Successful Experiences from Global Spread of Conservation Agriculture

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Since 2008/2009, Conservation Agriculture (CA) cropland area has been expanding globally at an annual rate of more than 10 M ha per year. In 2015/2016, the total CA cropland area was 180.4 M ha, corresponding to 12.5% of global cropland area. In 2018/2019, the total cropland area was 205.4 M ha, corresponding to 14.7% of global cropland area. The spread of CA has been expanding in Asia, Africa, and Europe in recent years because farmers are becoming better organized in working together and networking. More attention and resources are being allocated by stakeholders towards supporting farmers to adopt CA and in generating new knowledge to improve their performance.

Keywords: paradigm ; global ; conservation agriculture

1. Introduction

The history of agriculture has essentially been a history of tillage in agriculture, and the culture of ploughing or tilling the soil to establish crops and to manage weeds has been a central part of agricultural development worldwide. After WWI, agriculture began to be intensified to achieve greater output. This was essentially based on the intensification of the use of tillage and of agrochemicals as part of crop nutrition and protection management of higher yielding crops under standardised mechanized systems. Initially, this change process began in North America, but after WWII, it spread to other industrialized countries in Europe and Eurasia as well as in Australia and New Zealand and in the independent countries of the tropics, with emerging economies such as in Latin America and South Asia as part of the Green Revolution drive from the West.

From 1960 to 2000, no-till production was being tested in all continents by researchers and larger-scale mechanized farmers, and limited scaling began in the 1980s and 1990s, mainly in countries such as the US, Canada, Brazil, Argentina, Paraguay, Uruguay, Bolivia, Venezuela, UK, Australia, New Zealand, Spain, Germany, Kazakhstan, Zambia, and South Africa. By 2000, these countries together covered some 65 M ha of no-till cropland systems. Prior to this period, soil and water conservation programmes in the US had led to the development of a range of soil and water management practices such as bunding, terracing, contour ploughing, reduced tillage as well as no-tillage, which were brought under a common term called ‘conservation tillage’. During the period between 1970 and 1997, the no-till pioneers and champions, farmers, extension agronomists, and researchers had generated enough experience and expertise to be able to define the key components of a sustainable no-till system that was termed Conservation Agriculture (CA). This term was first proposed in Spanish at the IV RELACO (Latin-American Network for Conservation Tillage) meeting in Morelia, Michoacán, Mexico, in 1997 by the researchers Rolf Derpsch and Theodor Friedrich [1]. The term was also adopted in 1997 by the Food and Agriculture Organization of the UN (FAO) to describe sustainable production systems. This led FAO in 1998 to define the three interlinked principles of CA as people know them today at its first regional CA workshop in Harare, Zimbabwe as follows [1][2]:

- Continuous minimum or no mechanical soil disturbance: implemented by the practice of no-till seeding or broadcasting of crop seeds and direct placing of planting material into untilled soil; no-till weeding; minimum soil disturbance from any cultural operation, harvest operation, or farm traffic. Sowing seed or planting crops directly into untilled soil and no-till weeding reduces runoff and soil erosion; minimises the loss of soil organic matter through oxidation; reduces disruptive mechanical cutting and smearing of pressure faces; promotes soil microbiological processes; protects and builds soil structure and connected pores; avoids impairing movement of gases and water through the soil; and promotes overall soil health.

- Maintaining a permanent mulch cover on the soil surface: implemented by retaining crop biomass, rootstocks, and stubbles and biomass from cover crops and other sources of biomass from ex-situ sources. Use of crop residues (including stubbles) and cover crops reduces runoff and soil erosion; protects the soil surface; conserves water and

nutrients; supplies organic matter and carbon to the soil system; promotes soil microbiological activity to enhance and maintain soil health including structure and aggregate stability (resulting from glomalin production by mycorrhiza); and contributes to integrated weed, insect pest, and pathogen management and to integrated nutrient and water management.

