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Prediction of green house gas emission in the integrated farming system model: Implication on soil environment

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Abstract

Global warming is a important issue in this century. Among the different sectors contribution to the society, agriculture also got its own value interms of source as well as sink to the green house gases. To identify the source and sink of green house gas contribution towards the climate change in one of the farming system model of Tamil nadu, India work has been initiated. Model consists of different cropping systems viz., Maize - Cowpea (grain) – Tomato/ Radish, Bhendi - Maize + Cowpea (F) – Sunflower, Chillies- Maize - Green manure. Cowpea (veg.)- Cotton – Sunflower, along with perennial fodder grass and fodder legume and Fruit trees (Banana, Sapota, Anola, Guava) and border crops along with livestock components viz.,dairy and telicherry goat breed, Manure pit, threshing floor, vermicompost yard, etc. Among the different components, Livestock contribute more to the GHG emission (60%) followed by energy usage (20%) and then from crops (12%) and remaining by soil. In carbon sequestration, annual biomass contributed higher C removal followed by agroforestry (17%). Among cropping, forage crops contributes to 46% of carbon sequestration and forages can be recommended to build up underground carbon besides above ground biomass. Model as a whole, though crops contributed to green house gases, it also contributes for carbon sequestration and this will compensate the global warming potential created by livestock. The model for small and marginal farmers of western zone of Tamil nadu is carbon negative one. There is no harm to the environment by adopting the integrated farming system model consists of annual cropping along with agroforestry, livestock and vermicompost and fodder crops.

Keywords: Integrated farming system, green house gas emission, carbon sequestration, carbon pools

Introduction

Climate change is a variation in atmospheric properties due to natural and human activities over a long period of time. In the last few decades, there was a significant change in the gaseous composition of earth's atmosphere, mainly through increased energy use in industry and agriculture sectors, viz. deforestation, intensive cultivation, land use change, management practices, etc. These activities lead to increase the emission of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), etc (Bama *et al*. 2019) [1].

Climate change poses a major threat to food security through its strong impact on agriculture. It is thought to negatively affect crop, livestock and fishery production through yield reductions. Carbon dioxide (CO_2) is the most abundant carbon-based gas in the atmosphere. The increase in atmospheric CO_2 concentration is mainly attributed to the combustion of fossil fuels and land use change and deforestation.

The atmospheric CO_2 concentration has increased from 270 μmol mol^{-1} in the pre - industrial era to currently about 400 μmol mol^{-1}. The business-as-usual path of energy use based on fossil fuel consumption may raise the CO_2 concentration to 900 to 1100 μmol mol^{-1} by the end of 21st century. The current rate of increase at about 2 μmol mol^{-1} yr^{-1} is also the highest since the monitoring commenced in 1959. Atmospheric concentration of CO_2 is increasing at about half the rate of fossil fuel emissions. The remainder is either dissolved in ocean or is absorbed by terrestrial ecosystems. Soil and vegetation are the two major C sinks in the terrestrial ecosystems. As per the estimate of inter governmental panel on climate change (IPCC), cumulative anthropogenic CO_2 emissions to the atmosphere were 2040 ± 310 Gt CO_2 between the years 1750 and 2011. However, only 40% of the emissions have remained in the atmosphere and the rest has been stored in terrestrial ecosystems (in plants and soils) and in the ocean. The ocean absorbed about 30% of the emitted anthropogenic CO_2, resulting ocean acidification. Thus, the two mechanisms by which terrestrial ecosystems have a control over the CO_2 concentration is the transfer of atmospheric CO_2 into biotic pools through the process of CO_2 fertilization and to the soil system through soil carbon sequestration. Existence of human being on the earth is at risk owing to global climate change associated with anthropogenic activities on account of green house gas (GHG) emissions due to unabated increase in population coupled with rapid industrialization. Among the anthropogenic activities, agriculture is an important activity contributing significantly to GHG emissions (Lal, 2016, Bama *et al*., 2019) [2, 1]. Globally, agriculture contributes about 10-12 per cent of total GHG emissions. Nationally, agriculture contributes 17.6 per cent of total 1728 million tones of CO_2 equivalent GHG emission in 2007.

