Conservation Agriculture: Climate Proof and Nature Positive Approach

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Chapter

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Abstract

The development pathways of countries and regions have impacted land-climate interactions and shaped challenges, opportunities and actions. Adverse impacts of climate change increasingly threaten livelihoods and resilience of people around the globe, food security and the stability of environmental resources. Globally, the current food systems are not fit for purpose. Land-based options such as Conservation Agriculture (CA) were found to mitigate climate change, regenerate soils and ensure durable food systems. Achieving sustained results using CA systems, under climate change and social pressures, while maximizing co-benefits related to food and nutrient security, social and biological diversity, ecosystem restoration and services and sustainable development, requires appropriate country-specific policies and significant investment. CA implementation is challenging and context specific and necessitates an integrated framework and road map to enable deeper ambitions for social equity and development and inclusive economic growth.

Keywords: no-till, soil mulch cover, climate change, sustainability, environment, carbon sequestration

1. Introduction

The interaction between land and climate is a complex system thoroughly influencing the agriculture production systems around the globe [1]. Agricultural production systems are the largest single source of environmental degradation, responsible between 21 and 37% of global greenhouse gas (GHG) emissions through deforestation, depletion of soil carbon, release of nitrous oxide and enteric fermentation. Without intervention, these are likely to increase by about 30–40% by 2050, due to increasing demand based on population and income growth and dietary change. Agriculture is also responsible for 70% of freshwater use, 30% of energy use and 80% of land conversion [2]. Conventional agricultural practices revolved around the burning of crop residues to facilitate land preparation for the succeeding crop, regular plowing and tillage of the land for preparing seedbeds and controlling weeds. Reduced natural soil productivity and pest control were corrected with new high yielding breeds, fertilizers and pesticides. These practices initially had a positive effect on production and yield of crops but at the cost of continuous land degradation, erosion by wind or water, underground water pollution, oxidation of the soil organic matter due to tillage and emitting carbon dioxide (CO2) in large amounts [3]. Like in other aspects of the economy a trickle-down of benefits to poor farmers is assumed, but rarely materialized.

By the year 2050, the global population is expected to increase to 9.1 billion which would mean that the existing production systems need to gear up and increase their food production by 70 per cent by the year 2050, assuming food waste and change of consumer preferences continue unchanged. Producing sufficient food with finite resources to feed the growing global population while having a smaller impact on the environment has always been a great challenge. In addition, the 2022 IPCC reports generated enormous attention as a demand for immediate actions across all sectors and regions. There is a need for rethinking the actual food systems and address all the connected challenges and threats and explore the root causes of unsustainability. Consequently, healthy growth and stable productivity of crops and livestock require innovative models of food production for resource-saving, environmentally friendly agriculture. Conservation Agriculture (CA) has proven to overcome the shortcomings of tillage-based agriculture in terms of sustainability as a promising system-based approach [4]. Here, we review the environmental impacts of CA that should lead to a paradigm shift in goals and models of food production for promoting sustainable and regenerative agriculture worldwide.

2. Conservation agriculture: adoption evolution and trends

The need for a transformation of conventional tillage-based agriculture became obvious in the early 1930s after the 'Dust Bowl' trembled the mid-west farming communities of the United States and obliged the scientific community to reorient its research agenda and focus more on erosion mitigation and soil conservation through no-tillage systems (later called Conservation Agriculture or CA systems) [5]. CA is a resource-conserving agricultural concept that is steadily gaining ground and covers an estimated area of 205 million hectares (14.7% of global cropland) (also see **Table 1** for regional distribution). This represents an increase of 93% in global CA cropland area since 2008/09 and represents an annual increase of about 10 Mha.

The major countries practicing CA in 2018/19 are the USA (44.0 Mha), Brazil (43.9 Mha), Argentina (32.9 Mha), Australia (22.9 Mha), Canada (21.7 Mha) and others (39.6 Mha) [5]. In other terms, the total CA area is approaching 70% and 75% of the total cropland area in South America and in Australia, respectively. However, since 2008/09, percentage change in CA adoption has been greater in Asia, Africa and Europe than in the other continents, and corresponds to 33.1 Mha or about16% of the global CA cropland area [5]. CA as climate proof agriculture and its roles for soil sustainability and resilience are widely recognized and should favor increase in its adoption by mainstreaming the concept in agricultural and environmental policies.