- Diversification of species in the cropping system: implemented by adopting a cropping system with crops in rotations, and/or sequences and/or associations involving annuals and perennial crops, including a balanced mix of legume and non-legume crops and cover crops. Use of diversified cropping systems contributes to diversity in rooting morphology and root compositions; enhances microbiological activity; enhances crop nutrition and crop protection through the suppression of pathogens, diseases, insect pests, and weeds; and builds up soil organic matter. Crops can include annuals, short-term perennials, trees, shrubs, nitrogen-fixing legumes, and pastures, as appropriate.

The mindset that is driving the global CA community of practice (CA-CoP) defines CA as an ecosystem approach to regenerative sustainable agriculture and land management based on the practical application of the context-specific and locally adapted three interlinked principles described earlier. CA systems are present in all continents, involving rainfed and irrigated systems including annual cropland systems, perennial systems, orchards and plantation systems, agroforestry systems, crop-livestock systems pasture and rangeland systems, organic production systems, and rice-based systems. Conservation tillage, reduced tillage, and minimum tillage are not CA, nor is no-till on its own [1]. A practice such as no-till can only be referred to as being a CA practice if it is part of an actual CA system as per the above definition. This is similarly true for soil mulch practice and crop diversification practice, both of which can only be considered to be CA practices if they are part of a CA system based on the application of the three interlinked principles [1].

2. Global Uptake

The historical chart of CA uptake at the global level is shown in **Figure 1** [3]. The transformation of conventional tillage-based agriculture began in the 1930s after the 'Dust Bowl' that shook the farming communities in the midwestern US, causing the scientific community to rethink what was not going right with farming, particularly with regards to soil conservation. Minimization of soil disturbance with stubble mulching was a major breakthrough in the understanding of how the objective of crop production intensification could be combined with the objective of soil and water conservation at the practical level by farmers [1].

