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EVALUATION OF GREEN HOUSE GAS EMISSIONS FROM VARIOUS COMPONENTS AND FARMING SYSTEM MODELS IN SOUTHERN TELANGANA ZONE

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ABSTRACT

An experiment was conducted to compare and evaluate the greenhouse gas emissions from various components (crop, horticulture and livestock) and farming system models at IFS Unit, College farm, College of Agriculture, PJTSAU, Rajendranagar during 2021-22 and 2022-23. Theintegrated farming system was planned for 1.00 acre area and consisted of four cropping systems *i.e.,* Rice – Groundnut; Pigeonpea + Sweetcorn (1:3) – Bajra; Bt cotton + Greengram (1:2) – Maize; Pigeonpea + Maize (1:3) – Sunhemp, Napier grass and Hedge lucerne as fodder crops, guava orchard, poultry and two sheep units (each 5+1 each). Seven integrated farming system models were formulated by using suitable combinations ofdifferent components and compared. M_1: Rice – Groundnut; M_2: Rice – Groundnut, Pigeonpea + Sweetcorn (1:3) – Bajra, Bt cotton + Greengram (1:2) – Maize; M_3: Rice – Groundnut, Pigeonpea + Sweetcorn (1:3) – Bajra, Pigeonpea + Maize (1:3) – Sunhemp; Napier grass, Sheep (5+1); M_4: Rice – Groundnut, Pigeonpea + Sweetcorn (1:3) – Bajra, Bt cotton + Greengram (1:2) – Maize, Pigeonpea + Maize (1:3) – Sunhemp, Poultry unit; M_5: Guava, Hedge Lucerne, Napier grass, Bt cotton + Greengram (1:2) – Maize, Sheep (5+1); M_6: Guava, Bt cotton + Greengram (1:2) – Maize, Rice – Groundnut, Poultry; M_7: Rice – Groundnut, Pigeonpea + Sweetcorn (1:3) – Bajra, Pigeonpea + Maize (1:3) – Sunhemp; Napier grass, Hedge lucerne, Poultry, Sheep (5+1). Among different IFS models, higher mean negative net emissions (-2542 kg CO_2 eq.) were recorded in M_4 which was significantly at par with M_3 (-2360 kg CO_2 eq.), M_2 (-2372 kg CO_2 eq.) and M_7 (-2215 kg CO_2 eq.). Based on the findings, it can be concluded that integration of crops with livestock components results in net negative emissions and maintains the sustainability as compared to cropping systems.

Keywords: Green house gas emissions, farming systems, livestock, Telangana

The IFS approach comprises of optimal utilization of resources, and waste recycling which helps small and marginal farmers in obtaining good profits with less investment. Waste is utilized as a resource in IFS (Gupta *et al*., 2012), it eliminates the waste in the ecosystem and in addition increases the farm productivity and reduces the cost of production. Given the growing population pressure and the gap between demand and supply, deterioration of natural resources, agricultural enterprises diversification/intensification is the most suggestive means for rapid and yearround income generation. The approach of food and nutritional security through a wide range of food items within the farm and economic security which is possible with IFS improves the livelihood through individual farm holdings (Behera and France, 2016). The emergence of Integrated Farming Systems has enabled the development of framework for an alternative 'development model' to improve the feasibility of small sized farming operations over larger ones. Our honourable prime minister has intended to double the farmer's income in the coming years which could be potentially possible through IFS. The small farms (up to 2 ha) hold the key to ensure the food and nutritional security of India. Therefore, location-specific integration of field crops, orchard, floriculture, agro-forestry, livestock such as dairy, poultry, piggery, fishery, and other less land requiring activities such as mushroom, apiary, and boundary plantations are the keys to improve the livelihood of marginal and small holders.