Sectorial distribution of GHG emission comparing the emission levels at 2004 and 2010 is given by Lenka *et al*. (2015) [3]. By sector, the largest sources of greenhouse gases were the sectors of energy production (mainly CO_2 from fossil fuel combustion), and agriculture, forestry and land-use (AFOLU) (mainly CH_4 and N_2O). The contribution of AFLOU (agriculture, forestry and land-use) to total emission has come down from 31% (2004) to 24% (2010). Identification of GHG sources and quantification of GHG emission from agriculture sector has passed through many phases of refinement.

Among various approaches in the agriculture to mitigate climate change, Integrated Farming System (IFS) is a participatory and comprehensive age old approach Location and situation specific farming systems harnessing the interactions among components of a system for sustained environment. It is a single window system contains all possible interventions 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. C assessment enables farmers and land managers to estimate GHG emissions from farm activities and land vis-à-vis estimate the C sequestrated in soil and land management. This way C accounting of a farm identifies the sink and sources of GHG emissions giving scope to act upon the identification of 'hot spots' of GHG emissions to mitigate climate change. After benchmarking GHG emissions from a farm, C assessment enables the impact of changing farm practices on the effect of changes on a farm by overall GHG emissions. Also used to identify which cropping sequence is more potential to sequester carbon in the integrated farming system.

In the integrated farming system (IFS) system, the residues and wastes are recycled within the components. The product of one component is the raw material for other one. In IFS system, by adopting vermi compost, organic manures are properly added to the soil for maintaining SOC level and including legume in one of the cropping sequence could sequester nitrogen thereby reducing the usage of nitrogenous fertilizer to the extent of 25% ultimately nitrous oxide emission from the N fertilizer is reduced.

The soil carbon stock value indicated the capacity of the soil to hold the carbon. Bama *et al*. (2017a) [4] reported that, higher value of passive carbon recorded in bhendi- maize+cowpea-sunflower sequence might be due to legume crop of cowpea addition in the sequence might be due to more residue addition from sunflower and bhendi crops as well as intercropping of maize with legume crop.

Bama *et al*. (2020) [5] reported that, green manure included cropping sequence registered higher soil quality parameters. Irrespective of cropping sequences of fodder maize rotated with green manre along with FYM applied plots @25 t/ha recorded higher nutrient status, organic carbon and microbial population. Yazhini *et al*. (2019) [6] also reported that, inclusions of legume in the maize based cropping sequences leads to sequestrate more carbon in the deltaic zone of Tamil Nadu.

By planting agroforestry trees along the bunds sequester more carbon and stored for long time. Growing horticultural crops like Sapota, Guava, Amla, Lemon etc also sequester more carbon for long time besides stable income to the farmers. In the cropping components, among the crops, forages have high potential to store carbon for long life due to perennial nature as well as grass have high rooting capacity and store more below ground carbon. This also due to inclusion of livestock in IFS compulsorily forces to grow fodder crops.

To mitigate climate change, sequestering carbon for long time is the simple and easy approach and is possible in agriculture through soil carbon sequestration. Actually soil organic carbon (SOC) is the main component of soil organic matter. Soil organic carbon plays an important role as a source of plant nutrients and in maintaining the soil integrity. In soils, CO_2 release to the atmosphere occurs when organic residues or SOM are oxidized by soil fauna and below-ground roots from the soil to the atmosphere. According to Bama and Babu (2016) [7], forages particularly grass type fodder contributes to carbon sequestration in terms of long time carbon storage from roots i. e. below ground portion. and it can saturate carbon level quickly wherever the climate change mitigation is essential. Among the various forage crops, Cumbu napier hybrid grass removed higher carbon removal by above ground biomass and in the below ground biomass. Among the sources, farm yard manure. applied plot sequestered more below ground carbon.

In cumbu napier hybrid grass, there was a drastic improvement in the organic carbon status of the soil by the application of organic manures. The FYM applied on N equivalent basis recorded higher organic carbon content of 1.28 per cent, followed by poultry manure applied treatment (0.91%), from the initial carbon status of 0.62 per cent (Bama, 2014; Bama, 2017b) [8, 9]. Bama and Babu (2016) [7] reported that, among the different forage crops, Cumbu Napier grass had higher carbon sequestration potential of above ground biomass which removed 336.7 t CO2/ha than multicut fodder sorghum (148.7 t CO2/ha). The higher below ground biomass in Cumbu Napier grass removed 7.73 t CO2/ha from the atmosphere than Lucerne (4.21 t CO2/ha).

