Conservation Agriculture for Sustainable Intensification

Theodor Friedrich[1], Amir Kassam[2]

[1] Plant Production and Protection Division, FAO, Rome, IT, Theodor.Friedrich@fao.org
[2]School of Agriculture, Policy and Development, University of Reading, UK, kassamamir@aol.com

Global Issues

Agricultural production will have to increase by some 70% by 2050 (compared to production levels of the 1990s-2000) to satisfy global demand for food, feed, fibre, raw materials and bioenergy. Up to now growth of global agricultural production has not been adequate to match the growth on the demand side on an equitable basis. This is particularly true for parts of Africa and South Asia. **Production Intensification** is therefore mandatory because expansion of agricultural area as a response is not sufficient.

The **natural resource base** for agricultural production, namely water and soil resources are increasingly in short supply on a per capita basis and degraded. Agriculture already takes 70% of the available freshwater resources. By 2015 the growing demand for water will exceed the available resources in some regions. Most agricultural soils are in a degraded state which means that they do not anymore reach their full productive capacity or fulfil the expected ecosystem services. Practices such as clearing native vegetation in fragile ecosystems and replacing it with arable crops, cropping without replacement of soil nutrients, intensive tillage leading to erosion and depletion of soil organic matter, and destroying the vegetation cover by overgrazing have led to this widespread soil degradation and eventually to desertification processes endangering livelihoods of rural populations. As a consequence of tillage-based agricultural land uses, biodiversity at all trophic levels is being increasingly reduced, leading to a deceased functionality and capacity of ecosystems to adapt to changing environmental conditions including climate change. A more **sustainable** approach to agricultural **production** and agro-ecosystem management are mandatory to reverse these degradation processes [FAO 2011].

Labour shortage is increasingly affecting agricultural production, particularly in those regions where mechanization of agriculture is stagnating and where migration and diseases such as HIV/AIDS pandemic are reducing the available agricultural workforce. This, in some world regions, particularly in sub-Saharan Africa, is becoming a serious obstacle to expand, or even maintain, agricultural production levels. **Labour saving** technologies in such situations can reduce labour requirements significantly and raise labour productivity.

Climate change is an additional threat to rural communities and their livelihoods. Particularly the increasing climate variability and frequency of extreme climatic events make agriculture an ever more risky business. Unexpected drought spells vary with floods, often leading to complete destruction of crops and livelihoods. More **resilient cropping** and soil management systems are required to reduce the climate-related risks to rural populations.

Socioeconomic terms of production: small subsistence farmers are trapped in poverty, since under their traditional farming practices they spend a lot of their family time and labour on producing crops for survival, not having sufficient time left for value adding processing. Reducing manual labour requirement and drudgery in the crop production sector and increasing labour productivity leaves capacities for **income generating activities** . Adopting production practices that can increase productivity of purchased inputs of seeds, agrochemicals and fuel will help reduce production costs and improve profit margins.

What is Conservation Agriculture?

Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely: (1) continuous minimum mechanical soil disturbance; (2) permanent organic soil cover; and (3) diversification of crop species grown in sequences and/or associations. CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface. Soil interventions such as mechanical tillage are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes.

CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rainfed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes [FAO 2010].

CA can contribute to sustainable agriculture and rural development (SARD) by improving input use efficiency, increasing farm income, sustaining or increasing agricultural land, and protecting the natural resource base [FAO 2007].

How Can Conservation Agriculture Address the Global Issues?

Agricultural production: CA aims at improving the growth conditions for crops. It holds tremendous potential for a sustainable increase of yields and agricultural output and is by no means “low intensity, low output” agriculture. However, the increased yields are achieved with less purchased inputs due to higher input efficiency.

Natural resource base: CA reverses soil degradation processes and builds up soil fertility and productive capacity. It facilitates a better infiltration of rainwater, enabling the recharge of groundwater resources while at the same time reducing the pollution of water bodies through reduced erosion and leaching. It also increases biodiversity in the agricultural production systems. CA conserves and enhances natural resources while maintaining and sustainably increasing production levels.

