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GREENHOUSE GASES: CAUSES, LOSSES AND REMEDIAL MEASURES FOR SUSTAINABLE AGRICULTURE

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Abstract

The result predicted that major causes of greenhouse gases were found 'high use of inorganic farm inputs' (2.88), 'intensive tillage practices' (2.75), 'mechanization of farm practices', (2.66), 'non- adoption of diversified agriculture' (2.52), 'non-adoption of crop rotation; (2.46), and 'burning of crop residue in field' (1.95) with their respective weighted mean scores. The losses due to greenhouse gases were found 'crop benefit ratio decreased' (1.23), 'crop damaged due to adverse climatic uncertainty' (1.07), 'crop production decreased' (0.89), 'sowing season change (0.86), 'loss in bio-diversity' (0.84), 'less income from agriculture' (0.81), 'soil water holding capacity decreased' (0.68) based on their 'Z' scores. Results pertaining adoption of remedial measures for sequestration of greenhouse gases for sustainable agriculture were 'evolution of new crops cultivars' (2.95), 'crop diversification' (2.90), 'use zero tillage practices' (2.81) 'integrated farming system' (2.79) 'adapting cultivars against drought, pests, diseases, resistance' (2.78), 'soil/water testing for soil status' (2.77), 'encouraging of rice varieties that emit less CH_4 (2.73), 'campaigning for sequestration of GHGs (2.67)', 'growing intercrops/mixed cropping to compensate crop failure', (2.62) and 'management of natural resources soil, water and biodiversity' (2.61) considered very effective remedial measures with their mean scores, respectively.

Key words: *causes, greenhouse gases, losses, remedial measures, sustainable agriculture*

INTRODUCTION

GHGs are the responsible for increase in the temperature of the earth. It happens when gases like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and water vapour trap heat and light from the sun in the earth's atmosphere, which increases the temperature. This hurts many people, animals and plants. GHGs have an impact on our planet, agriculture, human and animals lives. Considering the seriousness of undesirable effect of GHGs problems, everyone should come forward to resolve these calamities. Perhaps, the application of the scientific knowledge and recommended farm practices to reduce the emission of GHGs is the best alternative for effective and sustainable development of agriculture.

In an effort to combat against sequestration of GHGs issues related to agricultural development, agricultural research scholars as a future generation of agricultural development need to possess awareness and perception about GHGs emission causes and losses occurred. The application of awareness and perception about GHGs hold tremendous potential to save earth and agriculture. Forced and timely efforts to apply knowledge by the agricultural research can enable them to stand successfully against the emission of GHGs problems to play a leadership role in overall development of agriculture.

To get complete benefit using the knowledge of GHGs, climate change and global warming, agricultural research scholars must prepare themselves to act as a leader of future generation in the development process as a change agent to save earth and agriculture. Realizing significant role of agricultural professional in the sustainable of agriculture in dealing with GHGs emission problems, a study was undertaken to assess the farmers' perception regarding causes, losses occurred due to GHGs emission and to find out suitable alternative measures for sequestration of GHGs emission.

MATERIALS AND METHODS

The present study was conducted in Haryana state. Two districts Hisar and Karnal were selected, purposively, because multiple

cropping systems are practiced in these districts. A total number of eight villages were selected, randomly then from each village, 15 farmers were selected, randomly. Hence, a total number of 120 farmers were interviewed. The data were collected personally by the researcher through a well-structured interview schedule containing items pertained the objective of the study. Qualitative data were quantified, appropriately tabulated and analyzed, and standardized statistical techniques as percentage, weighted mean score and Z score were implied to draw meaningful inferences.

For calculation causes, an inventory was developed containing 24 statements explaining the possible causes to measure the awareness and perception about the losses due to GHGs emission. The respondents were asked closed ended questions and were asked to reply for each possible cause. A list of causes was prepared and farmers were asked to speak out their response against each cause, whether it was 'very serious', 'serious' and 'not so serious' and a weightage of 3, 2 and 1were assigned to their responses, respectively. Than aggregate total score was calculated for each cause separately, and based on, calculated total score and weighted mean scores was obtained and ranked according to the maximum or minimum mean score possessed for assessing the seriousness of constraints.

For quantification of losses due to emission of GHGs, an inventory was developed containing 22 statements pertaining possible losses to measure the awareness about the losses due to GHGs emission the respondents were asked closed ended questions and to reply as 'very serious', 'serious' and 'not so serious' and weightages given to their responses category were 3, 2 and 1, respectively. An aggregate total score was calculated for each cause separately, and based upon this total score obtained, a mean score for each loss was calculated for assessing the seriousness of loss occurred.