The SOC content has come down to 0.3 - 0.4 per cent in the country. It is well below the acceptable limit and is a cause for concern. The SOC should be between 1 to 1.5 per cent. But it had been coming down rapidly because of increasing atmospheric temperature, over exploitation, extensive mining of soil fertility, soil degradation, inappropriate soil tillage, poor crop management, indiscriminate use of fertiliser, and accelerated soil erosion. Land use management that increases SOC by removing CO_2 from the atmosphere by storing it in the soil, is termed as carbon sequestration. It is an indicator for soil health for its contributions to food production, mitigation and adaptation to climate change, and the achievement of the sustainable development goals.

Organic source of nutrients sequestered more carbon in deeper depth than inorganic or intergrated nutrient management in the forage cropping sequences (Bama *et al*. (2017a) [4]. Zero tillage recorded higher soil carbon stock than crop establishment method combined with minimum or conventional methods (Bama *et al*., 2017c) [10]. Another study with different cropping sequences, Bhendi-maize + greengram – Greenmanure improved the passive carbon as well as carbon stock might be due to high organic carbon accumulation in that cropping sequence (Bama *et al*., 2017b) [9].

Carbon sequestration through agriculture involves three stages: 1) the removal of CO_2 from the atmosphere via plant photosynthesis; 2) the transfer of carbon to plant biomass (Above ground) and 3) the transfer of carbon from plant biomass to the soil where it is stored in the form of SOC in the most labile pool. These pools are characterized by the highest turnover rate (days - few years), includes recently incorporated plant residues which is readily decomposed by soil fauna, generally causing CO_2 emissions back into the atmosphere. Bama and Latha (2017) [11] reported that enforcing the standardization of analytical methods for carbon sequestration studies and explained about the role of land use and management on soil carbon fractions.

Hema *et al*. (2019) [12] indicated that long-term application of 100% organics exerted significant effect on the active pools of soil organic carbon Aboveground assessment of C stock is direct derivatives of biomass estimates which are often derived by total harvested biomass. In agriculture, trees are the important source for long time carbon storage, eg in agro forestry (Montagini and Nair, 2004) [13]. The belowground biomass is also a major C pool. However, measurement of belowground biomass is a difficult process. Hence, most of the crops, 25-40% of the above ground biomass taken as below ground biomass.

Soil organic carbon sequestration requires looking beyond capturing atmospheric CO_2 and necessitates finding ways to retain C in the slow SOC pool. Contrastingly, research shows that the stable pool has a negligible potential for carbon sequestration due to its resistance to change and irresponsiveness to management.

Currently instead of taking the SOC, the fractions/forms such as readily oxidisable, slowly oxidisable, very slowly oxidisable and recalcitrant C are getting importance in view of carbon storage. These forms are useful to know about the status of SOC in soil whether in labile or non labile form. Attempts have been made to develop color charts that match color to TOC content, but the correlation is better within soil landscapes and only for limited soils (Shreshtha, *et al*., 2006) [14]. Near infrared spectroscopy has been attempted to measure C directly in the field, but it is expensive. It is the fractions of TOC (total organic carbon) by using the different concentration of acid aqueous solution which are more sensitive indicators than the TOC alone for detecting the effect of land management practices (Chan *et al*., 2001) [15].

According to Blair *et al*. (1995) [16] and Chan *et al*. (2001) [15], the addition of crop residue under the management systems leads to increase the organic matter content in soil which increase the very labile (F1) fraction. The agricultural crops contribute to higher level of labile carbon than the recalcitrant, because of the continuous addition of the crop litter in to the soil in fresh form of easily decomposable nature. Labile C pool, with rapid turnover rate, is an important energy source for the soil food web and thus influences nutrient cycling for maintaining soil quality and its productivity.

