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Climate Smart Agriculture for Reduction and Mitigation of Green House Gas Emission

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Abstract

Agriculture is related to food security on this planet. The productivity is being adversely affected by the climate change which is the result of global warming. Global warming is the result of emission of greenhouse gases due to anthropogenic activity. Among these, Agriculture also contributes significantly to the emission of greenhouse gases. The agricultural activity may be dry farming, irrigation farming or water-logged farming like rice cultivation that emit greenhouse gases from soil. The main reason is unsustainable agricultural management practices in developing countries, not adapting to changing climatic and weather conditions to maintain its productivity. To cover these aspects and to approach towards sustainable agriculture, more efforts are required, not compromising the global efforts to ensure food security for all.

The United Nations Environment Programme (UNEP) is a programme of the United Nations (UN) which is working towards promoting technologies for mitigation of global warming. Among different technologies advocated for this purpose, agriculture is a unique activity, which on one hand is responsible for greenhouse gas emissions, on the contrary adoption of specific agricultural technology has the potential to reduce and mitigate the greenhouse gases emission. UNEP (2012) has summarised, especially for developing countries, well researched agricultural technologies for adaptation of agriculture to the changing climate conditions for improving its productivity, as well as contributing to the reduction in the emission of greenhouse gases, thus attaining sustainable agricultural development. Alternatively this is termed as Climate Smart Agriculture (CSA). The CSA is an approach for transforming and reorienting agricultural production systems and food value chains so that they support sustainable development and can ensure food security under climate change. Some of the prominent methods of Climate Smart agriculture are discussed in this paper with the hope of its wide acceptance in India.

Keywords: *Climate Change, Climate Smart Agriculture, GHG Reduction, Cropland Management, Rice Farm Management.*

1. Introduction

Our current food system is rife with inequalities and issues that prevent adequate food security for all, and has consequences for individuals as well as our global environment. Apart from this, aagriculture is the victim of the climate change. It is also one of the main drivers of climate change. The well-known factors due to climate change affecting the agriculture are droughts, floods, tornadoes, storms, rising sea levels, salinization of groundwater, frequent extreme weather, increasing species extinction and the spread of old and new diseases.

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The tropical and sub-tropical areas namely Africa, Latin America and South Asia suffer the most due to the impact of climate change. Here we are more concerned about the greenhouse gas emission from agriculture, which further aggravate the climate change, which in turn affect the agricultural productivity and food security.

The people are more concerned about the impact of climate change on agriculture. Climate change will probably increase the risk of food insecurity for some vulnerable groups, such as the poor. Animal agriculture is also responsible for CO2 greenhouse gas production and a percentage of the world's methane, and future land infertility, and the displacement of local species.Various mitigation measures have been in vogue and some are researched for adaptation of agriculture with climate to maintain its productivity. While agriculture activities account for significant GHG emissions, greenhouse gas (GHG) emissions from agricultural activities can be reduced through more efficient management of carbon and nitrogen flows within agricultural systems. Recently agricultural technologies have been developed by which the agriculture act as the agent for reduction and mitigation of greenhouse gases, at the same time adapting to the climate change. The United Nations Environment Program (UNEP) of United Nations (UN) is working towards promoting technologies for mitigation of global warming and have given efficient agricultural technologies for reduction and mitigation of GHG.Here are some beneficial management practices recognized for lowering greenhouse gas emissions.

Climate Change

Human activity is responsible for the emission of Greenhouse Gases (GHGs) right from the start of industrial age on earth. The GHGs mainly include CO2, CH4 and N2O. Global warming potential of CH4 is 25 times and of N2O is 298 times of that of CO2. These gases remain in the atmosphere as invincible blanket. The earth receives short and long wave radiations from sun. This blanket traps long wave radiation and do not allow them to exit from the atmosphere of the earth. This results in increasing the temperature of the atmosphere. The optimum concentration of GHGs is necessary to keep the earth to remain warm and inhabitable. However, higher concentrations of GHGs results in increase in temperature of atmosphere, called Global warming having many catastrophic effect on the natural resources like erratic rains, floods, shifting of seasons, decrease in agriculture, impact on biodiversity etc. these results in economic loss, food security challenges, and loss of homes and livelihood for many. The result of atmospheric temperature change from 2^0C to 4^0C has catastrophic effects like melting glaciers, rising sea levels as recorded by NASA (2017), increased precipitation in some areas and drought in some areas and an increase in extreme weather events (Gupta, 2014).

