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Conservation Agriculture newsletter

Getting Agriculture to Work for People and the Environment

Conservation Agriculture as an Adaptive and Mitigation Strategy to Combat Climate Change

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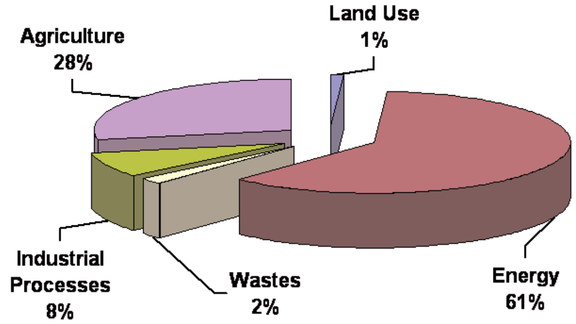
Contributing 21 percent to country's GDP, accounting for 11 percent of total export, employing 56.4 percent of total work force and supporting 600 million livelihoods directly or indirectly; agriculture is vital to India's economy. Global warming and associated climate changes are increasingly impacting agriculture in a number of ways which have serious implications for national and global food security. At the same time, agriculture related activities contribute significantly to climate change through release of green house gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and also by altering land cover which changes its ability to absorb or reflect heat and light, thus contributing to radiative forcing. Land use changes through deforestation and desertification together with use of fossil fuels is the major anthropogenic source of carbon dioxide, while agriculture is the primary contributor of methane and nitrous oxides.

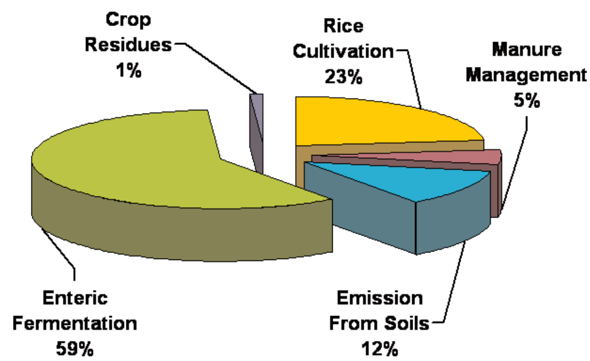
According to Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, agriculture sector consisting of cropland, pasture and livestock production, and forestry contribute 13 and 17 percent of total anthropogenic greenhouse gas emissions (GHG), respectively. This does not include agriculture associated emissions such as production of fertilizers (accounted under industry), food supply (transport and industry), cooling and heating (energy supply). While contribution of agriculture sector to CO_2 emission is relatively small, the sector accounts for about 60 percent of N_2O and 50 percent of CH_4 emitted mainly from soils and enteric fermentation respectively. The GHG impact through radiative forcing of N_2O is nearly 300 times that of CO_2. Methane and nitrous oxide emission increased by 17 percent from 1990 to 2005 and are projected to increase by another 35 to 60 percent by 2030 driven by growing nitrogen fertilizer use and increased livestock production. Increase in agriculture emission is expected, as population and economic growth increases demand on food.

According to MoEF estimates (NATCOM 2004), agriculture sector in India contributes about 28 percent of total GHG emissions and this is likely to increase due to the need to increase production to meet increasing food demand. Of these, emissions by livestock (through enteric fermentation) accounts for about 59 percent of emissions, while growing rice-paddy accounts for another 23 percent. Emissions from soils account for about 12 percent while manure management and crop residues burning account for the remaining 6 percent of the emissions. Over 90 percent of nitrous oxide emissions constituting 4 percent of India's GHG emission come from agriculture sector, largely due to fertilizer use.

Contribution of major sectors to emission of green house gases in India



Relative contribution of sub-sectors of agriculture to green house emissions in India



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In what way does climate change impact agriculture?

According to the IPCC Third Assessment Report, the impact of climate change on agriculture will be mediated through a combination of one or more factors :

- Direct impact of changes in atmospheric composition (e.g. increased CO_2 concentration),
- Increased mean/maximum temperature, and
- Changes in availability of water due to changes in pattern and amount of rainfall, resulting in increased GHG emissions.

Projected Climate Change Impact (IPCC, 2007)

CLIMATE RELATED CHANGE	***LIKELY IMPACT***
Warmer and fewer cold days and nights; warmer and more frequent hot days and nights over most land areas	*Decreased yield in warmer and increased yields in colder regions; increased pest incidence*
Warm spells and heat waves increasing in frequency over most land areas	*Reduced crop yields due to heat stress, adverse impact on health and productivity of livestock, increased danger of wild fires*
Increased frequency of heavy precipitation events over most areas	*Damage to crops; increased soil erosion; increased problems at time of cultivation due to water logging etc.*
Area affected by frequent drought will increase	*Reduced crop yields from crop damage and failures, increased livestock deaths, accelerated land degradation/soil erosion, reduced arable land, migration*
Intense tropical cyclone activity increase	*Damage to crops/trees/coastal ecology*
Increase in incidence of high sea level	*Salinization of estuaries and fresh water systems, loss of arable land, increased migration*

Source: FAO (2008)

Although increase in CO_2 can be beneficial to several crops, the associated increase in temperature and variability in rainfall will considerably impact food production. These broad implications will influence agriculture in a number of ways, importantly; changes in crop yields and cropping patterns due to direct effect of changes in temperature, precipitation and CO_2 concentration. Available evidence shows that a significant reduction in the potential yield of most crops will take place. This fall in production could have a significant impact on GDP, with rainfed areas being worst affected.

These factors will impact agriculture differentially depending on the nature and extent of change. The exact manner in which these climate related changes will impact agriculture in a region is uncertain due to uncertainities in nature and extent of changes. However, in a broad manner, climate change will impact agriculture through :

- Greater stress on land and water resources such as, shifts in land use, resulting coastal areas in response to rise in sea level
- Increasing threat to ecosystem functioning and biodiversity through indirect effect of changes in soil moisture, distribution and frequency of infestation by pest and disease
- Increased vulnerability to extremes of climate events like droughts, floods, and cyclones, particularly in coastal areas
- Potentially drier regimes in the arid and semi-arid regions. There is sufficient evidence to support that vulnerable sections of farming will be the worst affected and more vulnerable to hunger and food security.

