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The impact of long-term integrated farming on soil-derived greenhouse gas emissions

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Abstract
Climate change, caused by the raise in concentrations of greenhouse gases (GHGs) in the atmosphere, has emerged as the most well-known environmental issue all over the globe. It will have a considerable impact on agriculture including crops, livestock, boundary plantation and organic manure (FYM, vermi-compost and compost) *etc*. The GHG emissions were estimated from integrated farming system of AICRP – IFS, Sardarkrushinagar. GHG of different components of farming system was estimated by ICAR-IIFSR-IFS, GHG -Estimator tool for estimating GHG emissions in IFS model. Maximum GHG emission 3522.38 CO_2-e in kg was recorded under livestock (Cattle and buffalo) and minimum GHG emission was noted under energy used for household (150.0 CO_2-e in kg) as compared to other components of farming system whereas, carbon sink 31099.18 kg/year was maximum in agro-forestry components.

Keywords: GHG emission, farming systems, agro-forestry and carbon sink

Introduction
Rising carbon dioxide (CO_2) concentration in the atmosphere from pre industrial levels of 280 ppm to a present day value of 400.26 ppm has lead to increase in ocean acidification and may be contributing to climate change and a rising of global temperature (Biello, 2015) [1]. Doubling of man-made CO_2 emissions since 1970's coupled with geological facts, which shows that changes of this magnitude usually occur over timescales of 5,000 to 10,000 years, suggests that it is likely that man-made CO_2 is contributing significantly to this rise in atmospheric CO_2 (Tripati *et al.* 2009) [5]. If fossil fuel combustion is allowed to continue to grow unabated then it is projected that CO_2 emissions will reach 35.4 Gt per year by 2035. This is in line with the worst case scenario in the IPCC 2007 Climate Change report which couples CO_2 rises to a world average temperature increase from 2.4-6.4°C by 2100.
If the world is to maintain its current dependence on fossil fuels then carbon capture and storage (CCS) is a necessary technology for tackling rising atmospheric CO_2.
The effects of CO_2 in the atmosphere are controversial. However, the average temperature of the Earth is rising, especially when measured at the poles. The average earth surface temperature correlates well with the amount of CO_2 in the atmosphere (i.e. as the CO_2 levels in the atmosphere have increased, the surface temperature has gone up at the same time).

Table 1: Abundance and lifetime of greenhouse gases in the atmosphere (Source: IPCC, 2014)

Parameters	CO_2	CH_4	N_2O	CFCs
Average conc. 100 years ago (ppbV)	2,90,000	900	270	0
Current conc. (ppbV)	3,99,000	1,834	316	3-5
Projected conc. In the years 2030 (ppbV)	4,00,000 – 5,00,000	2,800 – 3,000	400 - 500	3 – 6
Atmospheric lifetime (year)	5 - 200	9 - 15	114	75
Global warming potential (100 year relative to CO_2)	1	21	310	4,750 – 10,900

Integrated Farming System (IFS) is a participatory and comprehensive approach of developing location and situation specific farming systems harnessing the interactions among components of a farm for higher and sustained agricultural production for environmental, social, economic and nutritional security. It is a single window system encompassing all possible intervention for a farm in totality. Studying and developing sustainable IFS can be a way forward for

mitigating the climate change. Integration of farming practices mitigating the climate change can only address the issues of global warming.

Material and Methods

Details of the experimental site

The Sardarkrushinagar Dantiwada Agricultural University is situated in arid and semi-arid tropical climate. The mean annual rainfall of this region is 2083 mm with 37 mean rainy days. Area received more than 100 % rainfall mainly through the influence of S-W monsoon. The lowest rainfall 68 mm was received in 1987 while the highest 2083 mm was recorded in 2017-18 during last 31 year. The maximum rainfall 1198.4 mm observed received on fourth week of July, 2017-18. The distribution of rainfall during the monsoon season was uneven. The minimum temperature during November, December, January and February was below normal. This is helpful for increasing production of *Rabi* season crops. The maximum temperature during April, May and June was recorded higher than normal which resulted poor performance of summer crops during the year.

Table 2: Treatment details of the one hectare integrated farming system

Sr. No.	Enterprises identified	Area (ha)	Treatment/Remarks
1	Crops and cropping system	0.70	Cropping Systems:
			▪ C_1: Castor + Green gram (0.32)
			▪ C_2: groundnut - Wheat – Multicut Fodder Rajka Bajra (0.08)
			▪ C_3: Green gram - Mustard - Pearl millet (0.24)
			▪ C_4: Hybrid Napier + Cowpea (F) - Lucerne + Fodder Chicory (0.06)
2	Multistoried horticulture fruits and vegetables	0.25	Fruit trees:
			▪ Mango: 8m x 8m (40 plants)
			▪ Lemon: In between two rows at 4 m distance (80 plants)
			▪ Custard apple: In between 2 plants of mango (36 plants)
			▪ Seasonal Vegetables in between fruit trees
3	Boundary plantation	-	Boundary plantation:
			▪ Timber wood/Fruit/Vegetable/ Medicinal plants
			1. Ardusa: 101 6. Mulberry: 03
			2. Eucalyptus: 10 7. Drum stick: 15
			3. Subabool: 10 8. Aonla: 03
			4. Custard apple: 10 9. Bamboo: 01
			5. Jambun: 04 10. Teak: 35
			▪ Fodder crops: Dhaman and Hybrid Napier on bunds
4	Livestock	0.025	Mehsani breed buffalo (Two)
5	Vermicompost, compost and nursery unit	0.010	Use of FYM, Farm wastes and cattle feed wastage
6	Water harvesting for recharging	0.015	IR is 15cm/hr. Source of irrigation is tube well. Water table is increasing at present
Total area		1.000	-

Greenhouse Gas estimation

The GHG emissions were estimated from integrated farming systems of AICRP – IFS, Sardarkrushinagar. GHG of different components of farming system was estimated by ICAR-IIFSR-IFS, GHG -Estimator tool for estimating GHG emissions in IFS model.