Bama *et al*. (2017b) [9], bhendi-maize cropping sequence registered higher carbon stock of 11.24 t/ha/yr. They also stated that irrespective of manures and cropping sequence, minimum tillage recorded higher carbon stock of 10.92 t/ha/yr than conventional tillage 110.72 t/ha/yr. Mulching of in situ crop residue with 75% recommended dose of fertilizers and 25% N through organic is revealed higher C stock than mulch with 100% recommended dose of fertilizers

Passive or recalcitrant pool is very slowly altered by microbial activities. Some C pools like microbial biomass C, mineralizable C, dissolved organic C (DOC), water extractable organic C (WEOC), hot water soluble C (HWEOC), $KMnO_4$-oxidizable C and organic C fractions of different oxidizability are used as indicators of organic matter lability (Benbi *et al*., 2012) [17]. These pools are considered to respond to agricultural management and land use changes more rapidly than the total organic carbon and thus could be used as sensitive indicators of organic C dynamics in soils.By adopting integrated farming system, soil health deterioration can be overcome in future. Based on the literatures work has been initiated to assess the GHG released from the IFS model as well as carbon pools in the soil system.

Materials and Methods

To identify the source and sink of green house gases viz., methane, nitrous oxide and carbon di oxide in the existing IFS model of western zone of Tamil Nadu, work has been initiated. The model consists of different cropping systems namely Maize - Cowpea (grain) – Tomato/ Radish 0.20 ha) 2. Bhendi - Maize + Cowpea (F) – Sunflower (0.20 ha),3. Chillies- Maize - Green manure (0.20 ha),4. Cowpea (veg.)-Cotton – Sunflower (0.25 ha), 5. Perennial fodder grass and Desmanthus (0.17 ha) and Fruit trees (Banana, Sapota, Anola, Guava). In the livestock components dairy (2 cross bred) and 10 nos of tellicherry breed. manure pit, threshing floor, vermicompost yard, etc also maintained. In the border, annual moringa, Curry leaf, agathi and glyricidia were established.

The greenhouse gas emission from different components of the IFS model predicted using the excel tool released by the Indian Institute of farming System Research, Modipuram, Meerat, Uttar Pradesh using the IPCC guidelines. The data are worked out based on already available predicted value, fertilizer usage, machinery usage and chemical usage for different crops. The green house gas emission from different cropping sequences and other component was converted in to carbon dioxide equivalent between components for easy comparison.

$$\text{Emission} = A \times EF$$

Where,

Emission	=Annual emissions in units of kg of CO_2 eq. per farm
A	=Activity data (kg of N used, liters of fuel used etc.)
EF-Emission factor	=IPCC default emission factors or Country specific emission factors.

Normally estimated GHGs was expressed in terms of CO_2 equivalent (CO_2eq). Due to their different radiative properties and lifetimes, the GHGs vary in their warming influence (radiative forcing) on the global climate. They are brought to a common footing using the concept of global warming potential. Global warming potential (GWP) as defined by IPCC (2006) [18] is "an index, based upon radiative properties of well-mixed greenhouse gases, measuring the radiative forcing of a unit mass of a given well-mixed greenhouse gas in today's atmosphere integrated over a chosen time horizon, relative to that of CO_2". The GWP of methane is 28 which means, over a time period of 100 years, one metric tonne of methane and twenty eight metric tonnes of carbon dioxide trap an equal amount of heat in the atmosphere. IPCC uses CO_2 as a reference gas; hence, all other GHGs are converted into carbon dioxide equivalents to ensure uniformity. According to IPCC fifth assessment report, 2015 GWP for important GHGs were given in Annexure I. The soil carbon fractions were analysed by following the procedures of a modified Walkey and Black's (1934) [19] method as described by Chan *et al*. (2001) [15] using H_2SO_4 solution ratios of 0.5:1, 1:1&2:1(which correspond to 12N, 18N, 24N H_2SO_4 respectively).The amount of SOC determined using the three acid –aqueous solution ratio allows transformation of total organic C into the following four fractions of decreasing oxidizability/lability. Fraction 1(very labile): Organic C oxidizable under 12N H_2SO_4; Fraction 2(labile): Difference in oxidizble organic C extracted between 18N & 12N H_2SO_4; Fraction 3(less labile): Difference in oxidizble organic C extracted between 24N & 18N H_2SO_4; Fraction 4(recalcitrant): Residual oxidizble organic C after reaction with 24N $H_2SO_4$when compared with the TOC.