There are predictions such as, changing rainfall pattern and rising temperatures during the coming decade will contribute to severe water shortages or flooding and cause shift in crop growing seasons. The predicted temperature rise of 1°C to 2.5°C by 2030 has serious implications by way of reduced crop yields, water availability and overall food shortage. Changes in mean rainfall and temperature as well as increase in extreme events will adversely impact agriculture, livestock, as well as fisheries; that will need to be addressed. There are projections on loss in production of wheat by 4 to 5 million tonnes for every rise in temperature by 1°C, while another projection indicated a probability of 10 to 40 percent loss in crop production with increases in temperature by 2080-2100 (IARI study, 2008).

Responding to Climate Change

Agriculture is both a culprit and a victim of climate change. There are opportunities, both to reduce the contribution of agriculture to climate change by reducing gaseous emissions and to define and pursue strategies to develop cost effective ways to assist the farmers adapt to changes. Interventions which are aimed at reducing the source or enhancing the sink of greenhouse gases constitute the mitigation strategy while adaptation refers to adjustments in the system in response to actual or anticipated climatic stimuli to moderate the potential harmful impacts and exploit the beneficial opportunities from expected changes.

IPCC sees agriculture sector as having a significant GHG mitigation potential and that a major portion of this is assumed to come from carbon sequestration in soils. Soil carbon sequestration is one of the most promising options. Increasing carbon content in soil through better management practices offer benefits for biodiversity, soil fertility and productivity and improved water storage capacity. Further such efforts help stabilize and result in increased production while optimizing use of inputs and reversing land degradation, also helping restore the ecological health.

There are other potential ways to mitigate GHG emissions through changes in agriculture technology and management practices. Changing crop mixes to include more perennials (agro-forestry system) or those having deep rooted system increase the amount of carbon stored in soils. Cultivation systems that reduce tillage and leave residue encourage build up of carbon. Improved crop, soil, water and nutrient management strategies can reduce both nitrous oxides and methane emissions. Mitigation options to reduce emissions from livestock include improving livestock waste management, and ruminant livestock management through improved diet, nutrients and increased feed digestibility. Farming practices that aim to achieve desired production level with reduced dependence on purchased inputs (e.g. through improved recycling of nutrients/ nitrogen fixing cover crop) would offer a sound mitigation option that simultaneously enhances adaptation.

Recognizing the main sources, efforts at mitigation of GHG emission need to focus on:

- Sequestering atmospheric CO_2 through enhanced storage in soils
- Enhancing agricultural/livestock productivity so as to reduce pressure on deforestation and denudation
- Emphasis on reduced dependence on non-renewable energy sources by improving use efficiency of inputs through available management options.

potential adverse effects or takes advantage of opportunities to cope with consequences. The term also refers to capabilities, resources and institutions of a country or a region to implement adaptive measures. As indicated earlier, the likely impact and possible adaptive strategies and interventions in response to climate change elements will be location specific, recognizing however, the need to include interventions into large scale and coherent adaptation programs. The most effective adaptation approaches, as highlighted in United Nations Framework Convention on Climate Change (UNFCC) meetings are those that address

GHG Mitigation Opportunities

GHG MITIGATION STRATEGY	*OPPORTUNITIES*
Enhance carbon sequestration in soils and biomass	• *Improved crop and grazing land management emphasizing agro forestry, cover crops, crop residue management* • *Restoration of degraded lands*
Reduce CO_2 emissions	• *Reduce biomass/crop residue burning* • *Reduced tillage system, recycling bio wastes* • *Efficient use of energy to reduce dependence on fossil fuels*
Reduce CH_4 emissions	• *Improved rice cultivation technologies* • *Improved livestock and manure management* • *Reduce biomass burning*
Reduce N_2O emissions	• *Develop and promote technologies for improved use efficiency of fertilizers* • *Enhance biologically mediated N_2 fixation in agricultural systems*
Reduce dependence on non renewable energy sources	• *Promote energy efficient technologies* • *Reduce use of chemical fertilizers and pest control chemicals through integrated management approaches*

Adapting to Climate Change

The term adaptation refers to adjustments which a system (natural or human) takes up in response to actual or expected climate stimulii or their effects which moderate harm or exploits beneficial opportunities. The term adaptive capacity accordingly refers to the ability of a system to adjust to climate change or variability in ways that it moderates the a combination of environmental stresses and factors aimed at enhancing food security and water availability, combating land degradation and soil erosion, reducing loss of biological diversity and ecosystem services as well as improving adaptive capacity within the framework of sustainable development. Addressing food security concern has to be the main criteria for effectiveness of adaptation strategies at national and local levels.

Adaptation Strategies to Cope with Climate Change

LIKELY IMPACT ON AGRICULTURE	*POSSIBLE ADAPTIVE STRATEGIES*
Greater vulnerability of production systems through: • *Direct impact of increased temperature* • *Indirect impacts on water availability resulting from increased incidence of droughts and higher intensity rains*	• *Promote agro-biodiversity (plant and animal) including agroforestry that can impart greater resilience to changing environmental conditions and stresses* • *Develop and promote adoption of drought resistant/ flood and salinity resistant crops, and livestock breeds with greater ability to withstand stressed environments* • *Develop, adapt and promote soil, crop and water management practices aimed at efficient use of available water resources in a watershed; to enhance use efficiency of nutrients* • *Develop and promote practices for improved livestock nutrition and managements to cope with stress*

Conservation Agriculture

The concept of 'Conservation Agriculture' which is rooted in giving a practical shape to a few scientifically proven basic guiding principles has globally emerged as a way to achieve sustainability goals. The basic guiding principles that can leverage a change from the conventional agriculture system include:

- Developing and promoting a system of raising crops with minimum soil disturbance through operations involving direct seeding of crops in untilled soils
- Keeping the soil surface covered by practices such as leaving and maintaining crop residues cover on the soil and/or growing cover crops
- Adopting diversified crop sequencing, spatially and temporally

Farming practice based on these basic principles when adopted in an integrated fashion over a period of time contribute to sustainable increases in crop productivity, improving soil health, biodiversity and in reversing processes contributing to land and water degradation. Sufficient evidence has accumulated to show that CA practices have both the potential to mitigate GHG emissions from agriculture related activities and as an adaptive strategy to cope increasingly with climate related changes. Table below summarizes the way in which elements of CA approach can mitigate climate change and provide a way to adapt to new situations.