An integrated farming system enables family nutrition, resource recycling for soil sustainability and generates more income and employment. Development

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of a suitable IFS model by the integration of two or three components may produce higher yields, income, soil sustainability, and employment compared to Rice-Groundnut system. The different components of the system have complementarities like waste products of one component becoming the source of food and energy for other components. The integration and advantage of each component need to be studied for their contribution to income, sustainability, and employment generation.

The contribution of farming to greenhouse gas emissions is around 10-12% from the world and 18% for India, where it is third placed after energy and industry sectors (USDA report, 2015). The IFS model creates a crop ecosystem where the CO_2 absorption is more with less emission which makes it climate resilient compared to cropping systems and it also reduces the dependence on external resources through efficient recycling of on-farm biomass and other resources. Conducting research on IFS helps to find out the contribution of each component and especially the contribution to soil sustainability. There is a need to develop location specific IFS models as soil, climatic and cultural conditions vary from place to place. Developing a climate smart IFS model for farmers is the need of the hour in the climate changing scenario.

MATERIAL AND METHODS

An experiment was conducted at IFS Unit, College farm, College of Agriculture, PJTSAU, Rajendranagar during 2021-22 and 2022-23 with a view to compare and evaluate the green house gas emissions from various components and farming system models. The details of the materials used and the methods adopted during the course of investigation are described in this chapter.

Location of the experimental site

The experimental site was situated at an altitude of 527 m above Mean Sea Level (MSL) at 17° 32‘10.45" N latitude and 78° 41‘ 02.77" E longitude E longitude in Southern Telangana Zone (STZ), India. The experiment was laid out in field No. B-20 of Agricultural College Farm, Rajendranagar.

Weather

The meteorological data recorded during the crop growth period of experimentation was taken from the meteorological observatory of Agro Climatic Research Centre (ACRC) located at Agricultural Research Institute, Rajendranagar, Hyderabad.

During the both years, the mean maximum and minimum weekly temperature duringthe study period ranged from 27.6^{0}C to 39.3^{0}C with the average of 32.1^{0}C and from 9.6^{0}C to 26.1^{0}C with the average of 20.5^{0}C, respectively.Mean weekly morning relativehumidity ranged from 67 to 98.9 per cent with the average of 88.1 per cent and evening relative humidityranged from 24.7 to 88.9 per cent with the average of 56.3 per cent, respectively. Mean weekly sunshine hours ranged between 1.4 and 10 with the average of 6.3. The average annual rainfall was 1017 mm with 32 rainydays whereas total evaporation was 256 mm.

Experiment details

Table 1: Treatment wise components allocation in 1 Acre area

IFS Model	Composition	Components	Area
M_1	Pre-dominant cropping system	Rice – Groundnut	4000 sq.m
M_2	Cropping systems (Family nutrition & income generating crops)	Rice – Groundnut Pigeonpea + Sweetcorn (1:3) – Bajra Bt cotton + Greengram (1:2) – Maize	1000 sq.m 1000 sq.m 2000 sq.m
M_3	Cropping systems (Family, livestock nutrition & income generating crops) + Sheep (5+1)	Rice – Groundnut Pigeonpea + Sweetcorn (1:3) – Bajra Pigeonpea + Maize (1:3) – Sunhemp Napier grass	1500 sq.m 1000 sq.m 1000 sq.m 500 sq.m
M_4	Cropping systems (Family nutrition & income generating crops) + Poultry (50)	Rice – Groundnut Pigeonpea + Sweetcorn (1:3) – Bajra Pigeonpea + Maize (1:3) – Sunhemp] Bt cotton + Greengram (1:2) – Maize	1000 sq.m 1000 sq.m 1000 sq.m 1000 sq.m