Aboveground assessment of C stock is direct derivatives of biomass estimates. The belowground biomass measurement is based on the root-to-shoot ratio which is a commonly used procedure to estimate in living biomass (Nadelhoffer and Raich, 1992) [20]. Assume that the belowground biomass constitutes a defined portion of the aboveground biomass and the values so assumed range from 40 percent. Soil carbon exists in various forms with differing longevity. Numerous laboratory methods are available. Soil organic carbon (SOC) pool is comprised of labile or actively cycling pool and stable and recalcitrant pools with varying residence time.

Results and Discussion

Assessment of green house gas measurement in the existing model of western zone of tamil nadu showed the green house gas emission in terms of carbon di oxide equivalent for fertilizer, manure, chemicals usage etc., and energy required and GHG emitted by the different components of IFS model in1.20 hectare (table 1). Among the different components, Livestock contribute more to the GHG emission of 2718 kg of CO_2 equivalent (60%) (fig 1) followed by energy usage of 900 kg of CO_2 equivalent (20%), crops by fertiliser usage of 640.8 kg of CO_2 equivalent (12%). The crop residue incorporation contributes to 144 kg of CO_2 equivalent, fodder crops contributes interm of fertiliser usage was 103.3 kg of CO_2 equivalent, chemical usage viz., pesticides, herbicides and insecticides contributes 51.4 kg of CO_2 equivalent and kitchen garden and border crops by minimum.

In terms of sink, carbon sequestration in annual biomass contributed higher C removal of 29499.2 kg of CO_2 equivalents followed by agroforestry (2756 kg of CO_2 equivalent) (fig 2). Among cropping, forage crops contribute to 46% (fig 1) and forages can be recommended to build up underground carbon besides above ground biomass. Model as a whole, though crops contribute GHG it also contributes for carbon sequestration and this will compensate the global warming potential created by livestock. The carbon di oxide sequestered in the soil over initial status was equivalent to carbon di oxide emitted from the soil. Positive point in this IFS system is, carbon fixed from the atmosphere by biomass i.e. (carbon foot print) temporary storage is high. It can be considered because almost more than half of the biomass is recycled in to the system and economic part also not directly and immediately exposed to the environment.

Assessment of green house gas emission from different cropping

Different cropping practiced in the integrated farming system model, from the fertiliser usage as N_2O emission, energy used for machinaries and chemical transport in terms of CO_2 equivalent, bajra napier hybrid grass contributes more emission of GHG (834.9 kg of CO_2 equivalent) followed by maize which contributes about 277 kg of CO_2 equivalent and then by chillies (238 kg of CO_2 equivalent), cotton (235 kg of CO_2 equivalent), ladies finger (227 kg of CO_2 equivalent) and cowpea (142 kg of CO_2 equivalent) (table 2)(fig 3).

Interms of N_2O emission alone, bajra napier emits more (603.5 kg of CO2 equivalent) followed by maize (175. kg of CO2 equivalent followed by ladies finger (154.9 kg of CO2 equivalent) and chillies (154.87 kg of CO2 equivalent) and cotton (147.93 kg of CO2 equivalent) (fig 4). From the energy used by machinaries, bajra napier contributes 86.1 kg of CO2 equivalent followed by maize, cotton and sunflower cultivation emits 64.58 kg of CO_2 equivalent. But for desmanthes due to wild field condition the energy used was more of 118.40 kg of CO_2 equivalent and it has to be checked in future. Chemical transport also follows the similar trend as that of fertiliser usage.

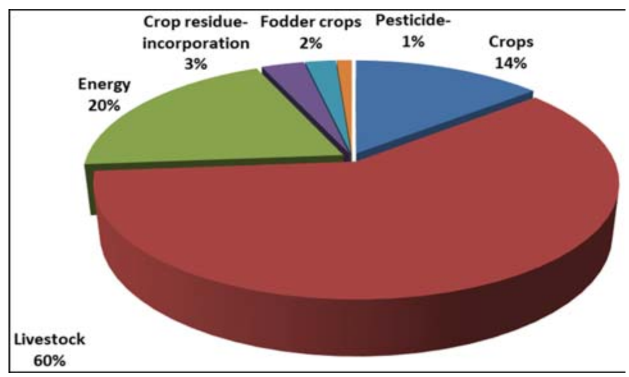

Fig 1: Percentage contribution of Green house gas emission (CO_2 eq) from different components of IFS model as source

