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Conservation Agriculture: An Overview*

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I

INTRODUCTION

Global agriculture is facing numerous challenges and adversely affecting food and nutritional security. Among others, intensive agriculture and excessive use of external inputs are leading to degradation of soil, water and genetic resources and negatively affecting agricultural production. Degradation of natural resources is posing a serious threat to meet the future demand for food, feed, fodder and fiber. Wide spread soil erosion, nutrient mining, depleting water table, and eroding biodiversity are the global concerns which are threatening the food security and livelihood opportunities of farmers, especially the poor and underprivileged. Soil degradation due to erosion and compaction processes is the most serious environmental problem caused by conventional agriculture. Estimates reveal that an annual loss of 75 billion tonnes of soil translates into US$ 400 billion per year; about US$ 70 per person per year (Vlek, 2008). About 10 million hectares of good quality land is lost annually for agricultural uses, due to soil degradation processes, which adversely affect agricultural production and profitability. Degradation of natural resources is adversely influencing livelihood opportunities of poor and dragging them to poverty trap. A study by the Food and Agriculture Organization of United Nations (FAO) revealed that an estimated 1.5 billion people depend directly on land that is degrading. Another study by the FAO indicated that land degradation is worsening rather than improving, with declining trends revealed across some 24 per cent of global land area. According to this study, the main driver of degradation is poor land management (Paroda, 2009). Besides, an enormous quantity of soil carbon is lost due to inefficient production methods. Soil carbon is key for crop production and considered to be black gold. It is reported that mechanization led to carbon loss in the form of carbon-di-oxide is as high as 78 billion metric tonnes (Lal, 2004). The recent fuel and food crisis have forced global community to take appropriate measures to substantially enhance food production in a sustainable manner to feed the growing population.

In the Indian context, especially in the western Indo-Gangetic plains, the production system is facing serious challenge of soil and water degradation, rising

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production cost and increasing uncertainty in the form of: (i) declining organic matter and organic carbon in the soil; (ii) practicing intensive agriculture by adopting extensive tillage, imbalance of nutrients, and residue burning to catch up next crop; (iii) falling ground water table; (iv) high wages and labor scarcity; and (v) rising and uncertain fuel prices. These factors are deteriorating the quality of natural resources, adversely affecting crop yields and witnessing unprecedented raising cost of production. These are fueling farmers' unrest and posing key supply side constraints of agricultural commodities. It is therefore, important to provide solutions to efficiently increase agricultural production and prevent degradation of natural resources, especially soil and water.

To conserve soil and water resources and overcome the agrarian challenges, the role of conservation agriculture is well recognised by most of the developed countries and many developing countries. Many global treaties have raised the concern to conserve natural resources for improving livelihood opportunities and enhancing the quality of the millions of small and marginal farmers living in abject poverty. It has been well recognised that the targets of the Millennium Development Goals can only be realised through improved technological options, institutional arrangements and appropriate policies in partnership with all stakeholders. Conservation agriculture has been identified as one of the technological options to meet the global challenges of increasing food production and conserving environment, thereby improves food and nutritional security and alleviates poverty. A global movement will be necessary for promoting conservation agriculture to address the complex challenges that world agriculture is facing today.

This paper gives an overview of conservation agriculture in the global and Indian context. It also highlights key global treaties with reference to conservation agriculture. Benefits of conservation agriculture and constraints in its large scale adoption are also discussed. The paper also provides key socio-economic and policy researchable areas for informed decision making to upscale the success stories and alleviate constraints.

II

CONSERVATION AGRICULTURE

The concept of conservation agriculture is relatively new in modern cultivation practices. It is differentiated with the conventional agriculture. It argues that the conventional agriculture promotes extensive soil tillage and burn crop residue. Bare soil is also allowed for weeks or months. Broadly, the conventional agriculture is characterised as intensive tillage, straw burning and external inputs. Such practices lead to soil degradation through loss of organic matter, soil erosion and compaction. In Brazil, it was estimated that 1 tonne harvest of soybean means degradation of 10 ha.

