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15. Conservation Agriculture in World, History, Status, Implications and Sustainability Issues

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Abstract:

With other complementary good agricultural practises of integrated crop and production management, conservation agriculture (CA) is the practical application of three interconnected principles, namely: no or minimal mechanical soil disturbance, biomass mulch soil cover, and crop species diversification. The practical evidence from throughout the world demonstrates that farmer-led transformation of agricultural production systems based on CA principles is already taking place and gaining momentum as a new paradigm for the 21st century. For intensive crop production, tillage-based soil management typically causes soil degradation and ultimately crop productivity loss.

Additionally, intense cropping forces farmers to pay high prices for labour, fuel, agrochemicals, and other production inputs. Farmers are getting better organised in their cooperative efforts and networking, which has led to the development of CA across Asia, Africa, and Europe in recent years. Stakeholders are giving CA adoption support for farmers and the creation of new knowledge to enhance their performance more time and money. The physical environment changes have an impact on many different groups of organisms, and while various species have a wide variety of reactions, most organism groups are more abundant under conservation agriculture than in tillage-based systems. For farmers to meet their economic needs, consumer concerns, and environmental concerns while also minimising their negative effects, sustainable agricultural systems will be more important than ever.

Keywords:

Conservation Agriculture, Sustainable, Tillage, Intensive Crop Production, Crop Diversification, Soil Management.

15.1 Introduction:

The soil resource base has been significantly deteriorated by conventional farming methods, particularly tillage and crop residue burning (**Montgomery 2007; Farooq et al. 2011**), which has resulted in a decrease in crop production capacity (World Resources Institute 2000).

Conservation agriculture (CA) is a farming strategy that puts an emphasis on the preservation and sustainable use of natural resources while both boosting output and enhancing incomes. By minimising soil disturbancethrough the use of minimal tillage, maintaining a layer of crop residue or cover crop on the soil's surface, and rotating crops, this practice can improve the health of the soil (**Kassam et al., 2013; Jat et al., 2014; Siddique and Farooq, 2014**) since CA provides a means of battling climate change, enhancing food security, and lowering poverty, it has been gaining popularity around the world, especially in developing nations. CA is an important agronomic practice which is concerned about agriculture sustainability and has progressively augmented globally to cover ~11 % of the globe's cultivable land (157.8 Mha) (**FAO 2016**).

CA is based on an all-encompassing method of farming that aims to maximise the utilisation of natural resources while reducing adverse effects on the environment. This strategy recognises that earth's natural resources, such as soil, water, and biodiversity, are limited and that their deterioration could have an adverse long-term impact on people's livelihoods and general well-being. In order to conserve natural resources without sacrificing the ability of future generations to meet their needs, CA promotes agricultural practices. The growing acceptance of CA on a worldwide scale reflects the understanding of the significance of sustainable agriculture in ensuring food security and eradicating poverty.Currently CA is practiced by farmers in almost 80 countries on over 200 million hectares that makes about 15 percent of annual cropland globally. Most of the farmers benefitting from CA are smallholders; 50 percent of areas adopting CA practices are in developing countries, according to the Food and Agriculture Organisation (FAO) of the United Nations, with great room for growth (**FAO, 2021**).

This chapter examines the tenets, advantages, and difficulties of CA and emphasises its significance as a sustainable agriculture strategy for tackling the complex problems the globe faces today.

History and status of Conservation Agriculture in world:

A mechanical manipulation of soil is referred to as "tillage". When people began engaging in more sedentary and traditional agriculture, particularly in the Euphrates, Nile, Tigris, Yangtze, and Indus valleys, they also began tillage millions of years ago (**Hillel, 1991**).

The Dust Bowl catastrophe of the 1930s in the United States, brought on by unsustainable agricultural practices, is where CA first emerged (**Friedrich *et al.*, 2012**). The "Dust Bowl" was a serious environmental catastrophe brought on by widespread soil disturbance and plow-over that resulted in soil erosion, desertification, and decreased agricultural production. As scientists and farmers began to experiment with reduced tillage and crop

rotations to conserve soil and water resources, it became clear that sustainable agriculture practices were necessary.With time, the idea of preserving soil by minimising tillage and keeping the soil covered became more and more well-liked. The method of soil preservation that followed had been referred to as conservation tillage (**Friedrich *et al*., 2012**).