On the other hand, after judging the responses of all the respondents for obtaining losses on a three-point continuum rating scale, the total score for losses was worked out and this total score was converted into weighted mean score. Finally, a 'Z' score was obtained for judging the seriousness of each loss contained in the schedule by using the formula as under:

$$\text{Z score} = \frac{X - \bar{X}}{SD}$$

Finally, for measurement of suitable alternative measures for sequestration of GHGs emission through farm practices, an inventory was prepared containing 32 statements of suitable alternatives for sequestration of GHGs for healthy environment for agriculture. The respondents were asked closed ended questions to reply as 'very effective', 'effective' and 'not so effective' against each alternative and a weightage of 3, 2 and 1, were given, respectively based on their responses. Aggregate total score was calculated for each alternative measure separately, and based on calculated total score, a weighted mean score were obtained and rank assigned which were ranked according to the maximum or minimum mean scores for assessing the effectiveness of alternative measure.

The maximum mean score percentage so obtained was given the rank 1st and the next subsequent one was given 2nd and so on the descending orders.

RESULTS AND DISCUSSIONS

Causes for emission of greenhouse gases (GHGs)

The data from the Table 1 revealed that 'high use of synthetic fertilizers/chemicals' was considered the very serious cause by the respondents and ranked 1st as per the mean score (2.88), followed by 'intensive tillage practices' (2.75), was ranked 2nd, 'low availability of organic fertilizers/manures' was 3rd in rank and 'mechanization of farm practices' (2.70), was ranked 4th, 'intensive cultivation of soil organic content' (2.66) and ranked 5th, 'crop residues deposition under wet condition' was ranked 6th as per the mean score (2.60), and 'decomposition of animal manure in uncovered lagoons'(2.55) was ranked 7th .

Table 1. Causes of greenhouse gases emission **(N = 120)**

Sr. No.	Emission causes	Total Weighted Score	Weighted Mean Score	Rank Order
1.	High use of synthetic/chemicals fertilizers	346	2.88	I
2.	Intensive tillage practices	330	2.75	II
3.	Low availability of organic fertilizers/manures	325	2.70	III
4.	Mechanization of farm practices	320	2.66	IV
5.	Intensive cultivation of soil organic content	317	2.64	V
6.	Crop residues deposition under wet condition	313	2.60	VI
7.	Decomposition of animal manure in uncovered lagoons	307	2.55	VII
8.	Clearing of natural vegetation/ Deforestation	305	2.54	VIII
9.	Non adoption of diversified agricultural practices	303	2.52	IX
10.	Burning of agricultural residues in the field	300	2.50	X
11.	Non adoption of different crop rotation	296	2.46	XI
12.	Lack of pastures in rural areas	294	2.45	XII
13.	Leach down of soil carbon, water, nutrients and fertilizers	293	2.44	XIII
14.	Exhaustive pumping up of underground water for irrigation	282	2.35	XIV
15.	Over cultivation	268	2.23	XV
16.	Intensive agricultural practices	263	2.19	XVI
17.	Conservation of grassland into cultivated lands	246	2.05	XVII
18.	Land degradation	237	1.97	XVIII
19.	Burning of fossil fuels (coal, oil and natural gas)	234	1.95	XIX
20.	Enteric fermentation in domestic livestock	228	1.90	XX
21.	Flood irrigation practices	203	1.69	XXI
22.	Early leach down of fertilizers in soil	197	1.64	XXII
23.	Urine and faeces deposition in grazed pastures	180	1.50	XXIII
24.	Rice cultivation leads to CH_4 and N_2O	170	1.41	XIV

(Figures in parentheses in column 3 indicate total weighted score; columns 4 indicate weighted mean scores and column 5 indicate rank order)

The data also revealed that the cause 'clearing of natural vegetation/ deforestation' (2.54) was ranked 8th, 'non adoption of diversified agricultural practices' (2.52) was ranked 9th, 'burning of agricultural residues in the field' and 'non adoption of different crop rotation' were as ranked 10th and 11th as per their mean scores (2.50) and (2.46), respectively (Table 1). It was also found in the study that awareness among the farmers about the causes of GHGs emission was low to medium.

Most of the farmers in this study could know the causes, which are responsible for the emission of GHGs in agriculture. Farmers could not aware about the high uses of inorganic inputs, which are, enhance the emission of GHGs, they used inorganic farm inputs only for increased the crop production.

In conformity of the results, it was also reported that deforestation for agriculture crop fields and pastures, transforming virgin soil into cultivated land and utilizing nitrogenous fertilizers, are all implicated in release of GHGs in the atmosphere [6].