IFS Model	Composition	Components	Area
M_5	Fruit orchard + Field crops + Fodder grass + Sheep (5+1)	Guava Hedge lucerne Napier grass Bt cotton + Greengram (1:2) – Maize	2000 sq.m 500 sq.m 500 sq.m 1000 sq.m
M_6	Fruit orchard + Field crops + Poultry (50)	Guava Bt cotton + Greengram (1:2) – Maize Rice – Groundnut	2000 sq.m 1000 sq.m 1000 sq.m
M_7	Cropping systems (Family nutrition, fodder grass & income generating crops) + Sheep (5+1) + Poultry (50)	Rice – Groundnut Pigeonpea + Sweetcorn (1:3) – Bajra Pigeonpea + Maize (1:3) – Sunhemp Napier grass Hedge lucerne	1000 sq.m 1000 sq.m 1000 sq.m 500 sq.m 500 sq.m

Table 2: Recommended package of practices of all crops in integrated farming system

S.No.	Name of the crop	Season	Seed rate (kg) unit area^{-1}	Spacing	Fertilizer dose ha^{-1}	Variety
1	Rice	*Kharif*	5	20 × 15 cm	120:60:40	RNR 21278
2	Groundnut	*Rabi*	15	22.5 × 10	20:50:30	K-6
3	Pigeonpea	*Kharif*	0.5	240 × 20	20:50:30	WRG-97
4	Sweetcorn	*Kharif*	1	60 × 20	200:60:40	Sugar 75
5	Bajra	*Summer*	1	45 × 15	80:40:30	
6	Bt Cotton	*Kharif*	0.5	90 × 30	150:60:60	Magna (RCH 530 BG II)
7	Greengram	*Kharif*	2	30 × 10	20:50:30	WGG 42
8	Maize	*Rabi*	2	60 × 20	240:80:60	Pioneer 3396
9	Pigeonpea	*Kharif*	0.5	240 × 20	20:50:30	WRG-97
10	Maize	*Kharif*	2	60 × 20	240:80:60	Pioneer 3396
11	Sunhemp	*Summer*	4	30 × 10	10:20:0	
	Fodder crops					
11	Hedge Lucerne	*Perennial*	1 kg	30 cm	40:60:20	RL-88
12	Hybrid napier	*Perennial*	926 cuttings	90 cm× 60 cm	180:60:60	
	Horticultural crops					
13	Guava	*Perennial*		4 × 4 m	100:40:100 2.5 kg Vermicompost plant^{-1} at the time of planting	Allahabad Safeda

Sheep

Two units of sheep were grown (each unit consists of 5+1) separately on platform system in partial grazing manner. One unit of sheep were fed napier grass whereas second unit were fed hedge lucerne in addition to napier grass. Every morning sheep were taken for grazing for 4-5 hrs and stall fed in the evening time. Deworming is done once in 3 months on the advise of veterinary doctors and they used to visit sheep shed every fortnight for health check-up.

Sheep were given serial number and the periodical live weight, growth rate per every 15 days (twice a month) were observed for a period of 24 months (June 2021 - May 2023). Sheep manure was collected at the end of year and supplied to the fields

Poultry birds

Each batch of one day old chicksconsisted of 50 birds. Everyday chick feed and water were provided as per the requirement. The periodical live weight of poultry birds, increase in live weight and manure production were monitered. Once they attain around 1.1 kg weight, they were sold @ Rs.300/kg.

Table 3. Details of livestock components

S. No.	Component	Breed name	Number of birds/animals
1	Sheep (2 units)	*Nellore Jodipi*	5 Ram+ 1 Ewe
2	Poultry	*Aseel*	50 batch^{-1} and 2 batches year^{-1}

Greenhouse gas emissions

GHG emissions from the experiment plot were estimated using Cool Farm tool. The cool farm tool is a Microsoft Excel spreadsheet basedprogramme that calculates global GHG emissions. The tool was developed by Unilever, the University of Aberdeen and the Sustainable Food Laboratory. The tool has global applicability as it uses equations based on modifications of the IPCC approach. It captures on-farm activity data easily as certained whilst in the field through seven input sections, each on a separate Excel worksheet related to crop, soil, inputs, fuel&energy use, irrigation, carbon and transport. Each section was properly fed with inputs according to specific plot conditions to get an estimation of CO_2, N_2O and CH_4 emissions separately as well as also total GHG emissions in terms of equivalents of carbon dioxide emissions (https://coolfarmtool.org).