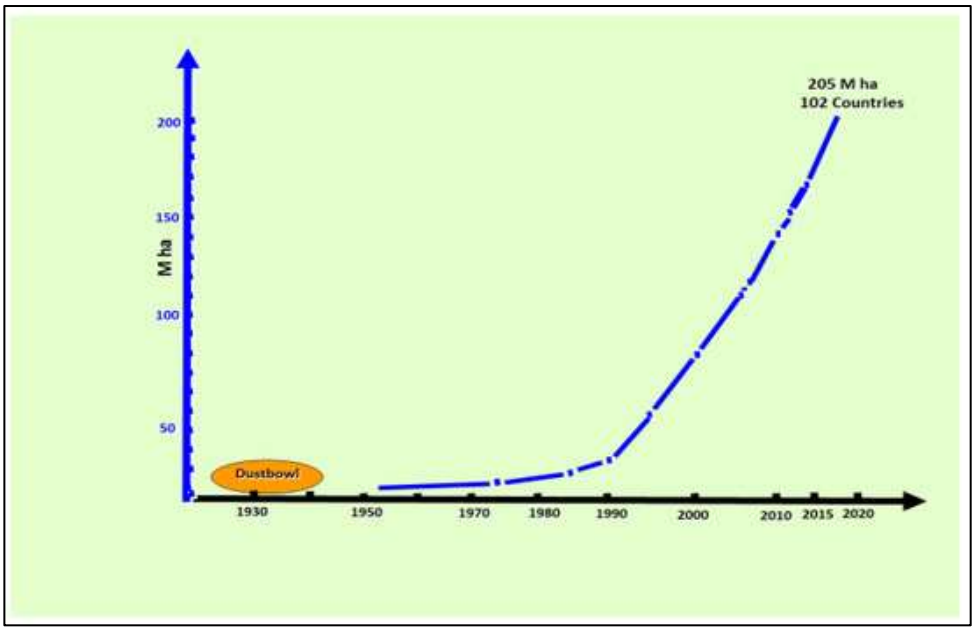

Figure 15.1: Historical chart of CA uptake at the global level (Kassam et al., 2021)

In the 1940s, the development of seeding machinery made sowing possible without soil tillage (**Friedrich *et al.* 2012**). Global agriculture was altered by the Green Revolution in the 1950s and 1960s with the introduction of high-yielding crop types, chemical fertilisers, and pesticides. Even though the Green Revolution significantly increased agricultural productivity, it also had detrimental effects on the environment, such as soil erosion, water pollution, and the loss of biodiversity.In addition, rising fuel prices in the 1970s encouraged farmers to switch to resource-saving farming systems (**Haggblade and Tembo, 2003**). In this situation, commercial farmers adapted CA to combat drought-induced soil erosion along with the fuel savings (**Haggblade and Tembo, 2003**). As the need for sustainable agricultural methods grew, researchers began looking into the potential of CA.

A programme called "Soil Conservation for Small Farmers in the Humid Tropics" was started by the FAO (Food and Agriculture Organisation) in the 1970s to encourage soil conservation methods in underdeveloped nations. Crop rotation, mulching, and intercropping were emphasised as crucial techniques to increase soil fertility and stop erosion. Additionally, the FAO acknowledged that CA had the potential to improve soil health, raise agricultural productivity, and lessen environmental degradation. The World Conservation Agriculture Network (WCAN) was founded in the 1980s to advance CA internationally. The network aims to promote policy reforms to assist sustainable agriculture and exchange information and knowledge on CA practices. The WCAN emphasised crop rotation, cover crops, and low tillage as essential CA practices.

As CA gained popularity as a sustainable agriculture technique in the 1990s, numerous nations began putting CA programmes into place. For instance, Brazil launched the "Zero Tillage" programme in the middle of the 1990s with the goal of lowering soil erosion, increasing soil moisture, and encouraging crop diversity. Brazil is currently one of the top countries for the adoption of CA practices considering the program's success.

With the promotion of CA's advantages by numerous organisations and institutions, it has become even more recognised in the twenty-first century. In order to promote CA internationally, the FAO founded the Global Conservation Agriculture Network (GCAN) in 2001.

Additionally, the UN proclaimed 2015 as the International Year of Soils, highlighting the significance of sustainable agricultural practices. Today, CA is used in many nations around the world and has proven successful in enhancing biodiversity, boosting crop yields, and reducing environmental degradation.

Conservation agriculture (CA) has a long history that extends back to the early 20th century, and it has developed into a recognised sustainable agriculture practice over time. Due to the detrimental effects of unsustainable agricultural practices, sustainable agricultural practices became apparent, and CA evolved as a method to enhance soil health, boost agricultural productivity, and protect the environment. Today, CA is used all over the world and has established itself as a crucial tool for achieving sustainable agriculture and guaranteeing food security.