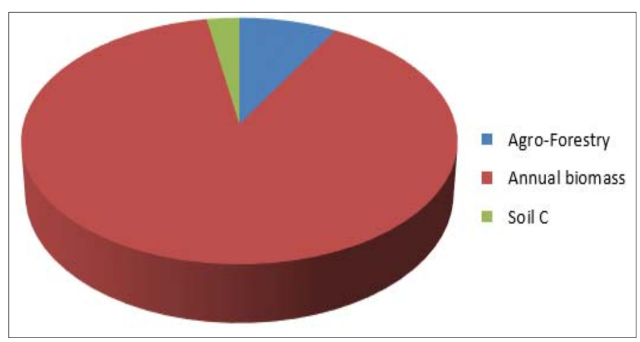

Fig 2: Percentage contribution of carbon sequestration from different components of IFS model as sink

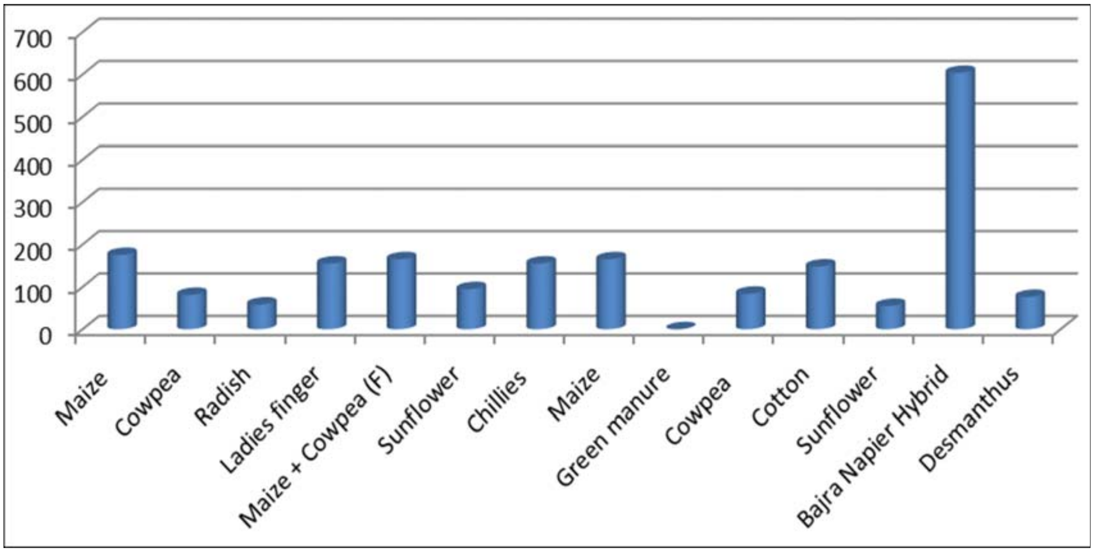

Fig 3: CO_2 emission from different crops by fertiliser and manures usage

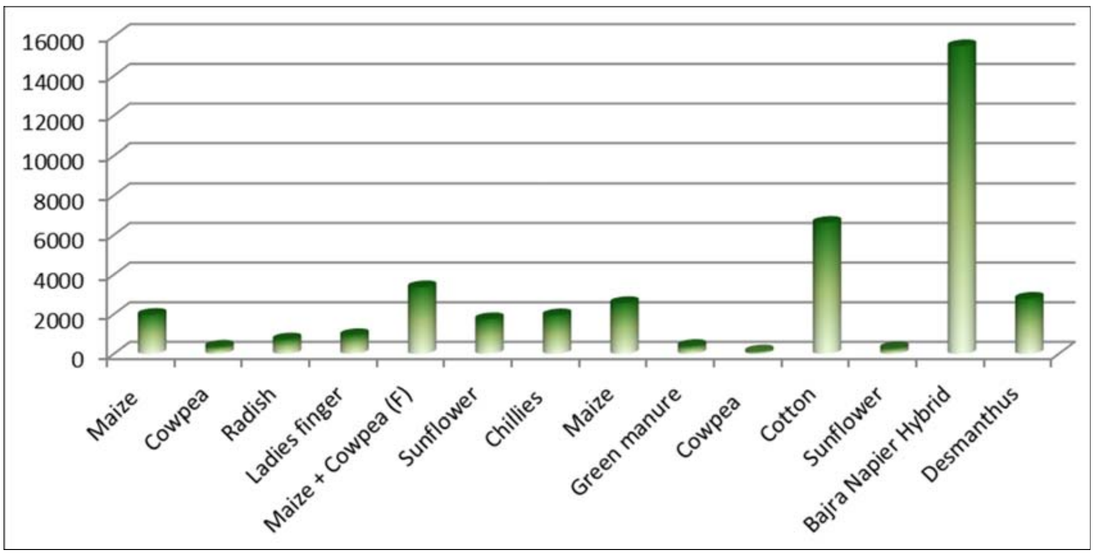

Fig 4: N2O emission from different crops by fertiliser and manures usage

Table 1: Green house gas emission from different components of the IFS model

IFS component	Energy lost as C (CO_2 equivalent kg)
Sources of GHG	
Crops (fertiliser)	640.8
Livestock	2718.1
Energy	900.2
Crop residue-incorporation	144.0
Fodder crops	103.3
Kichen garden	2.9
Pesticide-Insecticide-Herbicide use	51.4
Total Source	**4601.0**
Sources of sink	
Agro-Forestry	2756
Annual biomass	29499.2
Soil C	918
Total Sink	**33175**
GHG-IFS	-28253

Table 2: Assessment of green house gas emission from different cropping in the IFS model.

Cropping details	N_2O emission from fertilizer and manures (1)	Energy used for machineries (2)	Chemicals transport (3)	Total CO_2 emission (4) 1+2+3
CS1 maize- cowpea –radish (0.20ha)				
Maize	175.09	53.82	47.14	277
Cowpea	80.94	53.82	7.57	142
Radish	58.19	16.15	5.98	80
CS2 Ladies finger - Maize + Cowpea (F) – Sunflower (0.20ha)				
Ladies finger	154.9	43.06	29.29	227
Maize + Cowpea (F)	165.02	64.58	47.53	277
Sunflower	94.67	64.58	10.92	170
CS3 Chillies - Maize - Green Manure(0.20ha)				
Chillies	154.87	53.82	29.29	238
Maize	165.02	64.58	47.14	277
Green manure	0.00	21.53	0.00	22
CS4 Cowpea (Veg) - Cotton – Sunflower(0.25ha)				
Cowpea	83.85	32.29	10.83	127