Conservation agriculture constitutes an integrative approach to address multiple challenges facing the agriculture and environmental sectors – enhancing productivity in the face of acute and wide spread problems of resource degradation (soil erosion, declining water availability and quality, declining diversity) and increasingly stressed ecosystems and climate change. The approach enables addressing the immediate concerns of enhancing productivity, long term sustainability, and food security concerns. It is well recognized that the problems of enhancing productivity which are intimately linked to resource degradation and climate change issues are region specific and therefore the solutions have to be found in the context of prevailing problems. Thus, while Conservation Agriculture principles are fairly universal in nature, technologies aimed at translating these into practical solutions have to be specific to a region and the existing farming system. The principles of Conservation Agriculture are not new. They have been well known and tested for some time. What is new is the recognition of the need to pursue these in an integrated fashion - this is the real challenge.

It is apparent that CA based practices when adopted in an integrated manner and over a period of time hold a significant potential to mitigate GHG emissions and at the same time offer opportunities as an adaptive strategy to cope up with climate change related challenges increasingly facing the agriculture sector.

Policy Initiatives Needed

Elements of CA and the objectives to be achieved through CA are scattered around various development programmes of the central government sponsored by different Ministries such as Ministry of Agriculture, Ministry of Rural Development, and Ministry of Environment and Forests. However, these are largely being promoted at the farm level in an isolated manner resulting in limited impact. Similarly, research and technology generation efforts have also been viewed and pursued in a fragmented disciplinary mode and not in the context of a farming system or a problem solving integrative mode. To do this it is important that technologies are refined and adapted to different farming situations working together with farmers building on their experience and knowledge. This would ensure wider uptake of technologies in an integrated manner.

An important consideration is the development and operationalizastion of CA research projects that need to link and feed into major ongoing development programmes of the Government. There are several central/state government programs and schemes that have objectives of achieving both enhanced productivity and resource conservation. It will be crucial to ensure integration of CA objectives with the focus of central government programmes. In the next issue we would attempt a detailed analysis of various government schemes and bring to the fore the opportunities of CA integration into the current focus of these programmes, eg., Mission of the National Action Plan on Climate Change, and Biodiversity Conservation of the Ministry of Environment & Forest. Integration of technologies and practices based on CA principles would help recognize agriculture as part of a larger environmental concern. In specific agro-ecosystems CA will help to provide an effective, adaptive and mitigative

(continued on page 10)

CA Practices as Mitigation and Adaptive Strategies to Combat Climate Change

Elements of Conservation Agriculture	*How will CA mitigate GHG emission*	*How will CA contribute as an adaptive strategy*
• *Develop and promote management practices that are based on following key principles* • *Minimum soil disturbance, e.g. through no-tillage* • *Keeping soil covered, e.g. by maintaining crop residue, growing cover crops, etc.* • *Adopting diversified crops and sequencing*	• *Reduced CO_2 emission due to tillage induced oxidation of soil organic matter* • *Increased CO_2 sequestration through building soil organic matter/increased biomass* • *Reduced N_2O emissions by enhancing the use efficiency of nitrogenous fertilizers* • *Reduced CH_4 emission through opportunities to better manage livestock and rice paddy*	• *Moderating the impact of high atmospheric temperatures on soil temperatures and plants by soils cover providing crop residues etc.* • *Reducing the adverse impact of stress/drought or excess water periods through enhanced in-situ storage, reduced runoff and erosion, reduced water losses through evaporation*

IV World Congress on Conservation Agriculture

Conservation Agriculture and Environment

While the earlier article presents PACA Editorial team's viewpoint on Conservation Agriculture as an adaptive and mitigation strategy to combat climate change, this article is in continuation to our ongoing series on WCCA coverage, highlighting major issues deliberated at WCCA on the theme of environment through sessions on climate change, biodiversity and environmental services

Conservation Agriculture has emerged as one of the important mitigation strategies with a holistic approach that not only helps in carbon sequestration (CS) but also enhance soil fertility, higher agronomic productivity and biodiversity conservation. Agriculture offers an opportunity to offset CO_2 emissions which will be a small but significant role played in sequestering carbon. It is a way to achieve goals of higher productivity while protecting natural resources and environment. While environmental concerns related to agriculture are increasing, there is thus a need to see agriculture as part of the larger environmental concern and CA's ability to offer adaptive and mitigation benefits through carbon sequestration. At the WCCA, CA in the context of environment was deliberated through three major themes: Climate Change, Biodiversity and Environmental Services.

Climate Change

With Climate change (CC) being increasingly seen as a reality, there is an increasing need for mitigating climate change and better ensuring agriculture's adaptation for impending climate change through CA (Des McGarry, 2009). Review of the current literature and related activities reiterate the need to look at agriculture to mitigate CC and concurrently better adapt for change. The need was emphasized for a national program on sustainable consumption and production and specific solutions to these problems include processes of CA such as no till, biogas (methane), balanced fertilizer usage, rotation of crops and biofuel production. Others include:

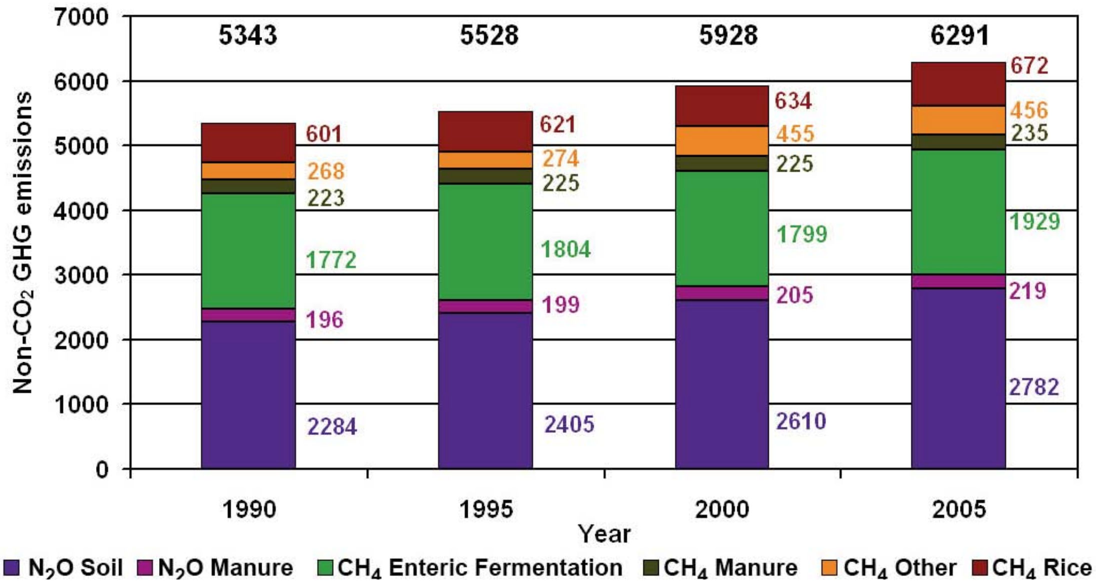
- Countries should work together on these approaches in comparable ecological/climate zones, and build regional networks, to aim for commonalities in approach and cross-sharing of technologies, successes, training and capacity building to achieve regional homogeneity of practices, and provide a framework (modality) to carry these over to other regions for more assured global impacts.
- Immediate emphasis should be on "what can be initiated now" with understood in-place technology that has shown success elsewhere. One aim is to ensure widespread uptake within minimum or no risk scenarios. Benchmarking, monitoring and evaluation of the impacts of the altered practices will be required to demonstrate and provide the means to convince others of the need and the positive impacts of change. Economic, environment and social indices need to be collected to show the cross-cutting nature of altered practices.

CA for Offsetting Green House Gases

Agriculture is considered as the main emitter of nitrous oxide emission from soils and CH_4 emission from enteric fermentation, rice cultivation and manure. Emissions of N_2O are often associated with applying fertilizer in excess of crop demands. Mitigation methods are to reduce excess fertilizer to match crop needs, split fertilization, and application of nitrification inhibitors. There are useful opportunities for mitigating non-CO_2 GHG and soil carbon emissions in agriculture. Various Carbon sequestration opportunities with smallholder communities through forestry, agriculture and agro-forestry have been discussed below (Louis V. Verchot and Virendra P. Singh, 2009):

Non-CO_2 Greenhouse Gases by Source in the Agriculture Sector

Source: Louis V. Verchot and Virendra P. Singh, 2009



- Agriculture ecosystem (grassland, community forestry and agro-forestry) has the potential to increase carbon storage thereby reducing atmospheric CO_2 by sequestering Carbon in soils and vegetation. Recently, zero-tillage approach to sequester Carbon in soil has been challenged because the data is based on samples not taken from sufficiently deep soils (less than 20 cms).
- Agriculture land also removes CH_4 from the atmosphere by oxidation. The authors have given calculation of the cost of C sequestration in different agricultural landscapes. There are opportunities for small emissions reduction at a net benefit or zero cost. There is potential for abatement of all sources, but with current technologies and the prevailing economic conditions, such potential is low. The analysis shows that 11-13% of non-CO_2 GHG and soil carbon emissions could be abated at a reasonable cost. Sequestration offers the most significant and cost effective means of reducing atmospheric concentrations of GHGs. There are large potentials in a number of practices in agriculture.
- CH_4 emitted by anaerobic manure management systems can be captured and combusted. CH_4 emission from enteric fermentation can be reduced by giving enriched diet to animals, use of forages with higher nutritional quality, mineral supplementation to overcome nutrient deficiencies, and improvement of sanitary condition of drinking water and animal health.
- Reduction can also be achieved through breeding or through dietary additives like ionophores. CH_4 emitted from rice field can be reduced by different strategies of flooding and draining the field, by management of organic inputs through the composted rice straw, mulching, removal of rice stubbles from the fields, application of mineral inputs like phosphogypsum, ammonia sulphate and urea tablet.
- Many of these abatement practices are economically beneficial but do not occur due to a number of barriers such as delayed returns on investments, lack of knowledge and labour shortages. Abatement costs are significant compared to current and projected rates of global investment in agriculture.

Reduction in investment by developing countries and reduction in the share of agriculture over the past three decades have led to land degradation and intensification of subsistence agriculture systems. This has led to large-scale losses in carbon from natural ecosystems. Investments aimed at sequestration and intensification of agricultural systems can reverse the trend. Investments to facilitate wider adoption of high carbon and higher profit production systems need to target these and other barriers that exist in rural areas. Investment targeted at overcoming these barriers is much less than the total cost, and therefore, there are opportunities to share costs with other beneficiaries.

Conservation Agriculture protocols for greenhouse gas offsets in a working Carbon market were also discussed. CA based projects can provide offsets to large emitters of greenhouse gases. With global carbon market growing rapidly, in some jurisdiction, companies can offset their emission by purchasing offset credits or contracts from others who have reduced their emission or can sequester carbon. Following stringent international standards of protocol development, Goddard and his coworkers have developed a range of agriculture protocols for greenhouse gas offsets in a working carbon market using the Alberta Emissions context. Four phases of the process of protocol development have been mentioned and a tillage reduction protocol (no tilling) has been described in more detail (Tom Goddard, Karen Haugen-Kozyra and Andy Ridge, 2009). Major conclusions include:

- A comprehensive system approach that integrates science, policy, theory, and agribusiness realities needed to develop offset protocols. The best learning occurs when all parties that have interest in the market work together.
- Considerable efforts and resources are needed and distribution of efforts across government departments and NGOs negates the need for a large administration in any one institution.
- In addition to protocol development, guidance documents, information centers and extension of the system as well as technologies are required for both sellers and buyers. Aggregators help bring sellers (farmers) to the market and can alert the regulator to adjustments that are needed. Buyers and sellers willing to participate in tillage carbon offsets have been found. Attempts have been made for driving CA through Carbon offset policies.