Table 15.1: Global spread of CA cropland area ('000 ha) in different regions for 2008/2009, 2014/2015, and 2018/2019, and corresponding percent change

Region	CA cropland Area 2008/2009	CA cropland Area 2013/2014	CA cropland Area 2015/2016	CA cropland Area 2018/2019	Percentage change in CA area since 2015/2016	Percentage change in CA area since 2013/2014	Percentage change in CA area since 2008/2009	Percent CA cropland area in the region 2018/2019
S and C America	49564.10	66377.00	69895.00	82996.18	18.7	25.0	67.5	68.7
North America	40003.80	53967.00	63181.00	65937.22	4.4	22.2	64.8	33.6
Australia and New Zealand	12162.00	17857.00	22665.00	23293.00	2.8	30.4	91.5	74.0
Russia and Ukraine	100.00	5200.00	5700.00	6900.00	21.1	32.7	6800.0	4.5
Europe	1560.10	2075.97	3558.20	5601.53	57.4	169.8	259.0	5.2
Asia	2630.00	10288.65	13930.20	17529.02	25.8	70.4	566.5	3.6
Africa	485.23	993.44	1509.24	3143.09	108.3	216.4	547.8	1.1
Total	106505.23	156759.06	180438.64	205.400.04	13.8	31.0	92.9	14.7

(Source: Kassam et al., 2021)

Implications and Sustainability issues of Conservation Agriculture in world:

Even in affluent countries with competent agricultural extension agencies and educated farmers, the adoption of CA has not been quick. This is probably because farmers are constantly drawn to quick fixes and tangible rewards, whereas the full technical and financial benefits of CA can only be realised in the medium- to long-term, once its guiding principles (no-tillage, permanent cover crops, and crop rotation) are well-established within the farming system. Today, CA is used on millions of hectares all over the world (**FAO 2011**), in countries like the USA, Argentina, Bolivia, Brazil, Chile, China, Colombia, Falkland Islands, Finland, Kazakhstan, Kenya, Malvinas, Morocco, Uganda, Western Australia, and Zambia, on soils that range from 90% sand (like those in Australia) to 80% clay (like those in Brazil's Oxisols and Alfisols).

According to **Derpsch and Friedrich (2009)**, any crop, including tuber and root crops, may be grown well under CA. The spread of CA has been incredibly quick in recent years. The current pattern of use of home resources by the farmer may no longer be beneficial due to shifting policies, falling financial incentives, or declining natural resource quality. The degree to which farmers believe that their natural resource base is gradually deteriorating is a matter of debate. There is currently enough information to say that smallholders are frequently aware of soil degradation, even when other production-affecting factors occasionally obscure this. This method of conservation agriculture has several implications for the world, including:

a. Sustainable food production: Conservation agriculture encourages actions that maintain soil fertility and health throughout time, which can contribute to a sustainable rise in food output. By doing this, farmers may be able to grow food in the same location year after year without causing environmental damage or soil degradation.
b. Mitigation of climate change: By lowering greenhouse gas emissions from agriculture, conservation agriculture can assist to prevent global warming. Farmers can limit the quantity of carbon dioxide released from the soil into the atmosphere by minimising tillage. A further benefit of conservation agriculture is that it can increase the amount of carbon that is stored in the soil, which can assist to balance emissions from other sources.
c. Biodiversity conservation: Natural habitats and ecosystems can be preserved or improved through conservation agriculture, which can then encourage biodiversity. In order to do this, techniques including crop rotation, intercropping, and the use of cover crops may be used. These techniques can create habitat for beneficial insects and other wildlife.
d. Economic benefit: Farmers may profit financially from conservation agriculture since it can lessen their reliance on costly inputs like pesticides and synthetic fertilisers. Additionally, by preserving soil health over an extended period of time, conservation agriculture can assist to guarantee that farmers can continue to grow crops on the same land for many years to come.
e. Food security: By encouraging sustainable food production and lowering the susceptibility of agricultural systems to climate change and other environmental challenges, conservation agriculture can support food security. Farmers can produce more food with less inputs by preserving the fertility and health of the soil, which can help guarantee that food is accessible and cheap for everyone.