Mostly farmers burned their crop resides on their fields and not interested to fallow the recommended crop rotation and farm practices because they more emphasis on cash crops for high returns. Most of the farmers' decomposes of animals' manures in uncovered lagoons, which increased the emission of GHGs, and enteric fermentation in domestic animals were highly responsible for the emission of GHGs

Farmers' perception regarding losses occurred due to emission of GHGs

The Table 2 revealed that the 'crop benefit ratio decrease' (Z score 1.23) and 'crop damage due to adverse climatic uncertainty' (Z score 1.07) were considered as very serious losses in agriculture due to emission of GHGs by the respondents as per the 'Z' score.

The data revealed that 'crop production decreased' (Z score 0.89) followed by 'sowing season changed' (Z score 0.86), 'loss in bio-diversity (Z score 0.84), 'less income from agriculture' (Z score 0.81) were found serious losses as per Z score perceived by the respondents.

It is obvious from the Table 2 that 'soil water holding capacity decreased' (Z score 0.68), 'deeper level of ground water table' (Z score 0.31), 'cropping pattern and cropping system changed' (Z score 0.28), 'high usages of synthetic or inorganic fertilizers' (Z score 0.23), 'soil fertility decreases' (Z score 0.13) and 'degradation of forests to barren lands' (Z score 0.10), 'soil erosion' (Z score 0.07), and

'cropping intensity decreased' (Z score 0.00) were also serious losses in nature according to the respondents' responses and so on.

Due to emission of GHGs, farmers found losses in their crop production and they shifted their cropping pattern due to uncertainty of climate conditions. Environmental temperature have been raising that because of GHGs emission and affecting the crop cycle.

Crop mature earlier because of high temperature and sometime late mature due to low temperature. Cropping season changed due to GHGs emission. Soil temperature affects the rate of organic matter decomposition and release of nutrients.

At high temperature, though nutrient availability will increase in the short term, in long run organic matter content will diminish resulting in decline in soil fertility [3].

On the same lines, have estimated that under the situation of doubling of carbon dioxide in the atmosphere the wheat yields could decrease by 28 to 68 per cent without considering the carbon dioxide fertilization effects.

Yield of C_3 crops like wheat, barley, rice, and potatoes may increase by 30% due to CO_2 fertilization [2] and [1], (Fig.1).

Table 2. Losses due to greenhouse gases emission **(N = 120)**

Sr. No.	Losses	Total Weighted Score	Weighted Mean Score	Z Score	Nature of Seriousness
1.	Crop benefit ratio decreased	335	2.79	1.23	VS
2.	Crop damaged due to adverse climatic uncertainty	328	2.73	1.07	VS
3.	Crop production decreased	320	2.66	0.89	S
4.	Sowing season changed	314	2.65	0.86	S
5.	Loss in biodiversity	317	2.64	0.84	S
6.	Less income from agriculture	316	2.63	0.81	S
7.	Soil water holding capacity decreased	310	2.58	0.68	S
8.	Deeper level of ground water table	293	2.44	0.31	S
9.	Cropping pattern and cropping system changed	292	2.43	0.28	S
10.	High usages of synthetic or inorganic fertilizers	290	2.41	0.23	S
11.	Soil fertility decreased	285	2.37	0.13	S
12.	Degradation of forests to barren lands	284	2.36	0.10	S
13.	Soil erosion	283	2.35	0.07	S
14.	Cropping intensity decreased	279	2.32	0.00	S
15.	Change of land for housing/industrial usage/SEZ	278	2.31	-0.02	S
16.	Quality deterioration of crop produce	'275	2.29	-0.07	S
17.	Crop loss due to flood and drought	273	2.27	-0.13	S
18.	Quitting agriculture leads unemployment	270	2.25	-0.18	S
19.	Desertification due to prolonged drought	257	2.14	-0.47	S
20.	Reduction in soil carbon stocks	239	1.99	-0.86	S
21.	Frequent crop failure	227	1.89	-1.13	NSS
22.	Loss in soil organic matter	213	1.77	-1.44	NSS

$\bar{X}$ = 2.00 **V S Very Serious**
S.D. 0.38 S Serious NSS Not so serious

Farmers' experiences high uses of chemical inputs to control the pest and diseases attack on the crop but they found less control on them and the amount of application of chemical inputs increases season after season. Farmers noticed that the groundwater table goes down due to low rainfall, farmers did not aware about the GHGs emission, and climate change is responsible for low rainfall. Farmers also experiences degradation of forestland into barren lands, soil productivity decreases, more soil erosion and soil salinity increases and crop loss due to adverse climate condition perhaps the major reason that farmers are quitting the agriculture. The income from the agriculture decreased day by day and now agriculture has becoming a risky profession.