Results and Discussion

GHG emission effects agricultural output, because of the relevance of agriculture to the world economy, and the sensitivity of crop yields to climate conditions. From 2010-11, the percentage changes in average yields of rice, wheat, pulses, oilseeds and cotton are also showing declining trends, which is a cause for concern (Kar and Das, 2015) [4].

Further, few studies have looked into the impact of elevated CO_2 concentrations on whole farming systems. Most models study the relationship between CO_2 and productivity in isolation from other factors associated with climate change, such as an increased frequency of extreme weather events, seasonal shifts and so on. Studies have shown that higher CO_2 levels lead to reduced plant uptake of nitrogen resulting in crops with lower nutritional value.

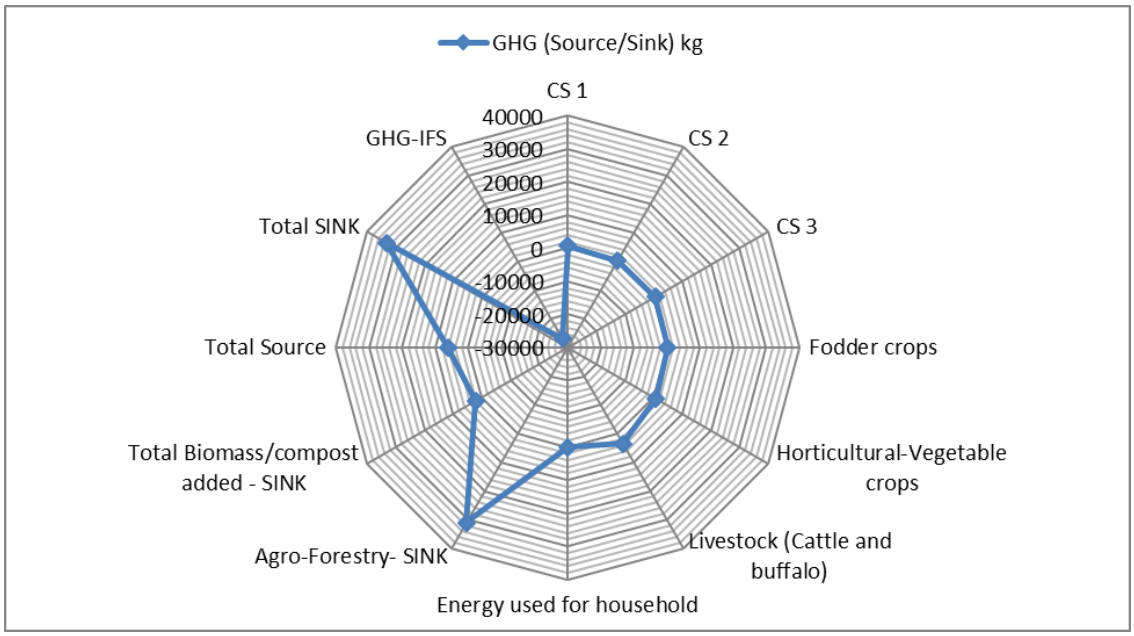

Fig 1: Overall CO_2-e (kg) emission and sink of on station IFS experiment in different components after eight years of experiment.

Data graphically depicted in Fig. 1 pertains to GHG emission under different IFS components. Higher value of GHG emission (3522.38 CO2-e kg) was found under Livestock (Cattle and buffalo) component and lowest value found with Energy used for household (150 CO2-e kg). Garg *et al*., in 2011 [2] observed that the cattle and buffalo are the major methane emitters (10.9 Tg), as compared to other livestock (0.86 Tg). Agricultural soils emit N_2O directly and indirectly from N application in the form of synthetic fertilizers, manures and crop residues. Fertilizer N application in soil results in direct and indirect emission of N_2O.

Trees remove CO_2 from the atmosphere through the natural process of photosynthesis and store the C in their leaves, branches, stems, bark and roots. Approximately half the dry weight of a trees biomass is C. The average tropical trees sequester about 22.6 kg of C per year. Accordingly, C sequestration by trees in IFS can be assessed. In our IFS system total agro-forestry sink of GHG is the 31099.18 kg sink after eight years of farming system.

Conclusion

Assessment of emission of GHG in IFS models gives indication of hot spot of emissions among different components required to be addressed to mitigate the emissions by using suitable technological options under the given situations. To develop C neutral or even C negative IFS modules based on the benchmark GHG emission or otherwise, mix of technological options *viz.* agroforestry systems, energy plantation, conservation agriculture, increasing nutrient use efficiency, balanced fertilization, improved cropping system, manipulation of feeding habit of animals etc. should be adopted without compromising the crop production and productivity.

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