In anticipation that yields of rice-wheat system from the Indo-Gangetic Plains (IGP) are likely to decrease due to climate change and global warming, the session also specifically deliberated on the Greenhouse Gas Mitigation in Rice-Wheat System with Resource Conserving Technologies (Pathak, 2009). The author observed that there are uncertainties in assessing the impacts of RCTs on GHG mitigation and CC adaptation under different agro-climatic and management conditions. For this, the need for developing mechanistic simulation models using exhaustive data on soil, climate and crop management was emphasized.

Biodiversity

Three paper presentations in this session focused on the importance of biodiversity in CA with a range of crops and sowing conditions. Crop diversification includes growing a range of crops suited to different sowing and harvesting times, assists in achieving sustainable productivity by allowing farmers to employ biological cycles to minimize inputs, maximize yields, conserve the resource base, and reduce risk due to both environmental and economic factors. Opportunities related to diversifying crop rotations with N_2-fixing legumes has been discussed (Alves et al, 2009). This paper focuses on the role of legumes in providing sustainable inputs of Nitrogen to crop rotations and particular advantageous features of their presence in conservation agriculture not only as a supply of Nitrogen, but also as stimulation of Soil Organic Matter (SOM) accumulation. The sustainable adoption of CA by resource-poor farmers is going to be difficult and large investments in fertilizer, agrochemicals and seeds will be necessary which will enhance their viability and increase their sustainability. Legumes as cover crops, and intercrops can play an important role in substituting industrial fertilizer and building up soil organic matter.

Crop rotation is a basic desirable agronomic practice that enhances long-term soil productivity. Adoption of crop rotation help interrupt weed, disease, insect, and nematode cycles, while the deep root penetration of many species into compacted soil layers can leave channels that improve water and air movement and enhance root penetration of subsequent crops. On account of numerous potential benefits that can be realised, many arable crops should be grown in rotation with forage grasses/ legume mixtures. The paper on the importance of biodiversity in crop rotations under direct drill in controlling weeds, plant weeds and crop pests (Fontaneli, et al, 2009) has been disussed through the case of Glyphosate, a unique herbicide and management method. Glyhosphate has been used by farms in Brazil for the last 30 years to control weeds. But it was found that in a very short time, the weeds got resistant to repeated glyphosate applications. Though there are other weed management herbicide technologies available to arrest this problem, they are expensive, less efficient and environmentally dangerous. Besides these papers, a critical appraisal of germplasm enhancement opportunities for CA initiatives were also discussed that includes varietal development programmes targeted to tillage requirement; selecting genotypes suiting to soil factors under reduced tillage; genotype suiting to water stress; strengthening pre-breeding activities for pest resistance, selecting genotypes for quick residue decomposition and varieties adapted to specific ecological, environmental, problematic soils and crop diversification (Gautam, et al, 2009).

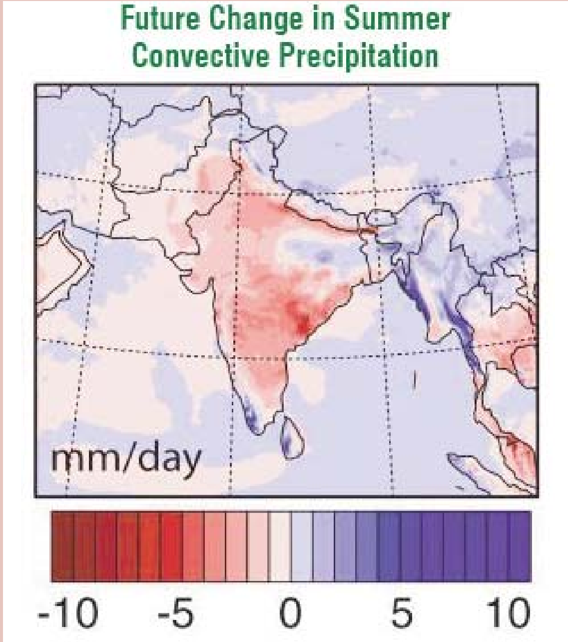
Environmental Services

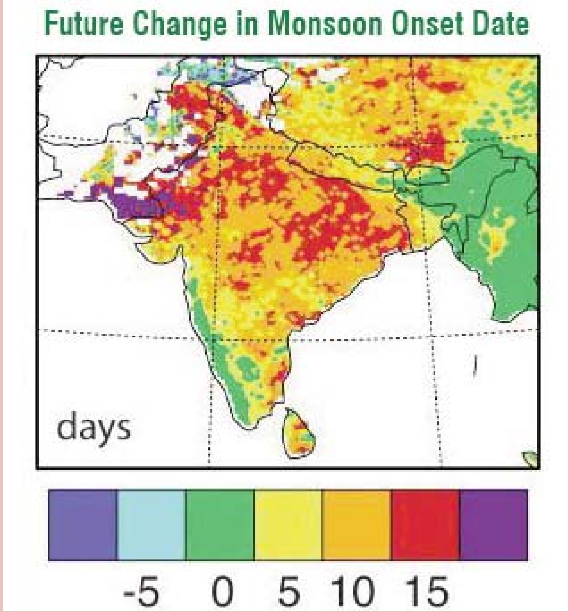
Agricultural practices have environmental impact that affect a wide range of ecosystem services such as water quality, pollination, nutrient cycling, soil retention, carbon sequestration and biodiversity conservation. As ecosystem services affect agricultural productivity, understanding the contribution of various agricultural practices to that range of ecosystem services would help inform choices about the most beneficial agricultural practices.

- CA is one among the strategies with implications for assessing environmental services in Tropical rural

INFOPIX

This section will present research data in pictorial form from past studies for benefit of readers





A Purdue University research group found that climate change could influence monsoon dynamics and cause less summer precipitation, a delay in the start of monsoon season and longer breaks between the rainy periods. The South Asian summer monsoon, critical to agriculture in Bangladesh, India, Nepal and Pakistan could be weakened and delayed due to rising temperatures in the future. The study has projected an eastward shift in monsoon circulation, which would mean more rainfall over the Indian Ocean, Bangladesh and Myanmar, and less over India, Nepal and Pakistan. Less moisture over the land in combination with the ambient dry summer air would lead to less moisture in the clouds and reduced rainfall.