Statistical analysis

The data generated from field experiment were analyzed in randomized block design (Gomez and Gomez, 1984) in three replications with ten treatments by analysis of variance (ANOVA). The significance of different sources of variation was tested by the error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Standard error of mean (SE) and least signiûcant difference (LSD) at 0.05 level of significance were used to compare treatments.

RESULTS AND DISCUSSION

Component wise greenhouse gas emissions

Mean GHG emitted by Rice - Groundnut system was found to be 400 kg CO_2 eq and sink capacity recorded by this system was found to be 483 kg CO_2 eqwhereas mean net emission were -82.5 kg CO_2 eq.Pigeonpea + Sweetcorn - Bajra system had emitted mean GHG emission of 172 kg CO_2eq and meansink capacity recorded by this system was 1344 kg CO_2 eq whereas mean net emission were -1172 kg CO_2 eq.Bt cotton + Greengram - Maize system had emitted mean GHG emission of 201 kg CO_2eq andsink capacity recorded by this system was 782 kg CO_2eq whereas mean net emission were -581 kg CO_2 eq.Pigeonpea + Maize- Sunhemp system had emitted mean GHG emission of 155 kg CO_2 eq andsink capacity recorded by this system was 928 kg CO_2eq whereas mean net emission were -773 kg CO_2eq (Table 4). Sink capacity increases with increase in biomass production. Sink capacity of Pigeonpea + Sweetcorn- Bajra system followed by Pigeonpea + Maize- Sunhemp system is higher mainly because of higher grain and straw yield which leads to higher negative net emissions in these systems. Total cropping unit system had emitted mean GHG emission of 928 kg CO_2 eq andmean sink capacity recorded by this system was 3536 kg CO_2eq whereas mean net emission were -2609 kg CO_2 eq. in total cropping unit (Table 4).

Mean GHG emission of guava orchard was 126 kg CO_2 eq and mean sink capacity recorded by this orchard was 1131 kg CO_2 eq whereas mean net emission were -1005 kg CO_2 eq. Mean GHG emitted by hedge lucerne was 12.7 kg CO_2eq andsink capacity recorded was found to be 84 kg CO_2 eqwhereas mean net emission were -71 kg CO_2 eq. in hedge lucerne.Mean GHG emitted by hybrid napier was 81 kg CO_2 eqand mean sink capacity recorded was found to be 1601 kg CO_2 eq whereas mean net emission were -1520 kg CO_2 eq. in hybrid napier.Mean GHG emitted by poultry unit was also 5.3 kg CO_2 eq and

Table 4. Component wise Greenhouse gases emission and its contribution in total sink and source (CO_2-e (kg))

Enterprise	Area (sq.m.) / Number	Source (kg CO_2-e)			Sink (kg CO_2-e)			Net emissions (kg CO_2-e)		
		2021-2022	2022-2023	Mean	2021-2022	2022-2023	Mean	2021-2022	2022-2023	Mean
Rice-Groundnut	1000	396	404	400	467	498	482.5	-71	-94	-82.5
Pigeonpea + Sweetcorn- Bajra	1000	171	172	171	1224	1463	1344	-1053	-1291	-1172
Bt cotton + Greengram- Maize	1000	200	202	201	737	827	782	-537	-625	-581
Pigeonpea + Maize- Sunhemp	1000	155	155	155	850	1006	928	-695	-851	-773
Cropping unit (Total)		**922**	**933**	**928**	**3278**	**3794**	**3536**	**-2356**	**-2861**	**-2609**
Guava orchard	2000	122.61	129.5	126	1130	1132	1131	-1007.39	-1002.5	-1004.9
Hedge Lucerne	500	12.5	12.8	12.65	83.1	85	84.05	-70.6	-72.2	-71.4
Napier grass	500	80.4	80.7	81	1582	1619	1600.5	-1501.6	-1538.3	-1519.9
Poultry	100 birds	5.25	5.25	5.25	-	-	-	5.25	5.25	5.25
Sheep unit I	5+1	639	1740	1190	-	-	-	639	1740	1190
Sheep unit II	5+1	653	2067	1360	-	-	-	653	2067	1360