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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

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 (source: [5]).

3. CA as climate proof agriculture

Since food production is sensitive to weather conditions, the very existence of mankind is being threatened by an unseen force referred to as climate change. Climate change is expected to adversely affect the climatic/weather phenomena thereby impacting the global food supply system [6, 7]. The evidence is irrefutable that GHG are choking our planet and placing billions of people in danger. An increasing number of people are not able to realize their right to adequate food. In 2020, between 720 and 811 million people in the world faced hunger, up to 161 million more than in 2019 ([8]). In other words, climate change, food security and biodiversity are the "trilemma of land use". Solutions to these challenges should be integrated to combine and tackle multiple goals. Hence, considering the world is at stake, various international organizations such as Food and Agriculture Organization (FAO), World Bank, and many more, have come together to tackle climate change and food insecurity and search for a reasonable, economical, and sustainable solution. In addition, these urgencies should also rely on the need for grassroots led structural change to stay within the ecological boundaries of the planet, several of which have already been exceeded.

Ingenious and meritoriously employed land-based measures [9], including specific measures to protect and enhance soil organic carbon stocks, can directly support the global environmental and sustainability goals under the UNFCCC [1], the UNCCD [10], and the CBD [11]. In lieu, among these measures, CA works as a systemic approach with its key contributions to sustainability, climate change adaptation and mitigation as well as food security [12–15].

From its wide-ranging adaptation and adoption, CA systems are being practiced in rainfed and irrigated systems, annual, perennial and mixed cropping systems, orchards and plantation systems, agroforestry systems, pasture systems, organic and nonorganic systems, and rice-based systems [16, 17].

Abundant literature and multi-stakeholder innovation platforms across various farming systems showed that CA is a climate proofing agriculture [18–20]. In fact, several recent studies have found that fully-implemented CA can improve crop yield stability—a measure of climate resilience—in different soil types, climates and cropping systems. Worldwide, CA has helped bolstering productivity, augmenting resilience to weather shocks, and tumbling negative externalities (i.e. [21] in USA; [22] in Australia; [23, 24] [25] in India; [26, 27] in China; [28–31] in Africa; [32, 33] in West Asia and North Africa, [34] in Europe). As sometimes observed, decrease in crop yield following the adoption of CA largely depends on whether CA has been correctly implemented, with the use of appropriate seeders, seed rates, fertilizer applications and management practices followed to manage weeds and pests. Some yield reductions in initial years were also due to problems of drainage and stagnation of water in cool and humid regions as result of poorly structured soils from a tillage-based farming history.

Experiences in drought conditions have shown that CA yields can be twice as much as conventional agriculture, peaking up to 4-fold higher yields in wheat [19, 35]. Sun et al. [36] found that in arid regions, CA permitted both increased carbon sequestration and crop yields. Based upon a meta-analysis comprising 610 studies, 48 crops and 63 countries, Pittelkow et al. [37] found variable responses from CA compared to conventional tillage systems. The authors concluded that CA are better performing under a range of crop species in arid regions – particularly where water is limiting to crop growth. The authors also reported that yield gaps are due to partial use of CA principles, which obviously will not produce all the CA benefits. When no-till is combined with residue retention and crop rotation, which is the full implementation of the CA principles, no significant yield reduction is noticed: indeed, this combination of techniques significantly increases crop yields in dry climates. A dataset containing 4403 paired (CA vs. CT) yield observations collected between 1980 and 2017 for eight major staple crops in 50 countries presented by Su et al. [38] also confirmed this trend. In addition, selecting high-efficiency crop varieties and optimizing agronomic (nitrogen) management practices to increase water/nitrogen use efficiency is an effective way to increase crop yield with less associated environmental costs under CA. In order to achieve increased yield stability across climate and soil gradients, it is of paramount importance to grow mixtures of crop species or mixtures of genotypes to exploit positive interaction effects and thus reduce the risk of crop failure [39].