Cotton	147.93	64.58	22.06	235
Sunflower	54.91	26.91	23.86	106
CS5-Bajra Napier Hybrid grass (CO CN 5), Desmanthus (0.17ha)				
Bajra Napier Hybrid	603.5	86.1	145.3	834.9
Desmanthus	76.21	118.40	4.78	199
Horticultural crops				
Guava	18.96	0.00	2.18	21.14
Sapota	16.19	0.00	2.99	19.18
Anola	10.78	0.00	1.20	11.98
All crops				51.30
Border crops				
Moringa, curry leaf	0.00	0.00	0.00	0.00
Total	2061.06	764.22	437.26	3263.64

Soil Carbon Sequestration

To study the carbon sequestration potential of different cropping sequences, soil carbon content was analysed at different depth and by different fractions. The results shows that, irrespective of different cropping sequences, the carbon content get decreased with increasing depth. But among different carbon fractions viz., very labile. labile, less labile and nonlabile, the less labile fraction content more with increasing depth. The report reveals that, storing carbon in high depth advantageous interm of mitigating climate by sequestering more carbon for long time. Among cropping sequences, CS V i.e. fodder crops cultivated soil recorded more carbon as well as less labile carbon in high depth (table 3). This is also line with Bama and Babu, 2016) [7]; Bama and Somasundaram, 2017 [21]; Bama, 2016 [22]; Bama, 2017 [23]; Bama *et al*.,2016 [24] The very labile carbon fraction was considered as a more sensitive indicator for change in organic carbon quality. The soil texture also influences the distribution of oxidizable C fraction. Under the clayey soil, the oxidizable carbon content was seem to high (Silva Galvao *et al*., 2005) [25].