(Credit: Diffenbaugh lab image) Source: Ashfaq et al. Suppression of south Asian summer monsoon precipitation in the 21st century. Geophysical Research Letters, 2009; 36 (1): L01704 DOI: 10.1029/2008GL036500

http://www.sciencedaily.com/releases/2009/02/090227112307.htm catchments in Brazil specially with respect to water and soil credits (Reichert et al, 2009). Among CA, no-till is one of the few agricultural practices that can deliver services that benefit farmers, society, and the environment, including benefits such as reduced erosion, Carbon sequestration, energy conservation, and decreased Nitrogen loss.

- CA practices increase soil aggregation, reduce erosion and sedimentation, and increases soil organic matter across a range of soil types, cropping systems and climates. Results of recent research (Southern Brazil) performed on surface hydrology, erosion and sedimentation in rural catchments in the process of adopting CA practices has been discussed. It also includes effect of soil pore quality and stability in relation to ecological functions and environmental services. The results are a part of hydrosedimentological studies performed in two rural catchments in southern Brazil in which significant changes in soil conservation practices occurred, leading to sediment yield changes, and also review of work on soil physics in Brazil and elsewhere. For conservation of carbon, soil and water, a change has been emphasized from a strictly physical approach to a biological approach in catchment planning and use.
- Improved agricultural practices have great potential to increase soil carbon sequestration and decrease net emissions of CO_2 and other green house gases that contribute to global environmental security. The soil contains two to three times as much Carbon as the atmosphere. Soil quality is the fundamental foundation of environment quality. Soil quality is largely governed by SOM content, which is dynamic and responds effectively to changes in soil management, primarily tillage and Carbon input. With CA practices soil can accumulate carbon to offset other carbon losses. Thus, the soil can be converted from a source of Carbon to a sink of Carbon with improved soil and crop management.
- CA has also been explored for its benefit to Africa's potential to ameliorate 21st century environments (R.M. Fowler, 2009). This paper explores and discusses some existing and possible options on how innovations could accelerate the adoption of CA in Africa which in turn could slow, and equip African farmers to better adapt to climate change. CA practices render a number of services to humanity that include the provision of cheaper and more reliable supplies of food as well as a range of environmental services such as increased soil health, reduced water pollution and runoff and decreased greenhouse gas emissions. In recent years, much attention has been given to rewarding of farmers practicing CA and other reduced tillage systems for their reduction of carbon emissions that tends to be site and tillage-system specific. Assessment and monitoring are expensive and therefore warrented on larger farms only. With current price of carbon credits, a system should exist which attempts to quantify benefits and reward African farmers for their part in these reductions. This especially with respect to small farmers who make up the majority of African agriculturists. Such benefits could be assessed, marketed and monitored by farmer organisations to promote CA and establish and maintain CA advisory services. Innovations could accelerate adoption of CA in Africa and equip them to adapt to climate change.

Role of carbon and its associated environmental benefits such as ecosystem services have been explored through research on CA based technologies, tillage-induced carbon losses and environmental benefits of soil carbon. This is to highlight the role of agronomist and the farmer who play a major role in optimizing the canopy conditions to maximize solar energy and carbon capture for photosynthesis and a major management role in nutrient cycling for optimum crop production and minimum environmental impact. CA practices aim to conserve, improve and make efficient use of natural resources through integrated management of soil, water and biological resources. Improved CA practices have great potential to improve soil carbon sequestration and decrease net emissions of CO_2 and other greenhouse gases that contribute to global environmental security. Soil organic carbon represents a key indicator for soil quality for both agricultural and environmental functions. Soil aggregation and stability of soil structure increases with increasing organic carbon which in turn increase the infiltration rate and water holding capacity of the soil as well as resistance against erosion by wind and water.

With CA techniques, soils can accumulate carbon to offset other carbon losses. It is therefore important that carbon loss from the soil system be restored to its natural potential using direct seeding and conservation tillage methods for sustainable production. The main direct benefit of direct seeding is the immediate impact on soil organic matter and soil carbon interactions. Agricultural policies are needed to encourage farmers to improve soil quality by storing carbon that will enhance air and water quality, improve water holding capacity and use efficiency, increase cation exchange capacity, reduce soil erosion, improve infiltration, decrease soil compaction, improve soil tilth, reduce fertilizer inputs, increase soil buffer capacity and biological activity, nutrient cycling, microflora diversity, absorption of pesticides, and capacity to handle manure and other wastes. CA without intensive tillage can play a major role in sequestering soil carbon and providing long-term global economic and environmental benefits. CA, with enhanced soil carbon management is a win-win strategy. The win-win scenario will increase productivity, improve soil quality, and mitigate the greenhouse effect with a major impact on our future and quality of life.

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Conservation Agriculture - Potential for Vertisols

Vertisols or the 'Black Soils' as they are commonly referred to occupy more than 60 million ha spread in the states of Maharashtra, Madhya Pradesh, Gujarat and northern parts of Karnataka and Andhra Pradesh. Annual precipitation generally ranges from 500mm to 1500mm. The soils vary in depth (from less than 30 cm to 90cm and more), have high clay content (30 to 70%), high water holding capacity and are highly erodible. Runoff is high and the soils are highly erodible depending on rainfall volume, intensity and slope. In shallow soils, only kharif cropping is possible because of insufficient moisture to sustain a crop during 'rabi' season. Conversely, in deep soils with undependable rainfall where soil moisture is usually insufficient to support two successive crops, 'kharif' fallowing is practiced and a rabi crop is grown on the moisture already in the soil being a less risky proposition.

Deep black soils with rainfall (750 to 1250mm/year) which occupy large areas in Madhya Pradesh and parts of Andhra Pradesh, Karnataka and Maharashtra can sustain successive 'kharif' and 'rabi' crop. These are the areas with the widest gap between actual and potential crop yields and hold promise for increasing crop production if farmers can be provided with appropriate technologies to cope with considerable management difficulties. The soil moisture range in which the physical conditions of these soils are suitable for tillage and planting is quite narrow: the soils have impeded drainage in the rainy season with consequent operational difficulties for farm equipment. Land management practices that facilitate drainage and improved aeration water intake and permeability of the soils will contribute to achieving sustained productivity increases.