A meta–analysis using data from 9686 paired site–year comparisons across South Asia in a variety of cropping systems found that, CA systems provided 5.8% higher mean yield than conventional agricultural practices [40]. In another study by Laik et al. [41], under CA systems, yields of wheat and rice increased by 46–54 and 10–24%, respectively, over conventional tillage, thereby obtaining ~53% higher total output from the CA system. In a review study by Das et al. [24], the CA systems increased yields of crops from 2% to 200% depending on crop rotations and years of implementation.

Through a meta-analysis of 933 observations from 16 different countries in sub-Saharan African studies, Corbeels et al. [42] showed that average yields under CA are only slightly higher than those of conventional tillage systems (3.7% for six major crop species and 4.0% for maize). Larger yield responses for maize result from mulching and crop rotations/intercropping. They also concluded that when CA principles are implemented concomitantly, maize yield increases by 8.4%, which proves the fact, that the lower yield benefits reported in the study resulted from mixing CA systems with systems that only adopted some of the CA principles.

One of the most entrenched benefits of CA systems is their ability to improve soil water storage. The maintenance of crop residues and mulches at the surface of soils under CA systems improves the water balance of the soil-cropping system. CA systems improve the uptake, conservation, and use of available water in the soil by the crops [43, 44]. All this increases the responsiveness of CA systems to changes in climate, meaning crops under these systems have a much better capacity for coping and adapting to drought. Under rainfed ecologies of eastern and south African countries, CA systems reduced the yield variability by 11% over CT [45].

When CA systems are implemented in warmer and drier regions, higher crop yields are often observed due to a lowering of soil temperatures in addition to increases in soil water storage. In irrigated regions, higher water storage and better water management under CA systems can reduce the amount of water required for crop production and help conserve water resources [46–48].

4. Environmental sustainability: soil re-carbonization, conservation, health and security

Soil's multi-functionality and health were generally neglected to address food and climate security challenges [3, 49]. However, after the Paris Agreement was signed, stakeholders committed in a voluntary action plan to implement farming systems and practices that maintain or enhance soil carbon stocks in agricultural soils and to preserve carbon-rich soils [50]. Global technical potential of SOC sequestration is 1.45–3.44 Pg C/year (2.45 Pg C/year) but varies with type of soils, management and ecologies [51].

The push to the CA-based system is due to its environmental and productivity sustainability and especially its ability to (i) reduce soil degradation, erosion and runoff, (ii) mitigate greenhouse gas emissions and (iii) sequester atmospheric CO_2 in the form of soil organic carbon, tackle climate change, (iv) improve biodiversity below and above the soil surface, and (v) enhance production system resilience to abiotic and biotic stresses [52–57]. In fact, CA systems were initially adopted for soil conservation and erosion control benefits, but they are gaining more and more attention as a practice to maintain and/or increase SOC and harness ecosystem services in agroecosystems [58].

CA aims to implement soil-based strategies and long-term soil fertility dynamics that restore soil functions and health [3, 56, 59] and increase carbon storage reversing consequently the food insecurity spiral [30, 60–62]. In other terms, it is beneficial for crop production and soil health and functions and hence to global food security and adaptation of agriculture to climate change [16, 17, 38, 62–65]. Lal et al. [66] concluded that evidence-based strategy based on CA can allow re-carbonization of depleted soils. Studies by Blanco-Canqui and Ruis [67] confirmed that when CA systems are applied in an integrative way, synergic effects of the principles give rise to levels of soil organic matters.

It goes without saying that carbon stored in the soil is the most stable carbon (C) pool, an essential part of ecosystem services and a tool to tackle climate change [68]. In view of its role in soil aggregation and erosion control, in availability of plant nutrients and in ameliorating other forms of soil degradation than erosion, CA systems have proven to reduce soil degradation and rebuild soil quality. However, in areas with low fertility, integrated nutrient management is essential to ensure a build-up of SOC and the success of CA systems (i.e., in Africa). This cycle can be broken by judicious addition of nutrients to the soil/crop system via organic or synthetic fertilizers and/or the incorporation of legumes into cropping rotations [56, 69].