Labour shortage: CA eliminates the power-intensive soil tillage work, thus reducing the drudgery and labour for crop production by more than 50%. Also for mechanized farms it likewise reduces the fuel requirements by about 70% and the need for machinery by about 50%. With this the requirements for investing in agricultural mechanization are much lower, facilitating this investment. For small-scale subsistence farmers, not disposing of major physical strength because they suffer from HIV/AIDS or other disease, or because they are children or elderly persons having to take care of households, CA can facilitate the continuation of the farming and maintenance of livelihoods.

Climate change: CA reduces the vulnerability of crops against unexpected extreme climatic events. It reduces crop water requirements by 30%, making better use of soil water and facilitating deeper rooting of crops, so that drought periods can be tolerated better. At the same time it facilitates greatly the infiltration of excess rain water, reducing the danger of soil erosion and downstream flooding. The yield variability under CA is reduced regardless of whether the years are dry, wet or normal.

Terms of production: The labour and time saving under CA enables farm families to invest their time in more rewarding activities than tilling the soil to produce a crop. Where CA has been adopted, it can be noticed that farmers often start processing of raw produce or other value adding activities, enhancing their farm income often more than the crop production would do. Improved livelihoods and options for rural income generation after the widespread adoption of CA have in some cases (i.e. southern Brazil) even reversed the migration to urban centres.

Conservation Agriculture and Ecosystem's Services

Agriculture, particularly intensive agriculture, is often considered to be a damaging factor to ecosystems in view of the negative impact it has on rural landscape, soil resources, water quality and biodiversity. The impact of agriculture on ecosystems through erosion, pollution of water bodies and dust and smoke emissions is also felt outside the actual agricultural area. However, CA together with other "good agricultural practices" can significantly contribute to a reduction of this impact.

Land: As described above, CA practically eliminates problems related to soil erosion.

Water: With this it does not only contribute to a reduced displacement of soil, but it also reduces the pollution of water bodies.

Air: Burning of crop residues is generally not practised under CA and also tillage and seedbed preparation, that creates considerable dust problems in some parts of the world, are not practised. With this the air becomes cleaner.

Landscape: The avoidance of ploughing in CA facilitates the introduction of trees and hedgerows into the agricultural landscape in a closer vicinity of field crops than under tillage-based agriculture. The greater diversity in the crop rotations also contributes to a more diverse and pest-free landscape.

Climate Change: CA can contribute to reduced green house gas emissions from agricultural crop production through reduced fuel use, better aeration of soils that reduces nitrous oxide emissions and, in no-till non-flooded rice (CA-SRI), methane emissions. In addition it binds atmospheric carbon in the soil in the form of soil organic matter. With this, CA helps to mitigate climate change.

History, Development and Relevance of CA

Tillage, particularly in fragile ecosystems, was questioned for the first time in the 1930s, when the dustbowls devastated wide areas of the mid-west United States. Concepts for reducing tillage and keeping soil covered were introduced and the term conservation tillage was introduced to reflect such practices aimed at soil protection. Seeding machinery developments allowed then, in the 1940s, to seed directly without any soil tillage. At the same time theoretical concepts resembling today's CA concept were developed by Edward Faulkner who published a book called Ploughman's Folly [Faulkner, 1945] and Masanobu Fukuoka who published a book called One Straw Revolution [Fukuoka, 1975]. But it was not until the 1960s for no-tillage to enter into farming practice in the USA. In the early 1970s no-till reached Brazil, where farmers together with extension scientists transformed the technology into the production system which today is called CA. Yet it took another 20 years before CA reached significant adoption levels. During this time farm equipment and agronomic practices in no-till systems were improved and developed to optimize the performance of crops, machinery and field operations. From the early 1990s CA started growing exponentially, leading to a revolution in the agriculture of southern Brazil, Argentina and Paraguay. During the 1990s this development increasingly attracted attention from other parts of the world, including development and international research organizations such as FAO, CIRAD and CGIAR. Study tours to Brazil for farmers and policy makers, regional workshops, development and research projects were organized in different parts of the world leading to increased levels of awareness and adoption in a number of African countries such as Zambia, Zimbabwe, Tanzania and Kenya as well as in Asia, particularly in Kazakhstan and China. The improvement of conservation and no-tillage practices within an integrated farming concept such as that of CA led also to increased adoption including in industrialised countries after the end of the millennium, particularly in Canada, Australia, Spain and Finland.