From 1991 to 2000, scientists at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, carried a series of field experiments to generate technological options for achieving enhanced productivity of the soils of the experimental area that are typically under vertisols. The efforts were largely in the context of rice-wheat cropping system but the results have implication for major cropping system of the regions. The results of some of the approaches tried and obtained are summarized here.

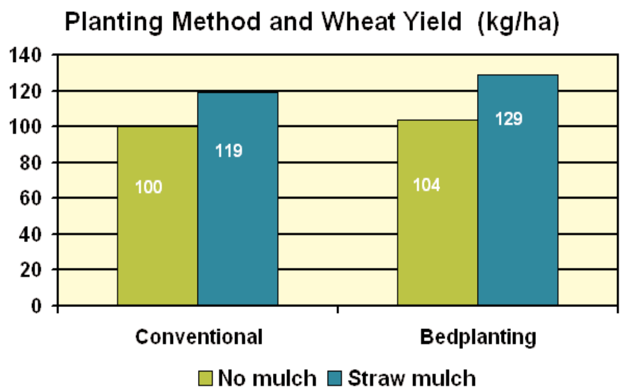
Tillage and crop productivity: In experiments extending over ten years effect of tillage practices (conventional, no tillage and deep tillage) on the productivity of wheat and rice crop was studied. Results showed that in both the crops, adoption of no-tillage had a slight advantage in terms of crop yields as compared to the conventionally tilled plots. Deep tillage did not benefit either of the crop yields compared to conventional tillage. Zero tillage, thus, not only resulted in similar of slightly improved yields, it also involved lower cost of production an account of savings in the term of fuel cost etc. Additionally, zero tillage benefited by reducing the turnaround time enabling sowing the wheat closer to the optimum date (see Table below).

Tillage and Crop Yields

Type of Tillage	*Wheat (kg/ha)*	*Rice (kg/ha)*
No tillage	2,943	3,913
Conventional tillage	2,918	3,773
Deep tillage	2,805	3,654

Bed planting and straw mulching

Bed planting of wheat has proved beneficial in terms of yield and use efficiency of inputs in several situations. Experiment in deep black soils showed that bed planting of wheat (3 rows per bed) resulted in significantly higher yields as compared to planting in conventionally tilled level field. Similarly, straw mulch application @ 5t/ha was found highly effective in further improving yield and the efficiency of water use.



The results of these studies provide a strong case for promoting zero-till mulch based farming practices and adopting innovative land shaping approaches e.g. Bed planting. In the studies reported, the two practices - zero tillage and mulch treatments were tested individually and thus the benefits do not reflect the likely additive effects. Similarly, when these practices are adopted over a period of time, the beneficial efforts are likely to increase due to improvements in soil quality and associated efficient resource use.

(Source: Tomar S.S. 2008, Conservation Agriculture for Rice-Wheat Cropping Systems – Journal of Indian Society for Soil Science 56:358-356, JNKVV Jabalpur, Madhya Pradesh - 482004)

NAIP Consortium Project on Conservation Agriculture Launched in Mewat with HAU, NCAP, IARI, CIRG, and PACA

A Conservation Agriculture project titled "Achieving Improved Livelihood Security through Resource Conservation and Diversified Farming Systems Approach in Mewat" under Component 3 has been approved and supported by National Agriculture Innovation Project (NAIP) – World Bank/Indian Council for Agriculture Research (ICAR) for the most backward district of Haryana, Mewat. The total approved budget for the project is Rs. 441.2 lakh. Component 3 of NAIP aims to improve livelihood security of rural people living in selected disadvantaged regions through innovation systems led by technology and encompassing a wider process of social and economic change covering all stakeholders. This project aims to use an innovative approach by establishing a new paradigm of livelihood pursuit based on tenets of Conservation Agriculture for improved economics and resource regeneration in Mewat.

Mewat district has been identified geographically and socio-ecologically as a disadvantaged region of the country represented by numerous bio-physical and socio-economic forces affecting rural dynamics. Problems in the district are not only numerous, but also complex, and only a multi-stakeholder, multi-disciplinary and multi-pronged approach can help achieve goals of promoting livelihood and ensuring its sustainability. While much development funds have poured into the region, results observed in the present day context are nowhere close to expectations and these are indicated not only through observations on a visual basis but also through human development indicators.

The project will be carried out in consortium mode to be led by Dr. R.K. Mallik from CCS Haryana Agricultural University, Hisar, Haryana. Other partners that have been brought together through this project include, National Centre for Agriculture Economics and Policy Research (NCAP), Indian Agriculture Research Institute (IARI), International Maize and Wheat Improvement Center (CIMMYT) and Central Institute for Research on Goats (CIRG), and PACA.

The overall objective of the project is to improve the socio-economic and ecological environment of chosen areas of Mewat region through use of CA approaches, keeping central the needs of gender mainstreaming, and broadening the opportunity window available to community through capacity building.

The specific objectives of the project are:

1. Improving the socio economic condition of marginalized farmers of Mewat region through science led interventions in agriculture
2. Implement resource conserving practices in agriculture to develop optimal production system
3. Strengthen local capacity of community and the institution system for long term sustainability
4. Help establish a new paradigm of field linked research and redefined extension system

About Consortium Partners: CCSHAU, premier agricultural university in Haryana, will have overall responsibility for coordinating the project programme and technological interventions related to CA in all clusters. NCAP will play a major role to analyze and understand farming systems interactions in each cluster and develop monitoring indicators that form the basis for technological and social interventions. PACA will manage specific components of CA practices with related research and documentation forming part of the effort.

Efforts will be more directed at secondary interventions identified in the project to support primary interventions along with few research studies that would be more focused on livelihoods. CIMMYT will bring its technological expertise related to rainfed based resource conservation technologies ranging from in situ conservation, watershed based livelihoods options and salinity based cropping systems. Other partners, IARI & CIRG would facilitate introduction of fodder crops, perennial grasses, shrubs and trees and interventions related to goat improvement in the district.