Similar threats were also quoted [5] that in tropical countries even moderate warming (1^0 C for wheat and maize and 2 ^{0}C for rice) can reduce yields significantly because many crops are already at the limit of their heat tolerance.

Alternative measure for sequestration of greenhouse gases:-

An analysis of the data from the Table 3 revealed that 'evolution of new crops cultivars' (2.95) was perceived as very effective alternative measures and 1st rank was given, followed by 'Crop diversification'

(2.90), 'use zero tillage practices' (2.81) and 'Integrated farming system' (2.79) and a rank order 2nd, 3rd and 4th were given, respectively. 'Adapting cultivars against drought, pests, diseases, resistance' (2.78) ranked 5th as per mean score.

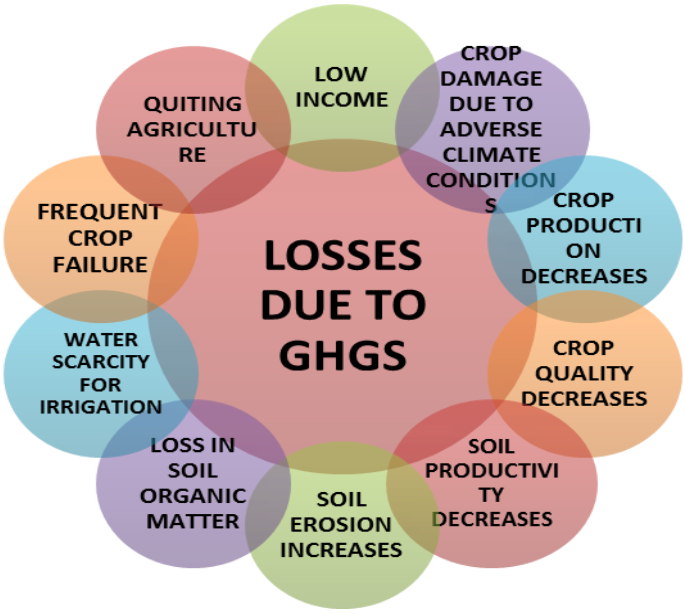

Fig. 1. Major losses due to GHGs in Agriculture

Table 3 further represents 'soil/water testing for soil status' (2.77) and 'Encouraging of rice varieties that emit less CH_4' (2.73) were found very effective alternative measures for sequestration of GHGs and their rank order were assigned 6th, 7th and 8th followed by 'campaigning for sequestration of GHGs' (2.67) was ranked 9th. The other alternatives were found as 'Growing intercrops/mixed cropping to compensate crop failure' has ranked 10th with mean score 2.62 and 'management of natural resources soil, water and biodiversity was ranked 11th with mean score 2.61 perceived by the farmers. Next suitable measures were found as 'Soil conservation measures' (2.57), 'reduce tillage practices' (2.56), and 'use Indigenous traditional knowledge (ITK) for crop production' (2.55), and 'water harvesting management practices' (2.50) ranks were given 12th, 13th, 14th and 15th, respectively. The respondents perceived that adoption micro irrigation (drip/sprinkler) (2.49), 'Use remote sensing technologies for analysis of vegetation and soil carbon' (2.48), 'application of compost/FYM/Green manuring (2.47), 'enhancing the area under agro-forestry and social forestry' (2.45) and 'organic farming practices' (2.42) and their rank order were 16th, 17th, 18th, 19thand 20th, respectively as per mean score and this type of alternative measures consider as effective alternative measures as per farmers response (Table 3).

For future prospective sequestration of GHGs is important and necessary to sustain the agriculture, environment and human also. Mitigation of GHGs is beneficial to the whole environment because GHGs amplify the climate change and global warming.

Majority of the respondents required that scientists released new or improved variety or cultivar for more production. Farmers also interested to adopt diversified agriculture practices. The findings were supported that organic and green manures as well as nitrogen from legumes can be managed very precisely due to the design of the crop rotations including cover and catch crops [8].

In conformity, another study on the integrated use of different organic fertilizers such as improved fallow and FYM provided encouraging results in increasing maize grain yield and improving soil chemical properties at eastern Ethiopia [4]. Most of the respondents had good knowledge about the sequestration of the GHGs by the adoption of farm practices. Farmers' use their indigenous

knowledge for crop production. Farmers also aware about the hazardous effect of GHGs, climate change and global warming on human health and environment and they want to adopt healthy agriculture practices such as organic farming.