On the contrary, conservation agriculture is a range of soil management practices that minimise effects on composition, structure and natural biodiversity and reduce erosion and degradation. Largely, the conservation agriculture practices include (i) direct sowing/ no-tillage, reduced tillage/minimum tillage, (ii) surface- incorporation of crop residues, and (iii) establishment of cover crops in both annual and perennial crops. These concepts confined to improve soil health and do not refer the farm income. To integrate farm income and soil health through conservation agriculture, the Food and Agriculture Organization of the United Nations (FAO), has focused the concept as resource-saving agricultural crop production. As per FAO definition, the conservation agriculture is to (i) achieve acceptable profits, (ii) high and sustained production levels, and (iii) conserve the environment (FAO, 2009). It further argues that conservation agriculture is based on enhancing natural biological processes above and below the soil surface. These go beyond zero-tillage and provide a range of technology and management options. Conservation agriculture practices are applicable to virtually all the crops, including cereals, horticulture and plantation crops. However, these are more popular in maize, soybean, rice and wheat. The conservation agriculture practices promises tremendous potential for different soils and agro-ecological systems. These are neutral to size of holdings but their adoption is most urgently required by smallholder farmers to reduce their cost of production, increase profit, and save resources (Derpsch, 2008).

Often conservation agriculture is considered to be organic farming. There is little difference between these two concepts. Though both are based on natural processes to improve soil health, organic farming prohibits application of chemical inputs while conservation agriculture does not. For example, herbicides are an important component in conservation agriculture, particularly in the transition phase until a new balance in the weed population is achieved. Also, in view of the importance of soil life in the system, farm chemicals, including fertiliser, are applied very carefully. Despite of these facts, the global experience reveals that farmers of conservation agriculture use fewer chemical inputs than comparable conventional farmers and, over the years, quantities of chemical inputs tend to decline.

III

EXTENT OF CONSERVATION AGRICULTURE

Conservation agriculture is widely adopted globally. However, the reliable estimates on the exact extent of all sorts of conservation agriculture practices are not available. However, there are some reliable estimates on the extent of zero-tillage, one aspect of conservation agriculture. The available information revealed that zero-tillage agriculture is largely adopted in different parts of the world. The estimates show that zero-tillage agriculture is adopted in an area of little more than 105 million ha (Brown, 2008). The adoption of zero-tillage practices was rapid; from 45 million hectare in 1999 to 95 million in 2005 and now estimated to be more than 105 million.

Table 1 shows that as high as 46.8 per cent of the total area under zero tillage is in South America, which is followed by North America (37.8 per cent) and Australia (11.5 per cent). More than a quarter (26 per cent) of the total zero-tillage area is in United State of America. It is followed by Brazil, Argentina and Canada. About 84 per cent of total zero-tillage is practiced in USA, Brazil, Argentina, Canada and Australia. In United States of America, about 22.6 per cent of all crop land is under zero-tillage system (Derpsch, 2008). In Brazil and Argentina, zero-tillage accounts for about 60 per cent and in Paraguay for about 65 per cent of entire cultivated area. Only in eastern Paraguay, the adoption is as high as 85 per cent of all cultivated area. Rapid growth of conservation agriculture in developing countries is clear indication of high dividends realised by the poor farmers.

