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Climate Change Impacts, Adaptation And Mitigation In Agriculture: Is Organic Agriculture a Viable Option?

- V. Saravanakumar

INTRODUCTION

The change in the climate, also known as global warming, has occurred faster than any other climate change recorded by human and so is of great interest and importance to the human population. Since the industrial revolution, human activity has increased the amount of greenhouse gases in the atmosphere. The increased amount of gases which absorb heat, has directly lead to more heat being retained in the atmosphere and thus an increase in global average surface temperatures. Together these affects are known as anthropogenic (human caused) climate change

What is climate change?

- Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).
- Climate change may be due to natural internal processes or external forcing or due to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC,2007).
- It is a result of the externality associated with greenhouse-gas emissions entailing costs that are not paid for by those who create the emissions.
- **Greenhouse gases** - The Earth has a natural greenhouse effect where certain gases (known as greenhouse gases – CO_2, methane, nitrous oxide, chloroflurocarbon) in the atmosphere allow the sunlight to enter but absorb the heat radiation. Because these gases absorb the heat, they keep the average surface temperature on Earth around 14°C. Without the natural greenhouse effect, the Earth's average surface temperature would be around -19°C.

1.1 Climate Change in India

These changes may culminate in adverse impact on biosphere and human health on which we depend. The multitude interactions among the human, microbes and biosphere resulted in increased concentration of GHGs causing warming of the globe in the form of shift in rainfall distribution, increase in temperature and rise in sea level. It affects soil fertility, salinization, organic carbon, nitrogen content, survival and distribution of pest population and biodiversity which in turn influence agricultural productivity, sustainability and food security.

Recent climate models suggest that India may experience further rise in temperature of 1^0C by 2050, which is about 2-3 times the rate of warming over past 100 years. The IPCC (2007) projected that temperature increase by the end of this century is expected to be in the range between 1.8 and 4.0°C. For the Indian region, the IPCC projected 0.5 to 1.2°C rise in temperature by 2020.

2. Agriculture: Victim or Culprit

2.1 Victim: Impact of Climate Change on Agriculture

The impact of climate change on agriculture was examined by the many researchers that how climate change affects agriculture in terms of crop mean yield, yield variability, food security and economic growth.

Further some studies reported that an increase in temperature would enhance the agricultural production in US (Mendelsohn and Dinar, 2003) and Germany (Lippert et al, 2009) and in contrary it may affect agriculture

negatively in Africa and South America (Mendelsohn, 1994). Schlenkar, W and Roberts. M (2006) studied "non-linear temperature effects indicate severe damages to U.S. crop yields under climate change" and reported that pair a panel of county-level yields for corn, soybean and cotton (a warmer-weather crop), with a new fine-scale weather dataset that incorporates the whole distribution of temperatures within each day and across all days in the growing season. They found that yields increase with temperature up to 29 degrees C for corn, 30 degrees C for soybeans, and 32 degrees C for cotton but that temperatures above these thresholds are very harmful. They indicate that the relation between temperature and corn yields is non-linear.

2.2 Culprit: GHGs Emission from Agriculture

2.2.1 At Global level

The global atmospheric concentration of carbon di-oxide, methane and nitrous oxide increased from a pre-industrial value of about 280 ppm to 379 ppm, 715 ppb to 1732 ppb and 270 ppb to 319 ppb in 2005, respectively (IPCC, 2007a). The reason behind the global increase in CO_2 concentrations are mainly due to use of fossil fuel and land use change. CH_4 concentration is predominantly due to agricultural activities and fossil fuel use and N_2O concentration is primarily due to agriculture.

2.2.2 Indian scenario

India accounts for only about 2.4 per cent of the world's geographical area, supporting about 17 per cent of the world's human population and 15 per cent of the livestock. Agriculture is the mainstay of 60 per cent of its population. An agriculture sector contributed about 17.6 per cent of total country's GHG emissions in 2007 and this figure is expected to increase further. India is mostly blamed for higher GHGs emission due to having large number of livestock and more area under paddy cultivation (INCCA, 2010).

3. Climate Change Impact Assessment Methods

Impacts of climate change on agriculture have been estimated using different approaches viz., (i) Structural approaches allow for detailed understanding of the biophysical responses as well as adjustments that farmers can make in response to changing climatic and other conditions (Adams, 1999). (ii) Spatial Analogue model uses cross sectional evidences to undertake statistical estimations of how changes in climate would affect agricultural production across different climatic zones. The three major approaches under the spatial analogue model are (a) Crop simulation models (b) Agro-Ecological Zone (AEZ) approach and (c) Ricardian Analysis.

(a) Crop simulation models draw on controlled experiments where crops are grown in field or

laboratory settings, simulating different climates and levels of CO_2 in order to estimate yield responses of a specific crop variety to certain climates, and other variables of interest.

(b) Agro-Ecological Zone (AEZ) approach, combines crop simulation models with land management decision analysis, and captures the changes in agro-climatic resources (Darwin et al. 1995; Fishcher et al. 2005).

(c) Ricardian approach measure the impact of climate variables performance i.e. farmland values or net revenues (Mendelsohn et al, 1994, 1996). In this model, prices of both inputs and output are assumed to remain proportionately constant.

4. Has organic agriculture potential to mitigate climate change?

4.1 Why organic agriculture?

Basically an organic production system is designed to enhance biological diversity within the whole system, increase soil biological activity, maintain long-term soil fertility, recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources and rely on renewable resources in locally organized agricultural systems. It also promotes the healthy use of soil, water, and air, as well as minimize all forms of pollution thereto that may result from agricultural practices (Muller, 2009).