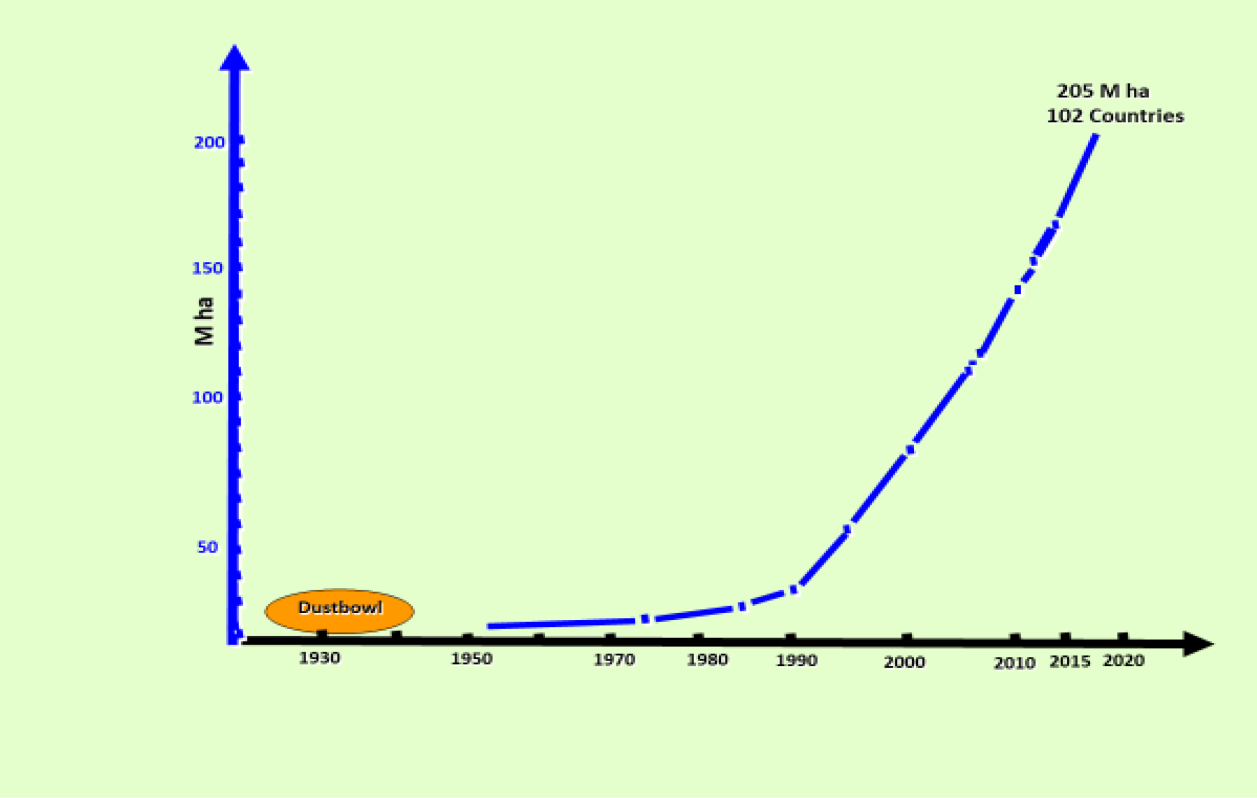

Figure 1. Historical chart of CA uptake at the global level [3].

Initially the intentions were to eliminate the erosion problem of tillage, for which the term conservation tillage became popular, determining the minimal necessary soil cover with crop residues to reduce erosion to acceptable levels. It took a

few more years before the concept of tilling the soil was questioned per se, not only for the erosion problems it created, but also for other types of soil degradation processes it accelerated. In the late 1960s, pioneer farmers showed that no-till seeding through stubbles and crop biomass cover was the way to avoid or eventually reverse soil degradation and erosion [1]. Yet, like the current problems with climate change, the general global public is not aware of the ongoing soil degradation caused by tillage.

The global total CA cropland area in 2018/2019 was approximately 205.4 M ha, corresponding to about 14.7% of the total global cropland. This represents an increase of 98.9 M ha or 92.9% from 106.5 M ha in 2008/2009, with the spread being more or less equally split between the Global South (50.5%) and the Global North (49.5%). The global CA cropland increased by some 48.6 M ha or 31.0% since 2013/2014 from 157 M ha, and some 25 M ha or 13.9% since 2015/2016, and from 180 M ha to 205.4 M ha in 2018/2019. Overall, the increase in the global CA cropland area since 2008/2009 has continued at an annual rate of approximately 10 M ha per year, from 106.5 M ha in 2008/2009 to 205.4 M ha in 2018/2019. Prior to that, the annual rate was about 5 M ha per year during the period from 1990 to 2008/2009. In 1990, the CA area of cropland was 11 M ha and in 2000, the CA area was 67 M ha.

A notable success was the establishment of the global CA Community of Practice (CA-CoP) in 2008 at an international conference held at FAO in July 2008 [4]. This has led to networking amongst CA associations internationally and sharing information on all aspects of CA with stakeholders. The doubling of the global rate of uptake since 2010 is another notable success. This reflects the fact that farmers worldwide are able to overcome local constraints to adoption of CA and move away from tillage-based production.

3. Regional Spread

The information on the spread of CA cropland area by regions in 2008/2009, 2013/2014, 2015/2016, and 2018/2019 is shown in **Table 1** [3]. The change in the CA cropland area in the different continents since 2008/2009 has been: 67.5% (from 49.6 to 83.0 M ha) in South America; 64.8% (from 40.0 to 65.9 M ha) in North America; 91.5% (from 12.2 to 23.3 M ha) in Australia and New Zealand; 6800% (from 0.1 to 6.9 M ha) in Russia and Ukraine; 259.0% (from 1.6 to 5.6 M ha) in Europe; 566.5% (from 2.6 to 17.5 M ha) in Asia; and 547.8% (from 0.5 to 3.1 M ha) in Africa.

A notable success at the regional level has been the fourfold increase in the global share of the spread of CA across Europe (including Russia and Ukraine), Africa. and Asia. In 2008/2009, some 4.77 M ha, or 4.48% of the global CA area, was in Europe (including Russia and Ukraine), Asia, and Africa. By 2018/2019, the area increased to 33.17 M ha or 16.18% of total, on a larger global total CA area. This again reflects the fact that CA is expanding relatively faster in these continents, and increasing numbers of smallholder farmers in more countries are harnessing the benefits of CA. This trend is expected to continue in the coming years.