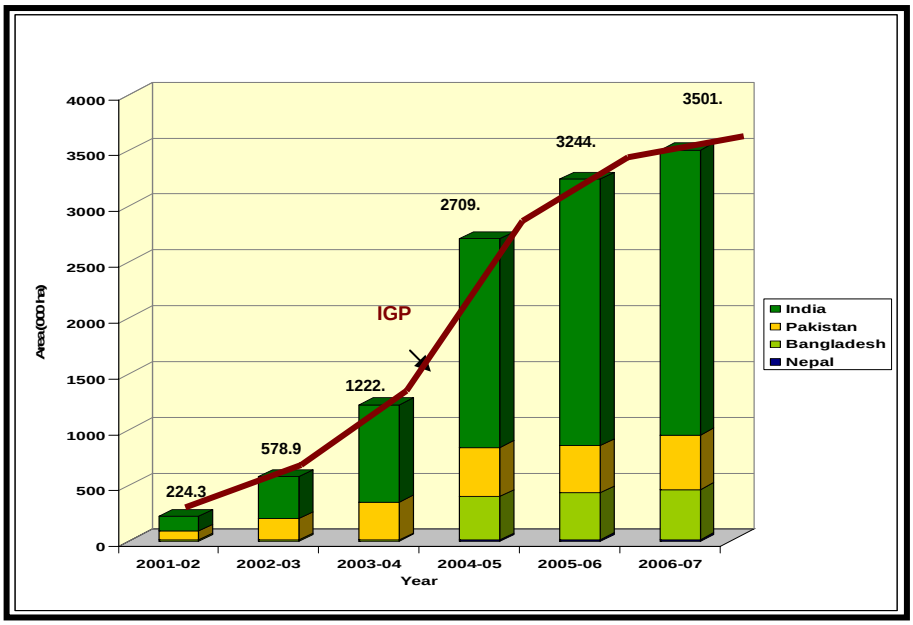
TABLE 1. CONTINENT WISE AREA UNDER ZERO TILLAGE

Continent (1)	Area, (m ha) (2)	Percentage of total (3)
South America	49.579	46.8
North America	40.074	37.8
Australia	12.162	11.5
Asia	2.53	2.3
Europe	1.15	1.1
Africa	0.37	0.3
World total	105.863	100.0

Source: Derpsch and Friedrich, 2009.

The fastest adoption of zero tillage was noticed in two South American countries, namely Brazil and Argentina. Area under zero tillage in Brazil increased from 3.00 million ha in 1993-94 to 25.5 million ha in 2005-06. Similarly, in Argentina, the increase was from 1.81 million ha in 1993-94 to 19.70 million ha in 2005-06. In United States of America, the adoption of zero tillage went up from 15.7 million ha in 1994 to 26.5 million ha in 2007.

The concept of conservation agriculture is relatively new in Asia. In Asia, a large share of the conservation agriculture is confined in India, and that is in the Indo-Gangetic plain. Earlier, way back in early 1980s, attempts were made for zero tillage (dry seeding) as a part of 'vertisol technology' launched by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The dry seeding was one of the key components of vertisol technology in rainfed agriculture. The purpose was to increase crop yields and expand copping intensities in rainfed areas of semi-arid tropics. The technology was partly adopted and was not pursued in rainfed areas. In recent times, the concept of zero tillage (and also conservation agriculture) has been well tested, perfected and widely adopted in irrigated areas of Indo-Gangetic plain. The progressive adoption of conservation agriculture in Indo-Gangetic plain is given in Figure 1 (Jat *et al.,* 2008). The area under zero tillage in Indo-Gangetic plains of India was estimated to be 1.90 million hectare in 2005, which increased to 2.5 million hectares in 2007. Farm level studies have shown that about 35 per cent of farmers in



Source: Jat et al., 2008.

Figure 1. Adoption of Conservation Agriculture in Indo-Gangetic Plain

TABLE 2. EXTENT OF AREA UNDER ZERO-TILLAGE IN DIFFERENT COUNTRIES

Country (1)	Area under no-tillage (ha) (2)
U.S.A	26,500,000
Brazil	25,500,000
Argentina	19,700,000
Canada	12,522,000
Australia	9,000,000
Paraguay	1,700,000
Indo-Gangetic Plains	2,500,000
Bolivia	550,000
South Africa	377,000
Spain	300,000
Venezuela	300,000
Uruguay	263,000
New Zealand	200,000
France	150,000
Chile	120,000
Colombia	102,000
China	100,000
Other (estimates)	1000,000
Total	105,863,000

Source: Derpsch, 2008.