In lieu of climate change, sequestering CO_2 has become inevitable. CA systems in comparison to the conventional practices saw an increase in SOC in top-soil (0–15 cm) by 3.8 Mg ha^{-1}, in the deepest layer (70–100 cm) by 2.5 Mg ha^{-1} and mean C sequestration rates of 0.09 and 0.27 Mg ha^{-1} yr^{-1} [70]. Soil carbon sequestration bids to improve soil fertility and reduce carbon dioxide levels in the atmosphere. Among continents, Africa is the smallest contributor to greenhouse gas emissions but is highly susceptible to climate change, which is mainly responsible for rising temperatures, fluctuating rainfall patterns, increased frequency of disastrous events such as droughts and floods leading to heavy losses in terms of resources. Gonzalez-Sanchez et al. [71] reported that an estimate of the potential annual carbon sequestration in African agricultural soils through CA amounts to 143 Tg of C per year, that is 524 Tg of CO_2 per year. This figure represents about 93 times the current sequestration figures. In addition, this potential is almost 3 times higher than the one found for Europe by Gonzalez-Sanchez et al. [72], which amounts to 189 Tg CO_2 per year.

In the rice-wheat cropping system, an improvement in carbon stocks by 20% and 40% at a depth of 0–15 and 15–30 cm was realized by following the CA principles [73]. A worldwide meta-analysis by Li et al. [64] found that, on average, the number of water stable aggregates in CA systems are 31% greater compared to conventionally tilled systems. Such soil quality improvements are based on greater SOM content which provides greater abundance of habitats to support microbial, micro- and meso-fauna activity. By enhancing soil health and re-carbonizing the soils [3], CA systems establish dynamic ecological conditions in the soil/plant/landscape continuum which offers resilient performance with maximum productivity (water and nutrient use efficiency and water productivity) [4].

Several authors reported that CA systems minimize on-site and off-site effects with regards to soil degradation and that benefits to soil health and ecosystems follow a chain-like process. Under CA systems, erosion is lessened, infiltration is improved, and water losses either through evaporation or runoff are reduced, allowing the crop to have more water in dry periods or years [64]. In other terms, CA also contributes to the environment by mitigating pollution as it reduces off-site transport of residual agrochemicals through runoff and soil sediments. This reduces the surface transport of nitrate and phosphorus from agricultural fields and the eutrophication of water bodies. Also leaching of nutrients under CA is usually reduced, as the water is mainly transported through macro pores (bypass flow) and not washing the soil matrix as long as synthetic or organic fertilizer or slurry is not applied directly before a heavy rainstorm, which can potentially increase leaching of nitrate to groundwater through the macropores [58, 74].

According to Lal [74], in addition to carbon sequestration and erosion control, adoption of CA systems accentuates several other ecosystem services such as biodiversity, elemental cycling, and resilience to natural and anthropogenic perturbations, all of which can affect food security. It was also reported that CA systems do not lead to significant compaction and higher bulk densities than traditional systems based on soil disturbance [64].

In addition, when combined with frontier technologies (precision agriculture, plant breeding and biotechnology, microbial biotechnology, smart fertilizers, biochar additions etc.), CA systems can help to soak up even more carbon in the soil, create soil resilience to achieve food security and mitigate climate change and allow higher and stable yields [54, 75, 76].

5. Economics under CA systems: no regret options

Countries seek to and should improve the well-being of people and especially farmers. The conventional system of agricultural production is hugely dependent on intensive tillage operations with the support of much labor or heavy farm machinery. The latter results in higher CO2 emissions and both in higher production costs [77]. Reducing the tillage operations has the potential of reducing emissions and fuel consumption. CA systems can save up to 80% of fossil fuel energy used by tillage [24].

The farmers, and mainly the resource-poor ones, need production systems that are regenerative, reliable, financially viable and profitable. However, many scientific studies agree that CA systems are cost-effective, energy efficient and allow farmers higher and more stable incomes [24, 34]. The major factor leading to lower costs in CA systems is attributed to bypassing soil manipulation and disturbance unlike conventional tillage systems, where 4–5 primary and secondary tillage operations are performed for seedbed preparation and weed control, which acquire higher costs [78, 79].