Contribution of Human activity to GHGS emission

Anthropogenic activities like fossil fuel burning for power generation, industrial manufacturing and transportation, agricultural activities such as rice production, synthetic fertiliser use, livestock rearing, and change in land use patterns such as deforestation as well as waste disposal have contributed to the increased atmospheric concentration of greenhouse gases.

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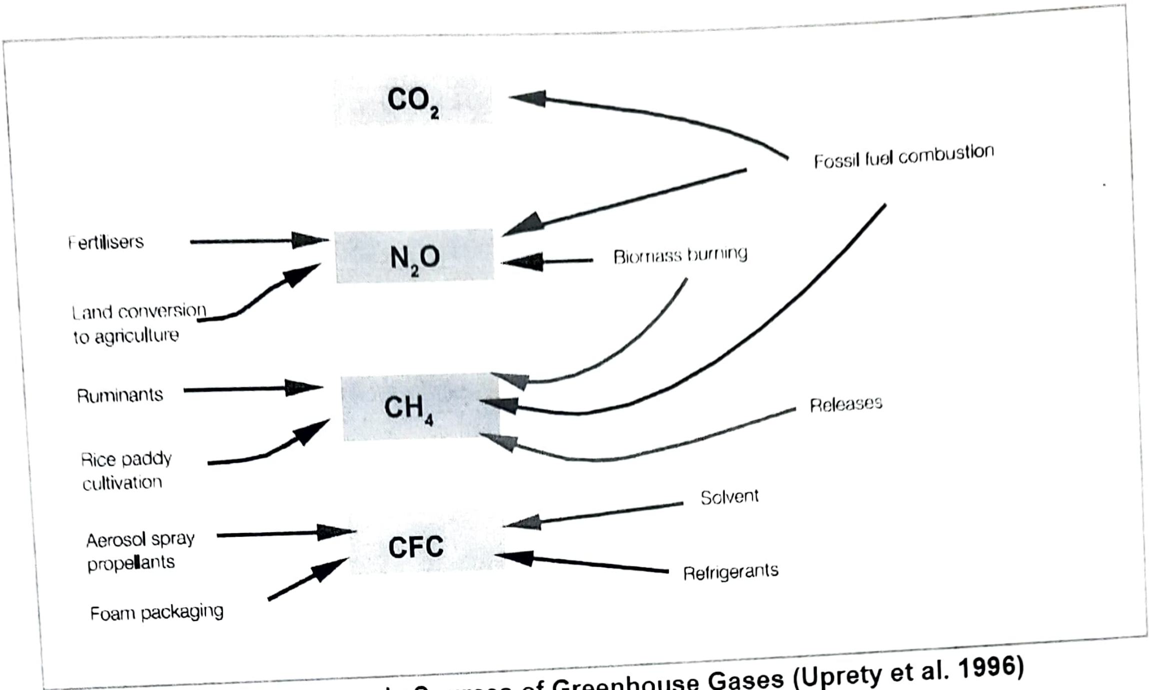

Figure 1: Anthropogenic Sources of Greenhouse Gases (Uprety et al. 1996)

Contribution of agriculture to GHGS emission

The agricultural sector accounts for about 13% (Barker et al., 2007) of global anthropogenic greenhouse gas emissions. It is predicted that the increase will be almost 40% by 2030 due to increasing demand from a growing population and changing consumption patterns of food, including increasing demand for ruminant meats (Smith et al., 2007).Agricultural sector emits all three GHGs CO2, CH4 and N2O. Over half of the global nitrous oxide and methane emissions are released from agriculture sector. Nitrous oxide is emitted mainly from inorganic fertiliser and manure applications to soils. Methane is emitted largely from livestock (fermentation in digestion), rice production, and manure handling. Carbon dioxide is released mainly from microbial decay of plant litter and soil organic matter, as well as from burning of plant residues (Smith, 2004).