mean GHG emitted by sheep unit I and II were 1190 and 1360 kg CO_2 eq, respectively. Increase in thenumber of sheep during 2nd year resulted in more GHG emissions. Meena *et al.* (2022) and Rathore *et al.* (2019) also found that presence of livestock led to high GHG emissions which could be offset by integrating them with cropping unit, trees and orchards.

Greenhouse gas emissions from different integrated farming system models

Model M_3 had emitted higher mean GHG emissions of 2197 kg CO_2 eq. which was significantly at par with Model M_7 which had emitted mean GHG emission of 2185 kg CO_2 eq (Table 5 & Fig 1). Rice crop and sheep are mainly responsible for the GHG emissions in these models. These results are in agreement with Babu *et al.* (2023) who noticed that greenhouse gas emissions are more from livestock and rice crop. Models having either sheep or rice crop in larger area have emitted more GHG compared to other models. Model M_6 had emitted lower mean GHG emissions of 733.0 kg CO_2 eq. which might be due to low input requirement of guava orchard.

Sink capacity also follows the same trend as GHG source. Model M_3 had recorded mean sink capacity of 4557 kg CO_2 eq. which was significantly at par with Model M_7 which recorded mean sink capacity of 4400 kg CO_2 eq (Table 5 & Fig 1). This might be due to having cropping components and napier grass which have produced higher biomass ultimately resulted in higher sink capacity. Although these models have sheep component, having cropping components and napier grass offsets the higher emissions of sheep. These results are supported by Pasha *et al.* (2020) and Li *et al.* (2017) whofound that integrating livestock with crop production is viable option to decrease GHG emissions that helps in environmental sustainability.