During the past decade, larger percentage increases occurred in these regions, but CA area continued to expand in the Americas, Australia, and New Zealand as well. In South America, the total CA area is approaching 70% of the total regional cropland area, and in Australia and New Zealand, CA area is approaching 75% of the total cropland area.

In North America, there has been a significant increase in CA area in the US [5] and Mexico [6]. In South America, there has also been a significant expansion of CA area in Brazil, particularly because the government over the past 10 years has facilitated the expansion of CA area, including cropping system diversification with legumes and trees, as part of its Plano ABC programme (the Brazilian Low Carbon Agriculture Plan or Plano de Agricultura de Baixa Emissão de Carbono [7][8]). In addition, countries in Central America have shown increasing interest to extend support to smallholders to adopt CA systems, including CA cropping with trees [6][9].

In Europe and Eurasia, there has been growing support to CA adoption generally. In the European Union (EU) countries, southern European areas in the Mediterranean region have made significant progress. The push for CA has been generally farmer-led, but there has been increasing level of government and EU support [10]. The expansion of CA has also included perennial systems including orchards and vineyards [11]. There has been a significant interest shown in the adoption of CA by most of the ex-Soviet states including Russia and the countries in the Caucuses and Central Asia [12] [13]. Since 2008/2009, the European Conservation Agriculture Federation (ECAF) has expanded its membership, which now includes several eastern European countries.

In Africa, since 200820/09, there has been more than a five-fold increase in CA area and a three-fold increase in the number of countries actively promoting CA [14]. Notable successes have been recorded in South Africa [15], Zambia [16], and Ghana [17]. The establishment of the Adaptability of Agriculture in Africa initiative at COP 22 in Marrakesh, Morocco [18] has added momentum to the CA adoption in Africa, and so has the launching of the African Union-FAO initiative on

Sustainable Agriculture Mechanization for Africa (SAMA) in 2018 [14], which is being operationalized by FAO and the African Conservation Tillage Network (ACT) in partnership with national governments and institutions. Support from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the Norwegian Agency for Development Cooperation (Norad), the Canadian International Development Agency (CIDA), Centre de cooperation internationale en recherche agronomique pour le developpement (CIRAD), the Aga Khan Foundation (AKF), the International Maize and Wheat Improvement Center (CIMMYT), FAO, the International Fund for Agricultural Development (IFAD), the African Development Bank (AfDB), and EU has been important in generating momentum for CA research and extension. The Buffett Foundation has also been supporting the No-Till Training Centre in Ghana and the establishment of the Rwanda Institute for Conservation Agriculture (RICA).

In Asia, there is now a greater attention being accorded to CA in all regions, with several countries making significant progress. In West Asia, Iran has been scaling CA through its nationally coordinated programme [19]. In South Asia, India and Pakistan have made considerable gains [20]. In southeast Asia, nearly all the countries have begun to promote CA [21], and in East Asia, China has continued to provide leadership [22]. The Asia region now has a dedicated CA network—CA Alliance for Asia-Pacific (CAAAP) hosted at the Conservation Tillage Research Centre (CTRC) at the China Agriculture University, Beijing. Research and development support for CA from FAO, GIZ, CIRAD, CIMMYT, and the International Center for Agricultural Research in the Dry Areas (ICARDA) has been effective in generating interest and action in research and extension in the individual countries.

4. CA Adoption at National Level

The decade of the 1990s is considered as the decade when CA took off (**Figure 1**). During the first and the second decades of the new millennium, CA uptake by farmers spread out to Africa and Asia while it continued spreading in the Americas, Europe, and Australia. Smallholders had already been adopting CA systems, both manual and mechanized, in the tropics in South America in the late 1980s and 1990s, and smallholders in Africa and Asia also began to adopt CA systems during 1990s and the first decade in the new millennium.

Table 1. Global spread of CA cropland area ('000 ha) in different regions for 2008/2009, 2014/2015, and 2018/2019, and corresponding percent change [3].