Even if CA systems in the beginning might have undesirable effects on crop yield levels, the cost of cultivating crops decreases with fewer use of machinery and compensates for eventual initial yield declines. Subsequently, continuous use of such practices improves soil properties, sustains crop productivity and ultimately economic returns [80]. In fact, according to several authors, there is mounting evidence that when CA is inconsistently applied, it leads to lower yields and higher costs than expected [38, 62, 81–83]. Arenas-Calle et al. [84] showed that the lack of climate-smartness resulted in yield penalties in early stages of CA implementation. However, in eastern and southern Africa the highest financial returns (90–95%) from CA investments by small–holder farmers were realized under low-rainfall conditions (<700 mm), thereby providing clear evidence of the climate smartness of CA systems under soil moisture–stressed conditions [45].

With the reduced expenses in terms of labor, energy and monetary inputs, CA practices reduce the cost of cultivation. Reduced expenditure in such a pattern was observed in winter wheat for no-tillage practices (1300 Yuan ha^{-1}), reduced tillage (2250 Yuan ha^{-1}) as compared to conventional tillage practices (2500 Yuan ha^{-1}) [85]. Especially in the case of small and resource poor farmers, with reduced usage of machinery cost (<65.52%) under CA, farmers spend less (14.46%) on different cultivation practices, increasing their net returns as compared to conventional agriculture practices [86, 87]. In sub-Saharan Africa, scientific studies revealed that with systematic use of practices such as no-tillage, residue retention and crop rotation the costs of cultivating maize or soybean were reduced (20–29%) and the net returns, the benefit-cost ratio increased to a greater extent [88–98]. A similar impact of less soil disturbing practices such as permanent beds and zero tillage was obtained on net returns or profitability of maize-chickpea rotation in India (28.8% and 24% respectively) [99–103].

In a regional study in Ethiopia, CA was found to have reduced the labor usage by 32–41% whereas 50–60% labor was replaced at the critical periods of crop production due to reduced tillage operations in the maize-soybean intercropping system. Further, a maximum return of 15,545 ETH birr ha^{-1} and 12,693 ETH birr ha^{-1} was obtained when soybean and haricot were intercropped in maize [104]. The net returns in production of the rice CA systems were 581 USD ha^{-1} in comparison to 412 USD ha^{-1} under the conventional system. The gross returns in the rice-wheat system were highest (2456 USD ha^{-1}) under the CA system [79].

Choudhary et al. [90] found 22.3 and 24.5% higher grain yield of pearl millet [*Cenchrus americanus* (L.) Morrine] and Indian mustard [*Brassica juncea* (L.) Czernj.] under CA systems, respectively, compared to conventional systems, which ultimately led to higher net returns (US$ 1270 ha^{-1}).

From a meta-analysis carried out by Ogle et al. [98], it was concluded that CA systems drastically reduce the number of field operating hours and associated fuel use by about 69%. From these studies, it is clear that broadening access to finance, including international and climate finance will catalyze adoption and accelerate the shift towards CA systems.

6. Conclusion

Research and development efforts in agriculture have been increasingly oriented towards improving modern, industrial or corporate agriculture—new chemicals, hybrid and genetically modified seeds, mechanization, factory farming, etc. Hence, the agriculture sector is replete with innovations but not all of them were found sustainable.

The CA systems backed by various institutions, research scholars, policymakers were found able to adapt to the fast-changing environment thus making the food system healthy, flexible, productive and profitable. Further, CA helps to extenuate the greenhouse gas emissions and increase the carbon stocks making soils resilient, reliable and sustainable. In other words, the main benefits of CA systems cover numerous areas and contribute to a number of SDGs. In addition, CA feasibility or adoption was assessed in contrasted biophysical, social and economic environments.