Indian Punjab and Haryana adopted zero tillage wheat in rice-wheat system (Erenstein *et al.*, 2007). The focus to promote conservation agriculture was to

minimise intensive agriculture and reduce tillage in rice-wheat system. In view of promising benefits, there are projections that by 2010 the area under conservation in the Indo-Gangetic plain would exceed 3.5 million hectares. Widespread adoption of conservation agriculture practices at a rapid pace in different countries is a testimony of higher benefits to the farmers in comparison of conventional agriculture with respect to reducing cost, enhancing profits and conserving precious resources. Country-wise adoption of conservation agriculture is given in Table 2. It is evident from the table that the conservation agriculture is becoming a global movement for sustainable agriculture.

IV

TREATIES AND CONVENTIONS ON CONSERVATION AGRICULTURE

Recently, Paroda (2009) documented the key global conventions and treaties for sustainable agriculture and conservation agriculture. Important ones are listed in Table 3. These include (i) United Nations sponsored conference on human and environment; (ii) establishment of United Nations Environment Protection; (iii) UNEP organized a conference on desertification; (iv) Earth Summit; and (v) World Summit for sustainable development. All these were focused to protect environment, increase agricultural production on a sustainable way. A number of global programmes in a partnership mode were initiated which were supported by United Nations and other donors.

TABLE 3. IMPORTANT EVENTS RELATED TO CONSERVATION AGRICULTURE AND SUSTAINABLE AGRICULTURE

Year (1)	Important global events (2)
1972	UN Conference on Human & Environment held at Stockholm, where 113 nations adhered to "safeguard and enhance the quality of land and environment"
1973	United Nations Environment Protection was established in Nairobi, Kenya. Its mission is "to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.
1977	UNEP sponsored Conference was organized on desertification in Nairobi, Kenya. The Conference revealed astonishing facts that more than US$ 42.3 billion is lost annually due to desertification.
1992	Well-known 'Earth Summit' was held in Rio de Janeiro, Brazil. And famous Agenda 21 (7 themes and one was efficient use of natural resources of land, water, energy, forests and biological resources)
2001	Convention of organizing 'World Congress on Conservation Agriculture' started by national agricultural research systems (NARS), Consultative Group of International Agricultural Research (CGIAR) centers, European Conservation Agriculture Federation (ECAF), and Food and Agriculture organization of United Nations. The first Congress was held at Madrid, Spain
2002	World Summit for Sustainable Development was held at Johannesburg, South Africa

Source: Drawn from Paroda (2009).

A convention of organising the world congress on conservation agriculture was also started in 2001. The purpose was to sensitise global community on the importance of conservation agriculture in increasing food production, reduce inputs and costs, and raise farm profits. So far, four congresses have been organised in different continents (Table 4).

TABLE 4. PROGRESS OF WORLD CONGRESS ON CONSERVATION AGRICULTURE

Year (1)	Location (2)	Theme (3)
2001	Madrid, Spain	Agriculture and environment: the need to adopt conservation technology
2003	Iguassu Falls, Brazil	Conservation agriculture: producing in harmony with nature
2005	Nairobi, Kenya	Linking production, livelihood and conservation
2009	New Delhi, India	Conservation Agriculture: Innovations for improving efficiency, equity and environment
2011	Brisbane, Australia	Current and future development of sustainable agriculture

The last conference was held in India and adopted a 'New Delhi Declaration'. The key feature of the declaration is to commit for including the concept of conservation agriculture in various programs and policies by various countries. It promotes national and international partnerships of all the stakeholders. It also sought more support from the government of all the countries. New Delhi Declaration is given in Annexure I.

The past efforts of various conventions and partnerships, aimed mainly to promote conservation agriculture practices, have sensitised policy makers and other stakeholders, and greatly contributed in managing precious and scarce natural resources for sustainable agricultural development. However, more aggressive and concerted efforts are necessary to promote conservation agriculture globally to harness the potential benefits for sustainable agriculture in the future.

