs (Reddy & Reddy, 2017) [7].

Table 13: Comparative performance of yield and economics during 2018 and 2023 after interventions

Particulars	Groundnut Equivalent Yield (Kg)	Net returns (Rs.)	Employment generation (man days)
Benchmark data 2018	987	25125	239
Yield and economics through different interventions by 2023			
Rainfed-CSR based faring system-marginal farmers	2688	87219	274
Rainfed-CSR based faring system-small farmers	3227	106430	322
Partially irrigated- CLR based faring system-marginal farmers	2080	72358	429
Partially irrigated- CLR based faring system-small farmers	2633	87494	456
Partially irrigated- C + SR + LR based faring system-marginal farmers	3183	115069	550
Partially irrigated- C + SR + LR based faring system-small farmers	3838	134151	585

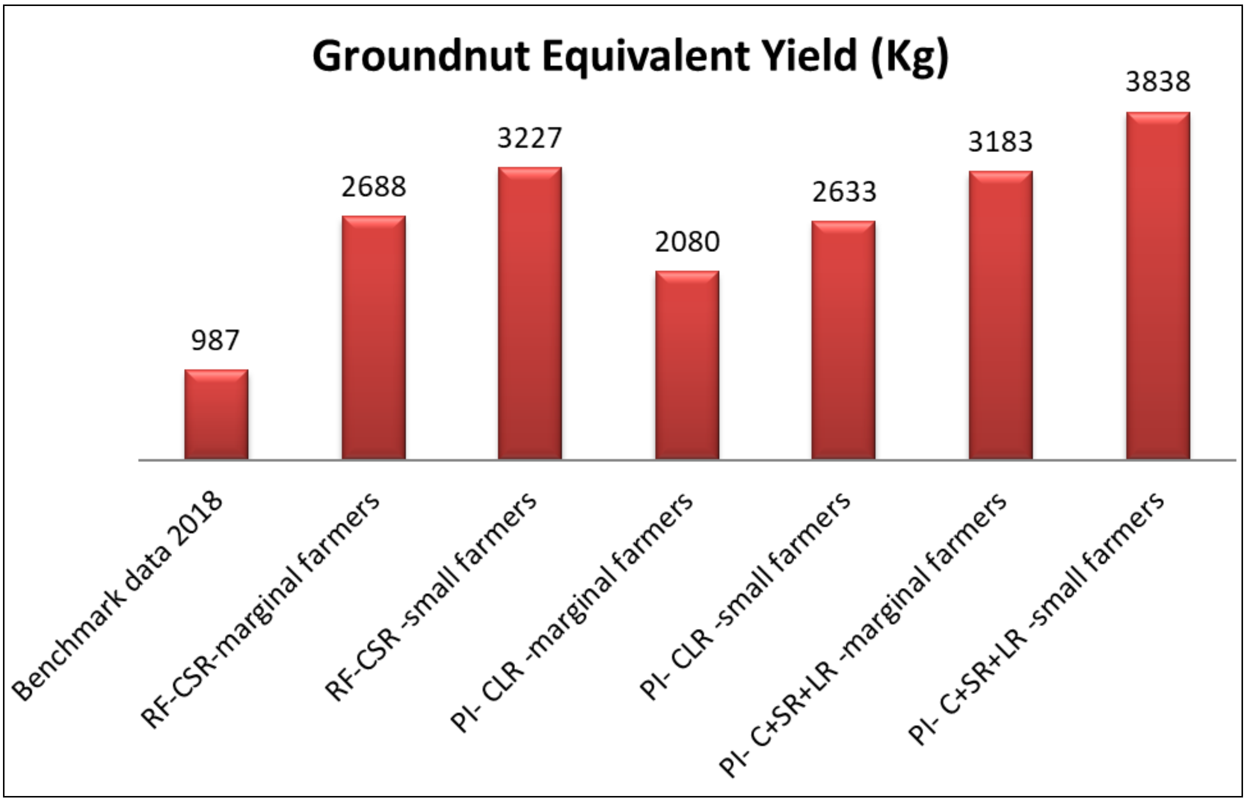

Fig 6: Comparison of bench mark yield with intervention yield

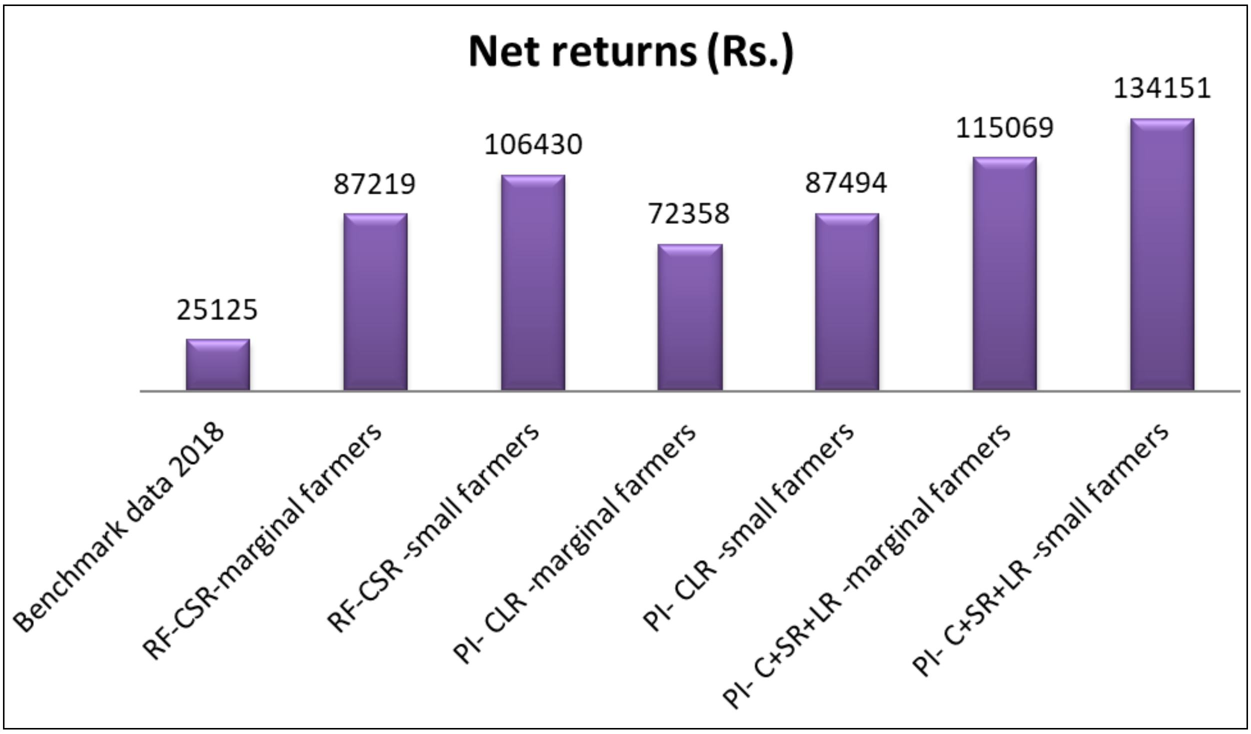

Fig 7: Comparison of bench mark net returns with intervention net returns

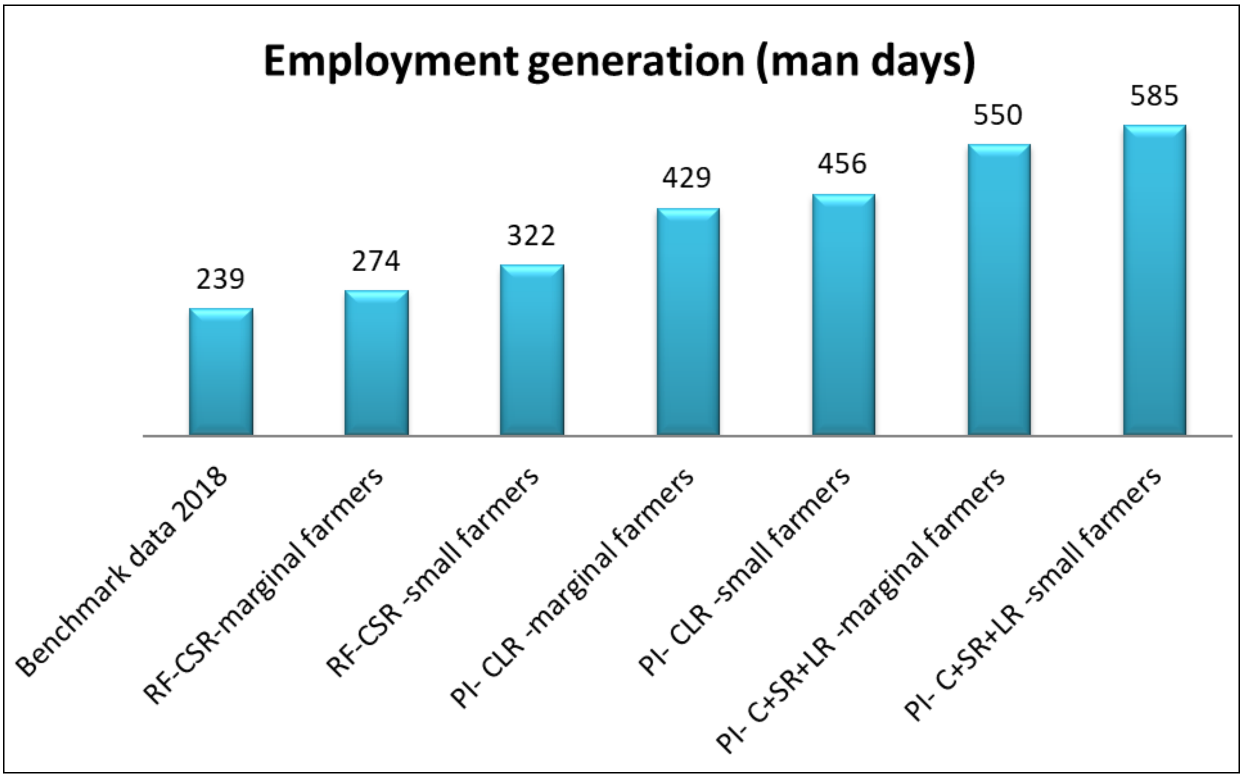

Fig 8: Comparison of bench mark EG with intervention EG

Conclusion

The interventions applied in the farming system significantly improved the yield and economic returns across various components. The integration of livestock and fodder crops further enhanced the overall productivity and sustainability of the farming system. In conclusion, the comprehensive approach in the farming system, incorporating advanced agronomic practices, effective water management, and diversification with livestock and perennial crops, has demonstrated significant improvements in productivity and economic returns. This integrated model can serve as a viable strategy for sustainable agriculture. The comparison clearly demonstrates that the implementation of RIFS interventions has significantly enhanced the yield, economic returns, and employment generation for both marginal and small farmers. This transition towards more integrated and sustainable farming practices is supported by substantial improvements documented in literature, indicating that RIFS can be a viable strategy for boosting agricultural productivity and rural livelihoods

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