CA systems are alternative pathways for agriculture to be more conducive to durable food systems and longer-term sustainability. Especially soil carbon sequestration and health improvement allowed by CA systems can support various ecosystem services related to climate change adaptation, food security and biodiversity due to enhanced soil fertility and nutrient pools, increased moisture retention, improved water availability to plants and reduced soil erosion and runoff [58]. The number of countries explicitly including SOC in agricultural land (including wetlands) in the Nationally Determined Contributions (NDCs) increased from 28 (15% of first-round NDCs assessed) to 35 (24% of latest NDCs assessed) [101] which is still insufficient. An international agenda for restoring soil health and inclusion of soil carbon sequestration in policies and actions should be advocated and supported [88, 102]. Policies promoting the target of land degradation neutrality can support food security, human wellbeing and climate change adaptation and mitigation [2].

Barriers to the adoption of CA system are more related to farmers' attributes (adopter's characteristics, limited availability of resources, level of perception, mind-set, cultural values, illiteracy, willingness for change, etc.) and their enabling environment (e.g., legal compliance, governance, lack of training and capacity building, stakeholder communication, lack of financial support, insufficient economic and social incentives) than to technical concerns (i.e. herbicide and machinery availability and costs, energy use and price, competitive uses of crop residues and livestock etc.). The science related to CA systems is currently advanced enough to inform the formulation of policy and incentive programs for CA adoption at a scale large enough to result in the radical transformation of mainstream agricultural production systems CA [5, 103].

Dis-adoption, accumulating challenges and difficulties of mainstreaming CA by additional farmers arise from two main issues: (i) CA is dynamic, meaning that it should respond to simultaneous changes in environment, social and/or economic contexts, (ii) CA is also a holistic concept based on a system-wide approach to solving farm management shifts and problems while considering the integrality of the food system. In addition, agriculture functions are changing over time and getting more complex with increasing socio-economic and environmental stresses and social and institutional shocks [33]. Approaches for upscaling CA range from sophisticated decision support systems to improved enabling environments (i.e., through land policies and subsidies focused on water, environment, and poverty) and promotion of social or sustainability-oriented learning processes [16].

The new Green Revolution (GR) of the twenty-first century must be: (i) soil-centric, based on soil health and resilience, (ii) ecosystem-centric, based on eco-efficiency of inputs, (iii) knowledge or innovation-centric, based on scientific principles, and (iv) nature-centric, based on nature positive solutions which restore and enhance nature [95]. The new GR should also recognize the "One Health" concept, which states that the "health of soil, plants, animals, people, ecosystems, and the planetary processes is one and indivisible [94].

The 8th World Congress on Conservation Agriculture (WCCA), which inspired from these paradigms of the new GR, set a goal to increase the global CA cropland area to 50% of the total cropland by 2050, in particular to respond to the global challenge to mitigate the advancing climate change and land degradation and reduce gaps in food security and nutrition (as well as other sustainable development goals). This represents an area of 700 M ha [92, 103]. In achieving such goals, policy and economic incentives should be enforced and augmented in most countries. In addition, the integration of CA benefits in the farming system (e.g., value chain design, marketing, labeling), can lead to giving carbon both economic and environmental values and thus increasing farmer income and stewardship. Social norms as well as psychological and behavioral factors must be considered for widespread adoption of CA systems. Accordingly, a multi-stakeholder engagement and joint coordination (i.e., science-policy dialog and engaged civil society) are major issues in the development and implementation of a CA Road Map for wide mainstreaming and large-scale adoption by farmers in markedly diverse ecologies. Implementing CA Road maps enable governments, landowners and land managers, and the community to share responsibility for land-based challenges mitigation and hence in achieving or reaching SDGs. According to Lal [93], sustainable intensification of agroecosystems (which includes CSA systems) can produce enough food grains to feed one person for a year on 0.045 ha of arable land. Hence, another issue of prime importance concerns socializing CA for the small land size farmers while integrating livestock and trees mainly in Africa and Asia. There is great momentum in merging principles of CA with those regenerative types of farming and especially those related to tillage, synthetic fertilizers and pesticide use [97]. However, issues related to GMOs are still largely debated within the agroecological stream. Kassam and Kassam [4] proposed an inclusive ethical and responsible system to integrate CA systems with plant-based diets and organic farming practices in order to move from corporate agriculture.

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