V

BENEFITS OF CONSERVATION AGRICULTURE

The benefits of the conservation agriculture can be seen at farm, regional and national level. The benefits can be classified into three broad categories: (i) agronomic benefits that improve soil productivity; (ii) economic benefits that improve the production efficiency and profitability; and (iii) environmental and social benefits that protect the soil and make agriculture more sustainable. Some of the benefits of conservation agriculture are listed below:

1. Improve the sustainability of different production systems.
2. Provides soil as sink for carbon dioxide, thereby improves soil organic carbon content and contribute in reducing global warming. Conservation agriculture is now receiving global focus for its carbon sequestration potential. It has been estimated that the total potential for soil carbon sequestration by agriculture could

reduce about 40 per cent of the estimated annual increase in CO2 emissions (FAO, 2009). The emergence of carbon credit payments for the farmers practicing conservation agriculture is now being considered seriously and expected to further add to the income of those farmers who adopt it.

3. Improves water infiltration and thereby reduces run-off of surface and ground water and enhance ground water recharge.
4. Improves habitation of organisms, from larger insects down to soil borne fungi and bacteria, which improve soil biological, physical and chemical properties, thereby contribute in increasing crop productivity.
5. Reduce cost of production (15-16 per cent) by saving energy, labor and water, thereby increase farm income.
6. Enhance biodiversity and improves the value of environmental services.
7. Reduction in poverty and enhance food and nutritional security due to higher, more stable yields and lower food prices.
8. Greater rural incomes, which are leading to check in rural-urban migration.

In changing climate change context, conservation agriculture is now receiving global focus for its carbon sequestration potential. The available studies reveled that conservation agriculture provides soil as sink for carbon dioxide; it improves soil organic carbon content and contribute in reducing global warming. It has been estimated that the total potential for soil carbon sequestration by agriculture could reduce about 40 per cent of the estimated annual increase in CO2 emissions (FAO, 2009). The emergence of carbon credit payments for the farmers practicing conservation agriculture is now being considered seriously and expected to further add to the income of those farmers who adopt it. Early experiments in Brazil revealed that best zero tillage systems contribute in carbon sequestration of more than 1 tonne per ha per year. Now more than 105 million ha area under conservation agriculture showing a large potential of this practice to remove atmospheric carbon-di-oxide (McGarry, 2009)

In India, Erenstein and Pandey (2006) did some systematic studies to quantify benefits of conservation agriculture in the Indo-Gangetic plain. Some of the measured benefits are listed below:

- Yield advantage of zero tillage to rice and wheat by 10-17 per cent over conventional tillage.
- Cost reduction by about Rs. 5760 per hectare (roughly by 5 to 10 per cent); ranging from Rs. 3055 to Rs. 8500 per hectare in different soils and eco-regions.
- Water saving by 20-35 per cent, and energy saving, especially of tractor time saved by 60-90 per cent.
- Projected saving of 1 million barrel of oil if the zero-tillage practice is adopted in about 3.5 million hectare area of Indo-Gangetic plain.

- High internal rate of returns (57 per cent) assuming 33 per cent adoption of conservation agriculture in Indian part of Indo-Gangetic plain.

VI

CONSTRAINTS IN ADOPTION

There are a number of problems encountered in adoption of conservation agriculture. The most important is the mindset of farming community who were educated extensively and convinced about the intensive agriculture and use of external inputs. In the past, farmers have realised huge economic benefits by intensive agriculture practices. A complete shift from intensive tillage to zero or minimal tillage needs extensive educational programme by demonstrating the benefits accrued by conservation agriculture.

The second problem is related with the high cost of machines and implements. Farmers in the Indo-Gangetic plain are small and poor, thereby may not immediately shift from the existing or available machines to the conservation agriculture machines.

The third problem is related with the access to information about the conservation agriculture. Farmers need complete information related to tillage practices, cultivation methods and improved varieties.

The fourth problem is related with the skills development. New machines (zero-till machine) and cultivation practices need skills development of the farmers. Agro-ecological based conservation agriculture technologies are available, which need capacity of farmers to adopt and implement those in their production environment. Most of the farmers lack skills in using zero-till machines and cultivation practices that prevents adoption of conservation agriculture practices.