Table 3. Alternative measures for sequestration of greenhouse gases **(N = 120)**

Sr. No.	Alternative Measures	Total Weighted Score	Weighted Mean Score	Rank Order
1	Evolution of new crops cultivars	355	2.95	I
2	Crop diversification	349	2.90	II
3	Use zero tillage practices	338	2.81	III
4	Integrated farming system	335	2.79	IV
5	Adapting cultivars against drought, pests, diseases, resistance	334	2.78	V
6	Soil/water testing for soil status	333	2.77	VI
7	Encouraging of rice varieties that emit less CH_4	328	2.73	VII
8	Campaigning for sequestration of GHGs	322	2.68	VIII
9	Evolution of crop varieties from long duration to short duration	321	2.67	IX
10	Growing intercrops/mixed cropping to compensate crop failure	315	2.62	X
11	Management of natural resources soil, water and biodiversity	314	2.61	XI
12	Adopting soil conservation measures	309	2.57	XII
13	Reduce tillage practices	308	2.56	XIII
14	Use Indigenous traditional knowledge (ITK) for crop production	307	2.55	XIV
15	Water harvesting management practices	301	2.50	XV
16	Adoption micro irrigation (drip/sprinkler)	299	2.49	XVI
17	Use remote sensing technologies for analysis of vegetation and soil carbon	298	2.48	XVII
18	Application of FYM/ compost//Green manuring	297	2.47	XVII
19	Enhancing the area under agro forestry and social forestry	295	2.45	XIX
20	Organic farming practices	291	2.42	XX
21	Improved rice cultivation techniques	288	2.40	XXI
22	Improved nitrogenous fertilizers to restrict leaching and volatilization	286	2.38	XXII
23	Afforestation and reforestation practices	285	2.37	XXIII
24	Adoption of precision farming practices	282	2.35	XXIV
25	Suitable crop rotation and cover crops	270	2.25	XXV
26	Prevent CH_4 emission from manure heaps and tanks	256	2.15	XXVI
27	Shifting from food crops into perennial crops	255	2.12	XXVII
28	Production of high residue yielding crops	236	1.96	XXVIII
29	Eco-friendly agriculture	235	1.95	XXIX
30	Covered manure pits and slurry storage	222	1.85	XXX
31	Including more hay crops in annual rotations	208	1.73	XXXI
32	Reduction in fallow period between two crops for green manuring	200	1.66	XXXII

(Figures in parentheses in column 3, 4and 5 indicate percentages; columns 7 indicate weighted mean scores and column 8 indicate ranks order)

It have been estimated reduction in wheat production by 10 % under anticipated enhancement 0.5 0C in mean temperature in the high yield States of Punjab, Haryana and Uttar Pradesh [7].

CONCLUSIONS

The study has made a very effective an inventory of causes and losses due to emission of green house gases by farmers. Farmers were found having many constraint of serious nature and these constraints can be minimized by providing availability of proper information, training, coordinating in-between farmers and various organizations.

Efforts should be made for providing proper guidance, training and implementation of the recommended farm practices to farmers to reducing the GHGs emission from agriculture and for sustainable development in agriculture and for providing healthy environment for better livelihood.

The following suggestions are made for improving the adoption of recommended farm practices for sequestration of GHGs and mitigate GHGs from village to district and national to international level:

(i)The study further indicated that a significant majority of the respondents had

not adopted the recommended farm practices for sequestration of GHGs for sustainable agriculture. Therefore, it would be worthwhile for the extension functionaries to organize training, demonstration and take up appropriate educational;

(ii)To improve the adoption level, extension agencies should give more emphasis on the farm practices, which required specialized skills like zero tillage, integrated farming practices, resource management, adoption of remote sensing technology adoption of micro irrigation and more application of organic compost etc;

(iii)Literature regarding recommended farm practices to reduce the GHGs should be published in local language and made available to the farmers locally;

(iv)The planner and policy maker have to take up each constraint as a challenge and have to work on scientific lines to resolve these constraints or problems;

(v)Generating leadership at all levels with clear vision, comprehensive plans and implementation strategies to meet the challenges of GHGs;

(vi)Farmers' eco-club should be involved in awareness program regarding climate change and environmental degradation;

(vi)Capacity building program should be organized to educate the field extension functionaries about safe and healthy environment;

(vii)Cross train of all efforts should be made to provide healthy food for all;

(viii)Agriculturist, environmental engineers and dietician come together for safe environment, rich nutritive food and development of nature loving agriculture.

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