15.2 Sustainability Issues:

According to CA's definition, regenerative sustainable agriculture and land management are approached from an ecosystem perspective, based on the effective implementation of three interconnected, regionally adapted, context-specific principles. They are frequently referred to as the three "pillars" of CA because they serve as the systemic support for CA's ecological sustainability, which is necessary for both economic and social sustainability. The integration of the three interconnected principles into practises has been shown to have a strong ecological science foundation, providing a base upon or into which complementary practises can be integrated, further strengthening the biophysical and biochemical processes of the system that nourish and protect plants and facilitating the functioning of the ecosystem. CA has demonstrated the enhanced potential of agricultural land usage for farmers, their families, communities, the larger community, and the planet. Natural resources including soil, water, and biodiversity are not destroyed in CA systems, in contrast to tillage-based farming systems, but rather become better over time. CA enhances the financial viability of farm households by lowering production costs while stabilising, maintaining, or even raising yield levels. By utilising diverse production methods, CA encourages the local production of a variety of foods, provides small family farmers and rural entrepreneurs with commercial options, and improves the social structure of rural communities while halting the trend towards urbanisation. CA is tackling sustainability in its three main spheres- environmental, economic, and social. Conservation agriculture's sustainability is influenced by a number of variables, such as the particular techniques employed, the regional environment and climate, and the socioeconomic setting in which it is carried out. To maintain the long-term viability of conservation agriculture, a few important elements might be considered:

a. Soil health: To ensure the long-term viability of conservation agriculture, soil health must be preserved and improved. This entails techniques like reducing tillage, utilising cover crops, and rotating crops, which can assist to increase soil organic matter, boost soil biodiversity, and improve soil structure.
b. Biodiversity conservation: Maintaining ecosystem services such as pollination, pest control, and soil fertility is vital for the sustainability of conservation agriculture. Practises including crop rotation, intercropping, and the usage of agroforestry systems can help achieve this.
c. Climate resilience: Resilience to the effects of climate change, such as drought, flooding, and extreme weather events, should be a goal of conservation agriculture. This can be accomplished by using techniques like water harvesting, drought-tolerant plant selection, and adoption of climate-smart agriculture methods.
d. Socio-economic viability: In order to ensure conservation agriculture's long-term sustainability, it must be profitable for farmers and communities. This calls for the adoption of local context-appropriate practises as well as the creation of institutions and laws that facilitate farmers' access to the tools they require to engage in conservation agriculture.
e. Knowledge sharing and capacity building: Sharing of knowledge and the development of capacity among farmers, communities, and other stakeholders are essential for the sustainability of conservation agriculture. This can entail the creation of training programmes, the sharing of knowledge and experiences among farmers, and the backing of conservation agriculture by regional organisations and institutions.

In general, it is accurate to say that established CA systems consume significantly less seed, water, fertilisers, pesticides, energy, and time than tillage systems, and with higher output, they provide jobs along the value chain. In order to reduce the consumption of agrochemicals, fuel, and farm power while increasing productivity and ecosystem services using CA, sustainable mechanisation activities and extension support are required. In response to the demand for food security, climate change adaptation, and carbon sequestration, CA is becoming more and more recognised as a sustainable production base. Because it generally makes good commercial sense, the private sector firms seem to be supporting agricultural change towards CA more and more.

15.3 Conclusion:

Food insecurity, climate change, biodiversity loss, environmental degradation, unsustainable diets, and human illness all contribute to the global burden of chronic crises. All of these situations can be addressed with CA systems. A major shift in the way we think about production systems is demanded by CA, which stands for the key elements of a new alternative paradigm for the twenty-first century. It requires a lot of expertise and management and goes against conventional wisdom. For environmentally friendly, sustainable crop production, CA is an intricate combination of technologies that includes adaptive soil manipulation, crop residue retention as soil cover, planned and diversified crop sequences, and efficient weed management. In terms of crop output, income, sustainable land use, ease of farming, and the timeliness of ecological services and crop practises, CA has shown to be helpful. Worldwide, the use of CA systems is growing, although in some nations, adoption is either minimal or nonexistent. Technologies for conservation agriculture are what will make agriculture sustainable in the future. Conservation agriculture has potential advantages for various agro-ecoregions and farmer groups. From the nano level (improving soil qualities) to the micro level (saving inputs, lowering cost of production, boosting farm revenue), to the macro level (reducing poverty, enhancing food security, and reducing global warming), there are many advantages of CA. In general, CA as a substitute paradigm for sustainable production intensification offers a lot of advantages to the producers, society, and environment that are not attainable with tillage agriculture (**Kassam *et al.,* 2010**). Therefore, Ca is smart in many other areas in 21addition to the environment.

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