Region	CA Cropland Area 2008/2009	CA Cropland Area 2013/2014	CA Cropland Area 2015/2016	CA Cropland Area 2018/2019	Percent Change in CA Area Since 2015/2016	Percent Change in CA Area Since 2013/2014	Percent Change in CA Area Since 2008/2009	Percent CA Cropland Area in the Region 2018/2019
S and C America	49,564.10	66,377.00	69,895.00	82,996.18	18.7	25.0	67.5	68.7
North America	40,003.80	53,967.00	63,181.00	65,937.22	4.4	22.2	64.8	33.6
Australia and New Zealand	12,162.00	17,857.00	22,665.00	23,293.00	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	10,288.65	13,930.20	17,529.02	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	106,505.23	156,759.06	180,438.64	205,400.04	13.8	31.0	92.9	14.7

The millennium opened with the first World Congress on Conservation Agriculture, which was held in Madrid, Spain. This helped to globalize the concept and principles of CA, and CA was promoted as part of sustainable production intensification by FAO and some donor agencies. Some centres of the CGIAR, particularly CIMMYT and ICARDA, began to conduct research on CA, and a number of national research systems also began to initiate CA research. More regional and national CA organizations and networks were established. Focus of attention also expanded to West Asia, South and South-East Asia, East Asia, and Africa, with countries such as Iran, Syria, India, Pakistan, China, South Africa,

Mozambique, Zambia, Kenya, Ghana, and Morocco making significant progress in the expansion of CA area as well as in CA research to facilitate the effective application of the CA principles in specific contexts.

In July 2008, an international Consultation was organized by FAO in Rome to take stock and discuss the conditions that were necessary to achieve scaling of CA cropland systems. Experiences from all continents were discussed, and a global action plan was formulated to globalize the adoption and uptake of CA. To facilitate the implementation of the plan, a communication platform of Conservation Agriculture Community of Practice (CA-CoP) was established in early January 2009. The platform has enabled global CA stakeholders to be connected and exchange information on all aspects of CA from science and practice to sustainable agriculture development, conservation, and regeneration of natural resources and ecosystem functions.

By 2010, more than 105 M ha (7.0% of global cropland) were under CA cropland systems across 36 countries, covering all continents and most land-based agroecologies. Three more World Congresses of CA had also taken place in Brazil (2003), Kenya (2005), and New Delhi (2009). During the period from 1990 to 2010, global uptake of CA was approximately 9 M ha per year.

During the 2010–2020 decade, the rate of global uptake increased to 10.5 M ha per year, reaching more than 205 M ha (14.7% of global cropland) in 2019 across 100 countries. CA area in Africa, Asia, and Europe expanded more rapidly as more attention and resources were directed to promoting and supporting the uptake of CA cropland systems. During this decade, three more World Congresses of CA were held, in Australia (2011), Canada (2014), and Argentina (2017).

The expansion of CA uptake continues to be largely farmer-driven, and an increasing number of governments are now providing policy and institutional support to the uptake of CA cropland systems in addition to private sector machine and service companies.

In 2008/2009, global CA area was spread over 36 countries. In 2013/2014, the number of countries with CA area had increased to 53 countries, and in 2015/2016, to 77 countries. In 2018/2019, the number of countries with CA area had increased to 102. The corresponding increases in the number of countries from 2008/2009 to 2018/2019 was from 8 to 13 in South and Central America, from 11 to 31 in Europe, from 2 to 26 countries in Asia, and from 9 to 25 in Africa. This shows that much greater interest is being shown for CA systems in recent years by farmers globally in every region. In addition, the extent of support from public sector institutions and governments, although modest, has been increasing steadily. This trend is expected to continue, benefitting an increasing number of smallholder farmers.

Globally, the ten lead CA countries are: the US, Brazil, Argentina, Australia, Canada, China, Russia, India, Paraguay, and Kazakhstan. In South and Central America, the lead five countries are: Brazil, Argentina, Paraguay, Bolivia, and Uruguay; in Europe, Spain, France, Romania, United Kingdom, and Italy; in Africa, South Africa, Zambia, Mozambique, Ghana, and Malawi; and in Asia, China, India, Kazakhstan, Pakistan, and Iran.

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