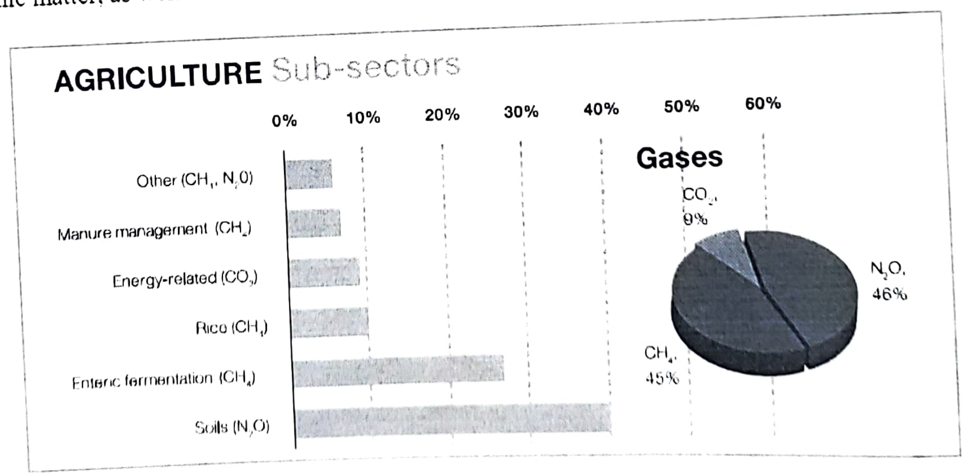

Figure 2: Greenhouse Gas Emission from Agriculture (Kasterine and Vanzetti, 2010)

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- Decrease bare fallow
- Avoid over application of fertilizers
- Manage tillage and residues
- Establish agroforestry systems

Cover Crop Technology:
Selections of Crop Varieties that are fast growing with enhanced carbon sequestration are used for cover crop technology. These are planted between regular crops, or entire area like surplus agricultural land, grassed water ways, field margins and shelter beds along with/without light mulch, to protect soil from erosion and to fix nitrogen (in case of leguminous crops. Later when ploughed under, they provide humus and carbon to soil and nitrogen to crop and provide water retention.

Such cover crops reduce emissions and sequester carbon. Suitable option on surplus agricultural land or on cropland of marginal productivity. Lu et al. (2007) present several examples - growing of cover crops is **profitable**. Cover crops are grown all over the world.
Cover crop species: Dhaincha (*Susbania acculeata*), Susbania (*Susbania speciosa*), *Susbania rostrate, Sunn Hemp (Crotalaria juncea)*.

2. Nutrient Management

Efficient use of N fertilizers: This method can reduce N2Oemission from fields, and by reducing the quantity of synthetic fertilizers required, improved management can also reduce *CO2* emission from manufacture chain.

Organic agriculture: It reduces N2O emission due to ban on use of mineral nitrogen and reduction in livestock per ha. Diversified crop rotation with green manure improves soil structure, makes more aerated soil with lower mobile N concentration & reduces N2O emission. This system has limited N with aim to balance N inputs and outputs and N use efficiency.

Nitrification inhibitors: Nutrient inhibitors like DCD (dicyandiamide) and urease inhibitors reduce the activity of nitrifying bacteria, thus reducing N2O emission.

Slow Release Fertilizers: of urea and NH4 based fertilizers can be achieved by using various coatings, chemical modifications, and changing the size of fertilizer granules. Increasing the size of pellet to 1g and adding DCD led to very slow nitrification rates, with 30% of the original N application still present 8 weeks after fertilizer application (Goose and Johnson, 1993).