CA crop production systems are experiencing increased interest in most countries around the world. There are only few countries where CA is not practised by at least some farmers and where there are no local research results about CA available. The total area under CA in 2010 is estimated to be 117 million hectares [Kassam et al., 2010]. CA is now practised by farmers from the Arctic circle (e.g. Finland) to the tropics (e.g. Kenya, Tanzania), to about 50º latitude South (e.g. Malvinas/Falkland Islands); from sea level in several countries of the world to 3,000 m altitude (e.g. Bolivia, Colombia), from extremely dry conditions with 250 mm a year (e.g. Morocco, Western Australia), to heavy rainfall areas with 2,000 mm a year (e.g. Brazil) or 3,000 mm a year (e.g. Chile). No-tillage is practised on all farm sizes from less than half a hectare (e.g. China, Zambia) to thousands of hectares (e.g. Argentina, Brazil, Kazakhstan). It is practised on soils that vary from 90% sand (e.g. Australia) to 80% clay (e.g. Brazil's Oxisols and Alfisols). Soils with high clay content in Brazil are extremely sticky but this has not been a hindrance to no-till adoption when appropriate equipment is available. Soils which are readily prone to crusting and surface sealing under tillage farming do not present this problem under CA because the mulch cover avoids the formation of crusts. CA has even allowed expansion of agriculture to marginal soils in terms of rainfall or fertility (e.g. Australia, Argentina). All crops can be grown adequately in CA and to the authors' knowledge there has not yet been a crop that would not grow and produce under this system, including root and tuber crops [Derpsch & Friedrich, 2009].

Global Commitments and CA

Conservation Agriculture and the Millennium Development Goals (MDGs): Through better productivity, higher profitability and reduced drudgery, CA systems contribute to improved food security and livelihoods (MDG 1: reduced hunger and poverty); enhanced quality of life for women (MDG 3: gender equity and women's empowerment); and sustainable resource management and environmental services (MDG 7: environmental protection) supporting in this way the goals of the CSD [UN 2010].

Global conventions: By reducing tillage and improving soil cover, moisture conservation, soil biodiversity and carbon sequestration, CA is an important tool for satisfying the demand for food through sustainable land management while implementing the goals of the United Nations Convention to Combat Desertification [UNCCD 2011], Convention on Biological Diversity [CBD 2011] and Framework Convention on Climate Change [UNFCCC 2011].

References

CBD 2011. Convention on Biological Diversity http://www.cbd.int/convention/

Derpsch R., Friedrich T 2009. Global Overview of Conservation Agriculture Adoption. In: ICAR (eds.): Proceedings of the IV World Congress on Conservation Agriculture, New Delhi, India, February 2009

FAO 2010: What is Conservation Agriculture; FAO CA-website http://www.fao.org/ag/ca/1a.html

FAO 2007. FAO-SARD Initiative, www.fao.org/sard/initiative

FAO 2011. Save and Grow; a policymaker's guide to the sustainable intensification of smallholder crop production; FAO, Rome, 102 pp

Faulkner E H 1945. Ploughman's Folly. Michael Joseph, London. 142 pp

Fukuoka M 1975. One Straw Revolution, Rodale Press, English translation of shizen noho wara ippeon no kakumei, Hakujusha Co., Tokyo. 138 pp

Kassam A H, Friedrich T, Derpsch R 2010. Conservation Agriculture in the 21st Century: A Paradigm of Sustainable Agriculture. European Congress on Conservation Agriculture, 4-6 October 2010, Madrid, Spain

UN 2010. United Nations Millenium Development Goals http://www.un.org/millenniumgoals/

UNCCD 2011. United Nations Convention to Combat Desertification http://www.unccd.int/

UNFCCC 2011. UN Framework Convention on Climate Change http://unfccc.int/2860.php