4.2 Global status of organic agriculture

Globally, the total area under organic agriculture constitutes 80 million hectares. Out of which 37 million hectares represent organic agricultural land including in conversion areas which shares 0.9% of the world's total agricultural land. Oceania shares the highest area of organic land (12.1 mha) followed by the Europe (10 mha), Latin America (8.4 million ha), Asia (7.5%), Northern America (7.2 per cent) and Africa (2.9 per cent) area under organic agriculture Country wise area under organic agricultural land is the highest in Australia (12.0 mha), followed by the Argentina (4.18 mha). United states (1.95 mha), Brazil (1.77 mha), Spain (1.46 mha), China (1.39 mha), Italy (1.11 mha), Germany (0.99 mha) and India consists 0.78 million hectares (IFOAM, 2012). According to the IFOAM (2012) statistics, there are 1.6 millions of organic producers and among which 34 per cent are in Africa followed by Asia (29%) and 18% in Europe. Among the countries, India is the largest producer of organic commodities (4,00,551 millions) followed by the Uganda (1,88,625 millions) and Mexico (1,28,862 millions). In 2010, the global sales of organic food and drink reached to 59 billion US dollar which was three fold more as in the year 2000.

4.3 Status of organic agriculture in India

Area under organic farming in India increased from 42,000 hectares in 2003-04 to more than 4.43 million ha in 2010-11

Among the states, Madhya Pradesh contitutes largest area under organic farming followed by Himachal Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Uttarakhand, Karnataka, Gujarat, Tamil Nadu and Orissa. The overall area in all states increased from 2007-08 to 2010-11 except in the state of Gujarat. But area under organic farming increased several fold (5 lakh ha to 30 lakh ha) in the state of Madhya Pradesh as compared to other states of the country. In case of north east states of India, Mizoram consist of the highest area under organic farming (38674.62 ha), followed by the Nagaland (29715.28 ha), Manipur (10871.3 ha), Sikkim (7393.09 ha), Assam (6223.12ha), Meghalaya (2254.12 ha), Arunachal Pradesh (1897.27 ha) and 281.06 ha in Tripura (fig.1). The north east region of India is blessed with rich biodiversity, rich soil organic carbon and has low fertilizer consumption.

India has great potential to grow crops organically and have emerged as a major supplier of organic products in the world's organic market.

4.4 Potential of Organic Agriculture for Climate Change Mitigation

In principle, organic farming basically depend upon the crop rotations, crop residues, animal manures, farm organic waste, mineral grade rock additives, biological system of nutrient management and pest and disease control. It avoids the use of chemical fertilizers, pesticides, hormones, feed additives etc. Therefore, organic agriculture is looked as one of the solutions for climate change mitigation because it emits much lower levels of greenhouse gases (GHG), and also effectively sequesters carbon in the soil (Panwar *et al.*, 2010; IFOAM, 2009). In addition to this, organic agriculture also makes farms and people more resilient to climate change, mainly due to its improved water efficiency, resilience to extreme weather events and lower risk of complete crop failure.

It is believed that shifting from conventional crop production systems to organic crop production systems would significantly lower the emission of greenhouse gases because organic production systems produce smaller amount GHG emissions than conventional farming systems (Meredith, 2008; Mullar, 2009; Pandey and Singh, 2012).

Organic Practices to Reduce GHG Emission

Potential of organic agriculture for climate change mitigation is based on its capacity of carbon sequestration, reduction in the energy use and lowering the greenhouse gases emission.

(i) Enhancing carbon sequestration: Soils are the major sink for atmospheric CO_2. Organic farming increases organic carbon through organic manures, crop cover and crop rotation and restores it

for the longer duration.

(ii) Reduction in energy use in agriculture: Organic agriculture reduces the direct and indirect use of energy in agriculture. It is reported that organic farming systems use 20 to 50 per cent less energy compared to the conventional farming system (Pimentel *et al.*, 2005; Schader *et al.*, 2011 and Muller *et al.*, 2012).

5. Lower greenhouse gas emissions: Olesen *et al.* (2006) reported that organic agriculture emits lower N_2O from nitrogen application, due to lower overall nitrogen input per ha than in conventional agriculture. Greenhouse gas emissions were calculated to be 48-66 percent lower per hectare in organic farming systems in Europe and were attributed to no input of chemical N fertilizers. The FAO also reported that organic agriculture is likely to emit less nitrous oxide (N_2O).

6. The way forward

The study provides the following insights into the organic farming in the country to reduce greenhouse gases emission.

i. Potential for accreditation of an organic farming for the Voluntary Carbon Market .

ii. Allocations based on the account for interactions in the farming systems

iii. Revisit the focus of the organic programme using multi-stakeholder involvement to

- locate suitable targets and measures for expansion with the provision of adequate financial assistance

iv. Appropriately, anchor organic agriculture in the agriculture policies of the centre and state, developing coherence between these policies.

v. Explore mechanisms for providing financial assistance to farmers during conversion and providing monetary support for FPGs and NGOs supporting organic agriculture.

vi. There is much to learn from the farmer innovations and climate coping practices and it must be documented as climate adaptation strategies.

7. Conclusion

In the context of global warming and climate change, organic agriculture can be a potential strategy to mitigate consequences of climate change either by reducing GHG emissions or by sequestering CO_2 from the atmosphere in the soil. Although the yield potential is little less in the initial period of conversion from conventional agriculture to organic agriculture, this can be managed by the reduction potential of the greenhouse gases emissions. Organic agriculture is potentially capable of ushering twin role of country is "**food security and the environment**

protection". Even though the organic agricultural area in the country is increasing, there is still need for further improvement, especially in the areas of research, extension and awareness among personnel directly or indirectly involved in the organic farming.

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