VII

CONCLUSION

Conservation agriculture technologies are the future of sustainable agriculture. There are potential benefits of conservation agriculture across different agro-ecoregions and farmers groups. The benefits range from nano-level (improving soil properties) to micro-level (saving inputs, reducing cost of production, increasing farm income), and macro-level by reducing poverty, improving food security, alleviating global warming. In view of huge expected benefits, as witnessed during the green revolution period, the conservation agriculture may be aggressively promoted. The advantage of this technology is easy adaptability in heterogeneous agro-ecological and socio-economic environment. The need is aggressive demonstration and information dissemination programs and well complemented by skill development of the farmers. There is a need for a global movement for promoting conservation agriculture. Institutions such as the World Bank, Food and Agriculture Organization

of the United Nations, International Fund for Agriculture Development, Asian Development Bank and African Development Bank in partnership with various networks by launching aggressive programmes in poor countries. In India, NABARD (National Bank for Agriculture and Rural Development) may take lead to make conservation agriculture a national movement in a consortia mode by involving government agencies, research institutes, financial and insurance institutions, non-governmental organisations and private sector (manufacturers and agri-business).

Appropriate institutional arrangements are needed to be evolved so that small and marginal farmers who may not afford to maintain the machines and other equipments for practicing conservation agriculture. In addition, a massive training program for capacity development of farmers needs to be developed. Krishi Vigyan Kendras (KVKs) in partnerships with the research institutions engaged in conservation agriculture R&D, may take lead in this endeavor.

In view of urgency and complex challenges in agriculture, a mission mode program is needed for promoting conservation agriculture to increase and sustain agricultural production and raise income of farmers in developing countries and make them more competitive when global markets are rapidly integrating. In India, the concept of conservation agriculture may be integrated with various government programs by sensitizing policy advisors, professionals and financial institutions. The benefits of conservation agriculture need to be effectively communicated to all the stakeholders for its widespread adoption by the farming community. Failing that the sustainability of agriculture would be under threat and adversely affect natural resources and agricultural production. The most affected would be the underprivileged and poor farmers in unfavorable and marginal areas.

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ANNEXURE I

THE DELHI DECLARATION ON CONSERVATION AGRICULTURE

The 1,000 delegates, gathered in the IVth World Congress on Conservation Agriculture, held from 4 to 7 February 2009 in New Delhi, India, among them farmers, private sector enterprises, scientists, development organizations, donor organizations and policymakers from all world continents, recognizing the urgent need

- to double agricultural production over the next few decades,
- to reverse the trend of degradation of natural resources, in particular soil, water and biodiversity,
- to improve the efficiency of the use of ever scarcer production resources,
- to address the fact that agriculture and agriculturally induced deforestation cause 30% of the actual green house gas emissions,
- to answer the increasing threats of a changing climate to agricultural production,

agreed that Conservation Agriculture based on the three principles of

- minimum mechanical disturbance of the soil
- permanent organic cover of the soil surface and
- a diversified sequence or association of crops

is the foundation of a sustainable intensification of crop production, being as such the necessary condition to achieve, along with other complementary technologies, a sustained increase of world agricultural production and at the same time a recovery of the natural resource base and environmental services.

The delegates there urge all stakeholders involved in agricultural production, research and policy making at international, regional and national level to mainstream Conservation Agriculture as the base concept for agricultural production.

Governments of the world are requested to

- harmonize their policies in support for the adoption of Conservation Agriculture
- introduce mechanisms which provide incentives for farmers to change their production system to Conservation Agriculture
- pursue the case of Conservation Agriculture as the central mechanism for agricultural sector climate change mitigation in the international negotiations for a post Kyoto climate change agreement
- include Conservation Agriculture as base concept for the adaptation of agriculture to the challenges of climate change in the National Action Plans for Adaptation
- support the UN Food and Agriculture Organization in the endeavor to establish a special program on Conservation Agriculture to facilitate this process in its member countries.