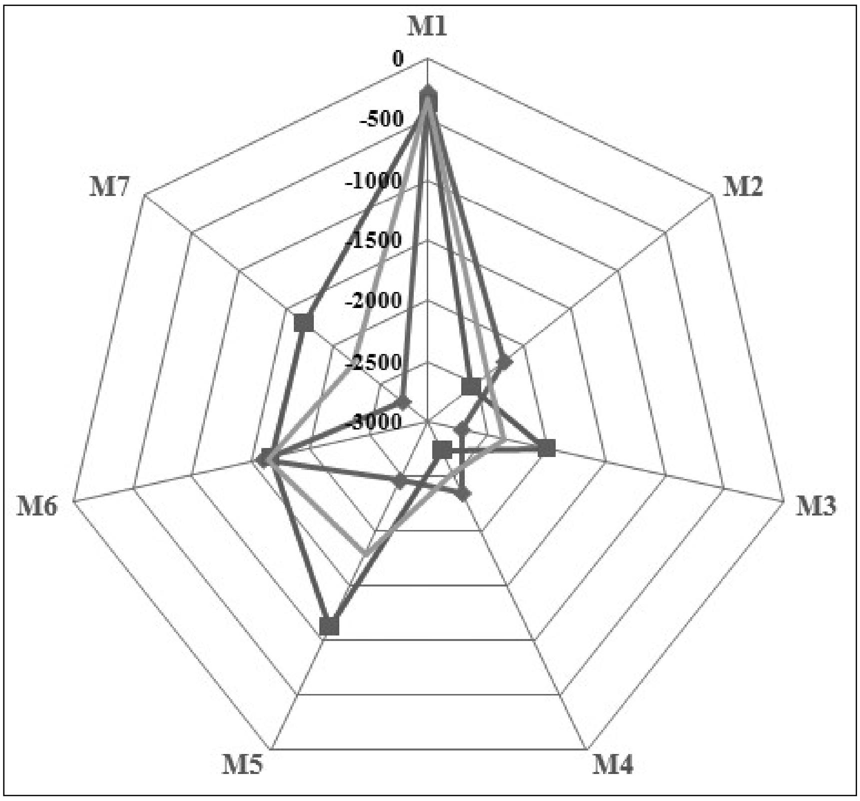

Fig 1: Greenhouse gas emissions from different integrated farming system models

Model M_1 recorded lowestmean sink capacity of 1930 kg CO_2 eq. as well as mean negative net emissions of -330 kg CO_2 eq. among all the models. This might be due to higher GHG emissions from rice crop and lower sink capacity compared to other crops which has resulted in low negative net emissions. Islam *et al.* (2015) reported that rice enhanced the methane emissions which should be integrated with livestock components like duck, fish etc. to reduce the GHG emissions.

Table 5. Greenhouse gas emissions from different integrated farming system models

IFS Models	Source (kg CO_2-e)			Sink (kg CO_2-e)			Net emissions (kg CO_2-e)		
	2021-2022	2022-2023	Mean	2021-2022	2022-2023	Mean	2021-2022	2022-2023	Mean
M_1:C_1	1584	1616	1600	1868	1992	1930	-284	-376	-330
M_2:C_1+ C_2+ C_3	967	980	974	3165	3525	3345	-2198	-2545	-2372
M_3:C_1+ C_2+ C_4 + N + S_1	1639	2754	2197	4356	4757	4557	-2717	-2003	-2360
M_4:C_1+ C_2+ C_3 +C_4 + P	927	939	933	3278	3671	3475	-2351	-2732	-2542
M_5:G + H+ N+ C_3+S_2	1069	2492	1781	3532	3618	3575	-2464	-1126	-1795
M_6:G+ C_1+ C_3 +P	724	741	733	2334	2412	2373	-1610	-1671	-1641
M_7:C_1+ C_2+ C_4+H+ N + S_2+ P	1473	2897	2185	4206	4593	4400	-2733	-1696	-2215
SEm(±)	50.22	80.66	63.43	140.27	150.58	145.05	88.42	71.47	77.96
LSD (p=0.05)	154.76	248.56	195.46	432.21	463.98	446.90	272.47	220.24	240.22

Model M_4 had recorded higher mean negative net emissions of -2542 kg CO_2 eq. in which was significantly at par with M_3(-2360 kg CO_2 eq), M_2 (-2372 kg CO_2 eq.) and M_7 (-2215 kg CO_2 eq.). Multiple enterprises or components present in a integrated farming system enhances the sink capacity which results in negative net emissions. These results are supported by Meena *et al*. (2022) and Sridevi *et al*. (2021) who identified that more intensification of crops and other components enhances the carbon sink which makes the IFS model environmentally benign.

CONCLUSION

In this experiment, we have compared and evaluated the greenhouse gas emissions from various integrated farming system models. Among all the cropping systems, Pigeonpea + Sweetcorn- Bajra recorded higher mean net emissions (-1172 kg CO_2 eq.) followed by Pigeonpea + Maize- Sunhemp system (-773 kg CO_2 eq.). Compared to all components, mean net emission were higher in hybrid napier (-1520 kg CO_2 eq.). Mean GHG emitted by poultry unit, sheep unit I and II were 5.25, 1189.5 and 1360 kg CO_2 eq., respectively. The IFS model M_4 recorded higher mean negative net emissions (-2542 kg CO_2 eq.) which was significantly at par with M_3 (-2360 kg CO_2 eq.), M_2 (-2372 kg CO_2 eq.) and M_7 (-2215 kg CO_2 eq.) which indicates that multiple enterprises enhanced the sink capacity leading to higher negative net emissions.

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