The project commences in July 2009 with a 3 year duration planned for its implementation.

Conservation Agriculture as an Adaptive and Mitigation Strategy to Combat Climate Change

(Contd. from page 4)

strategy to overcome climate change related impacts through carbon sequestration. CA's induction as a preferred practice will help position relevant mechanisms related to climate change adaptation. Similarly, CA facilitated through state/districts plan schemes of the Ministry of Agriculture through Rashtriya Krishi Vikas Yojana (RKVY), National Food Security Mission and National Rainfed Area Authority will help bring about integrated development of foods crops, mechanization needs, soil health and productivity for specific farming systems to help farmers facing problems to cope with changing technological needs.

To operationalise the CA approach, therefore, it would be important to put in place a 'CA Adaptive Research, Policy and Development' initiative that cuts across scientific disciplines and links to development department activities in respective regions. The primary aim of the initiative will be to contribute build and enhance capacity of farmers to sustainably manage their own resources to respond to multiple challenges. CA approaches have the potential to benefit both small and large holding farmers and both irrigated and rainfed farming situations. It also has the potential to take an integrated view of interconnected concerns relating to enhancing productivity and conserving resources. CA principles can thus facilitate integrated approaches to meet larger goals of sustainable agriculture.

PACA POSTER ON CA

A 11″ x 17″ poster has been created by PACA, highlighting basic principles of CA and benefits to farmers who undertake CA practices. We hope to have this ready in Indian languages in days ahead. Should you want to download the full size English poster you may do so from www.conserveagri.org/poster1.pdf

SNIPPETS

NEWS

Delivery and Adaptive Research Planning Workshop

First Planning workshop on "Delivery and Adaptive Research" (objectives 1 and 2) under Cereal System Initiative for South Asia (CSISA) project funded by Bill & Melinda Gates Foundation and USAID was organized on May 28-29, at CSSRI, Karnal. Main aim of the workshop was to plan and discuss the activities related to cost reduction and yield enhancing conservation agriculture based resource conserving technologies to improve livelihood of the farmers. This first meeting of the CSISA Delivery Hub for India provided an opportunity to all project stakeholders to participate and deliberate on issues such as development of work plans, potential collaboration with stakeholders, technologies that would need adaptive research for a double check to meet farmer's need and resource requirements for the planned works and the implementers. PACA also participated and provided feedback to meet the objectives of this initiative in South Asia. For more details on the workshop, please view the following link: http://www.cssri.org/workshop280509.pdf

Conservation Agriculture Systems Alliance

The Conservation Agriculture Systems Alliance (CASA) is the association of representatives of local, regional and national organizations who are working to promote the adoption of the principles of Conservation Agriculture within the regions they represent. CASA primarily connects these individuals in North America. CTIC coordinates the development and growth of CASA. A CASA meeting and tour of conservation agriculture systems will be held in August. Special guests include representatives from American Confederation of Farmers Organizations for Sustainable Agriculture (CAAPAS). For more information, contact Karen Scanlon at scanlon@conservationinformation.org.

http://www.conservationinformation.org/?action=article&id=52

Using Cover Crops to Facilitate the Transition to Continuous No-Till

With a 2008 Conservation Innovation Grant, CTIC is providing technical, educational and social support to farmers in Ohio and Indiana transition to continuous no-till using cover crops. In addition to matching farmers with consultants who will assist with the transition, CTIC will organize two workshops and develop and strengthen farmer networks in both the states. The workshops will focus on how cover crops improve soil quality and can be used to help facilitate the transition to continuous no till. Plus, a new matrix designed to assist Midwest farmers with choosing the appropriate cover crop for their operation will be introduced. Through meetings and regular communication, CTIC will help to build and/or strengthen dialogue among farmers in both states - providing a support network for those working through the transition to continuous no-till.

For more information, contact Angie Williams at williams@conservationinformation.org.

http://www.conservationinformation.org/?action=article&id=52

Unpuddled rice transplanting trials yield well in Bangladesh

More than 110 farmers attended a field day in Alipur village, Durgapur, Rajshahi district, Bangladesh on 16 May 2009. The farmers' day was set up to assess the first field trial for transplanted boro rice in unpuddled soil using strip-tillage, a minimal form of land preparation, and raised beds. Almost all boro rice farmers in Bangladesh have been transplanting boro rice to puddled fields despite the fact that puddling destroys soil structure, is more costly, and requires more water and labor. A few skeptical farmers stepped forward and agreed to try the new practice. Farmers said they needed to weed only twice instead of the three times typical for conventional tillage, and reported savings of 75% on land preparation, 30% on irrigation water, and 5-6% on fertilizer. At the end of the day, a quick show of hands indicated that all farmers present would continue to transplant boro rice using these resource-conserving practices.

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C.J. Baker, No Tillage Seeding in Conservation Agriculture, 2nd Edition (2006) Centre for International No-tillage Research and Engineering (CINTRE), New Zealand; K E Saxton, formerly of USDA, ARS; W R Ritchie, CINTRE; W C T Chamen, 4Ceasons Agriculture and Environment, UK; D C Reicosky, USDA, ARS; F Ribeiro, Instito Agronomico do Parana, Brazil,; S E Justice, National Agriculture and Environment Forum, Nepal; P R Hobbs, Cornell University, USA

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Petr Kosina and Roberto La Rovere (2009) Impacts of CIMMYT's International training linked to long-term trials in Conservation Agriculture: 1996-2006, at CIMMYT-El Batán. Jirina Svitáková. The study (available online at http://www.cimmyt.org/english/wps/publs/Catalogdb/index.cfm) focused on outcomes and impacts of training for scientists in public, private, and non-governmental sectors in agronomy and sustainable management of natural resources.

BIBLIOGRAPHY

Based on the action point emerging from the PACA National Operations Group meeting, a bibliography has been compiled that we hope to revise regularly. You are requested to intimate us about any new publications worthy of inclusion. A PDF copy may be downloaded from www.conserveagri.org/biblio.pdf