Nitrogen Management Technology: Nitrogen management is done by synchronous timing of N fertilizer application with N demand from plants. N uptake is low at the beginning of growing season, increase rapidly during vegetative growth and dropping sharply at maturity.

Placement of N Fertilizer into the Soil: near the root zone of crop or injection of liquid urea, ammonium nitrate in soil (10-15 cm) resulted in 40-50% lower emission of N2O.

Application of Fertilizer Immediately after Rain: this method will increase N use efficiency of plants and mitigate N2O emissions. Practice of alternate flooding in rice fields reduces the losses of N through leaching, volatilization, and denitrification.

The advantages of nitrogen management technology are reduction in N2O emission, increase in farm nitrogen use efficiency, reduced leaching and making crops more N-use efficient and thus decreasing the need of inorganic N fertilizer thereby reduce emissions from fossil fuel associated with their manufacture.

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Mycorrhiza for Mitigation of CO2

Mycorrhizal inoculation was done to colonize roots irrespective of fertility gradients and crop growth stages (Subramanian et al., 2009). Mycorrhiza release glomalin that help in enhancing soil carbon sequestration, improves soil physical property, and offers protection against biotic and abiotic stress conditions. This also prevents loss of carbon to the atmosphere and sustains soil fertility.

Specific mycorrhizae: *Glomus intraradices, Glomus mosseae, Glomus fascicullatum, Glomus margarita,Glomus pellucida,* and arbuscular mycorrhizal fungihave been reported to enhance soil carbon due to the release of glomalin.

Tillage or Residue Management

Tillage stimulates microbial decomposition of soil organic matter - emissions of CO2.Minimum tillage promotes sequestration of carbon in the soil. Lately advancements in weed control methods and farm machinery allow minimum tillage (Smith et al., 2008).

Conservation Tillage (Types- zero-till, strip-till, ridge-till and mulch-till)

Conservation tillage keep previous year's crop residue in at least 30% soil surface (Dinnes 2004) – reduce soil erosion, run-off & promote rain water absorption and carbon sequestration (MDA, 2011). It conserves soil, water and energy resources. Economical advantages are less labour time and cost, saving of fuel cost, lower machinery and repair and **maintenance.**

Biochar

Crop residues carbonized by partial combustion to a highly stable carbon compound **'biochar'**, carbon-rich fine-grained, highly porous structure with increased surface area that makes it an ideal soil amendment for carbon sequestration (Lehmann, 2007; Newsletter, CRIDA, 2010). The advantages are soil conditioner for ideal soil amendment, sequester C, enhance nutrient use efficiency, and reduce non-CO2 GHG gases emissions, and Provides habitat for micro-organisms, increase soil microbial diversity.

Irrigation Management for CO2 Mitigation

All types of effective irrigation, such as flood, sprinkler, surface and sub-surface drip, can all enhance crop yields with subsequent increases in crop residues and enhanced carbon sequestration. Eighteen per cent of cropped areas are currently irrigated. If additional areas can be put under irrigation, then additional carbon sequestration can occur.

Management of rice production system

Rice cultivation gives 10% of GHG emissions. In developing countries, it is even higher, 16% in 1994 (UNFCCC). A variety of technologies are available for reducing emissions from rice cultivation.CH4 mitigation technology is by fertilizer and manure management in rice fields.

Technology consists of *change of fertilizer types; fertilizer nutrient ratios; the rates and timing of applications, and use of nitrification inhibitors* to reduce methane emissions by affecting methanogenesis in rice fields. These technologies are mentioned below.

- Fertilizer and manure management
- Mid-season water drainage
- Alternate wetting and drying
- Potassium fertilizer app
- Nitrification inhibitors for both N2O and CH4 mitigation, nitrification and methanogenesis inhibitors.
- Agriculture biotechnology
- Methane mitigation using reduced tillage
- Direct seeding technology
- Amendment in methanogenic activity using electron acceptors

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