Loss *et al*. (2011) [26] Observed that legumes contribute the greater level of crop residues and percent recalcitrant was greater under the forest than the cultivable area. Hema *et al*. (2019) [12] and Smyrna, 2016) [27] also reported that, legume included cropping sequences are sequestering more carbon. Global warming potential for different cropping sequences were worked out. The table (4) shows that, the CS5 shows higher emission of 1034 kg CO_2 equivalent followed by CS2 (675 kg CO_2 equivalent) CS3 (536 kg CO_2 equivalent) and CS1 (499 kg CO_2 equivalent). Though higher kg CO_2 equivalent released from the cropping, equally these cropping sequences the carbon from the atmosphere. Hence, the global warming potential of cropping is negative.

Table 3: Soil carbon content and fractions as influenced by different cropping sequences

Cropping System	Depth (cm)	Carbon Fractions (%)				
		OC (%)	Very labile	Labile	Less labile	Non Labile
CS1 maize- cowpea – radish	0-15	0.620	0.125	0.186	0.132	0.184
	15-30	0.605	0.098	0.165	0.145	0.196
	30-45	0.592	0.072	0.138	0.132	0.256
	45-60	0.485	0.035	0.072	0.120	0.273
CS2 Ladies finger - Maize + Cowpea (F) – Sunflower	0-15	0.680	0.137	0.204	0.145	0.202
	15-30	0.650	0.105	0.177	0.156	0.211
	30-45	0.596	0.072	0.139	0.133	0.258
	45-60	0.480	0.035	0.071	0.119	0.270
CS3 Chillies - Maize - Green Manure	0-15	0.620	0.125	0.186	0.132	0.184
	15-30	0.582	0.094	0.159	0.139	0.189
	30-45	0.502	0.061	0.117	0.112	0.217
	45-60	0.475	0.034	0.071	0.118	0.267
CS4 Cowpea (Veg) - Cotton - Sunflower	0-15	0.650	0.131	0.195	0.138	0.193
	15-30	0.610	0.099	0.166	0.146	0.198
	30-45	0.584	0.071	0.136	0.130	0.253

	45-60	0.510	0.037	0.076	0.126	0.287
CS5-Bajra Napier Hybrid grass (CO CN 5), Desmanthus	0-15	0.750	0.151	0.225	0.160	0.223
	15-30	0.725	0.117	0.198	0.174	0.235
	30-45	0.682	0.083	0.159	0.152	0.295
	45-60	0.620	0.045	0.092	0.153	0.349

Table 4: Global Warming Potential (Co_2 Equivalent in Kg) Of Different Cropping Sequences

Cropping	N_2O emission (CO_2 eq) from ferti and manures (1)	Energy used (2)	Chemical. Transport (3)	CO_2 eq released (1+2+3) (4)	CO_2 seq (biomass) (5)	GWP (5-4)
CS1 maize- cowpea –radish	314	124	61	499	3066	-2567
CS2 Ladies finger - Maize + Cowpea (F) – Sunflower	415	172	88	675	6062	-5387
CS3 Chillies - Maize - Green Manure	320	140	76	536	4912	-4376
CS4 Cowpea (Veg) - Cotton - Sunflower	287	124	57	467	7029	-6562
CS5-Bajra Napier Hybrid grass (CO CN 5), Desmanthus	680	205	150	1034	18284	-17250

Conclusion

The green house gas emission in terms of carbon di oxide equivalent predicted for fertilizer, manure, chemicals etc usage and energy required for cropping is approximately equal that of green house gas emitted by the livestock component in the integrated farming system.. The important point in this IFS system is, carbon fixed from the atmosphere by biomass is high. It can be considered because almost more than half of the biomass is recycled in to the system and economic part also not directly and immediately exposed to the environment. Among the different components, Livestock contribute more to the GHG emission followed by energy. In Carbon sequestration though annual biomass shows higher C removal, its lifetime should be considered. Among cropping forage crops and tree crops can be recommended to build up underground carbon rather than above ground biomass. In the IFS model itself conservation practices such as minimum tillage, slow release N fertilisers, mixed intercropping, including legume in the cropping (to reduce N use) along with perennial planting. Estimation carbon fractions in different depths and finding out of which cropping sequester more carbon in passive pool in high depth.

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