Global Overview of Conservation Agriculture: Principles, worldwide spread and main benefits

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Outline

Why is Conservation Agriculture (CA) needed? – what is not right with conventional tillage agriculture?

CA principles and systems – Development of No-till farming and modern concept of CA

Global adoption and spread

Main benefits – farm and landscape level
Modern conventional tillage agriculture – high mechanical disturbance, bare soil, poor diversification, high agro-chemical, energy & capital, high cost .......

But underneath?

Rothamsted Research

Partners:
Conventional land preparation
regular tillage, clean seedbed, exposed

Effects:
• Loss of organic matter
• Loss of pores, structure → soil compaction
• Destruction of biological life & processes
Sealed soil under tillage and open soil under not-till

Soil crusts – no mulch
low SOM

Residue retention distinguishes CA from conventional farming systems
CLODS OF TOPSOIL FROM ADJACENT PLOTS

Tillage destroys soil structure and makes it dysfunctional

Turning healthy soil into bricks with tillage - Tajikistan April 2015
Puddling and waterlogging in tilled soils

Water infiltration, just after a thunderstorm

DIREKTSAAAT
semis direct
zero tillage

PFLUG
labour
plow
Tillage agriculture -- root cause of erosion
Erosion & water pollution from tillage agriculture

A village reservoir, Germany

Iguassu Falls, Brazil
This is millions of tonnes of topsoil going over the edge
UK -- Tillage agriculture removing top soil, polluting water system and the seas

River Lodden, lower Earley, Reading, February 2013

Google16-2-2014
Sediment Plumes
The Guardian
The Future of Farming and Food in the UK
Donald Curry policy commission report 2002, UK Cabinet
(Concern at the national political level in the UK)

• “Farming and food industry is on an unsustainable course in economic terms. We believe it is also unsustainable environmentally ..... in the last 50 years...soil organic content has declined...

• Agriculture is now the number one polluter of water in the country. Land use changes have contributed to increased danger of extreme flood events, affecting thousands of homes.

• Beyond any doubt the main cause of this decay has been the rise of modern, often more intensive, farming techniques. ...things are still getting worse...in soil compaction and erosion, in the loss of certain species. A lot of the environmental damage in the countryside over the last 50 years has to be laid at the door of modern farming techniques. .... Much damage by farmers is not willful but arises out of ignorance.

• We believe a major advice effort will be needed... to help farming meet its new challenges. It will be very important that advice should also cover environmental issues.”
Degradation of soil, water and biodiversity resources

- World map of severity of land degradation – GLASOD (FAO 2000)
- Millennium Ecosystem Assessment 2005 – 89% our ecosystems degraded or severely degraded, only 11% in reasonable shape.
- 400-500 M ha agricultural land lost since WWII, and continuing
Stagnating Yields (yield gap)

Rising-plateau regression analysis of wheat yields throughout various European countries

But inputs and input costs going up, diminishing returns setting in,

(Brisson et al. 2010)
Consequences of tillage-based agriculture at any level of development
(Economically, environmentally & Socially Unsustainable)

FOR AGRICULTURE, FARMER AND SOCIETY

Higher production costs, lower farm productivity and profit, sub-optimal yield ceilings, poor efficiency and resilience, not climate-smart, operating a degrading cycle ........

FOR LANDSCAPES, ECOSYSTEMS AND SOCIETY

Dysfunctional ecosystems, loss of biodiversity, degraded ecosystem services -- water, carbon, nutrient cycles, sub-optimal water provisioning & regulatory water services etc, high environmental costs to society ............

FOR AGRICULTURE & FOOD SYSTEMS AND CONSUMERS

Unsustainable economically and environmentally, sub-optimal and degrading agricultural systems, nutritionally of lower quality, high indirect costs to consumers, not aligned to healthy food systems, human and environmental health ........
Switching to sustainable solutions

The need for a paradigm shift to Conservation Agriculture
The dust bowl
Development of no-till farming & modern concept of Conservation Agriculture

1930-1936
• Dust bowl period in the USA and Canadian prairies

1935-1945
• Soil and water conservation programme based on physical structures such as bunding and contour ploughing
• Realization that soil disturbance through tillage and leaving the soil bare was the real cause of erosion
• Initial research into conservation or reduced tillage involved early version of chisel ploughs which also allowed the surface retention of plant residues to reduce water and wind erosion
• Stubble mulching was then added to the portfolio of soil and water conservation practices, and this became the forerunner of no-till farming.
• The above collection of practices led to what became known as Conservation Tillage defined as any tillage practice that leaves 30% of the soil covered with plant residue (corresponded to some 75-80% decrease in erosion)
• 1943 – Ploughman’s Folly, a book by Edward Faulkner, and extension agronomist in Ohio, was a real milestone in the development of agriculture conservational practices. He questioned the wisdom of inversion ploughing and explained the destructive nature of soil tillage. He said “there was nothing wrong with our soils except our interference.”
Development of no-till farming & modern concept of Conservation Agriculture

1945-1960s-1980s
• Research in the USA & UK in the late 1940s and 1950s and in Africa & elsewhere in 1960s made no-till farming possible (essentially no-till with soil mulch cover plus whatever cropping system was in place).
• No-till began to spread in the USA in 1960s, in Brazil in 1970s, in Argentina, Paraguay and Uruguay in 1980s and also in Canada and Australia, and in Africa in South Africa, Zimbabwe, Zambia and Kenya with large-scale farmers.

1990-Present
• No-till farming took off globally in 1990s, including spreading into Europe, Asia and Africa
• The term Conservation Agriculture first used at an FAO meeting in 1997 Ibadan Nigeria, but Conservation Tillage still had a strong hold.
• The word tillage was dropped from the term Conservation Tillage at a meeting in Mexico (Latin American Network for Conservation Tillage) in 1997 at the insistence of two people, Rolf Derpsch, a German working in Brazil and Theodor Friedrich, a German working for FAO. They argued that there was nothing conservational about tillage. It was at this meeting that the term Conservation Agriculture was first put on record. From there onwards, Theodor Friedrich and Jose Benites from FAO decided that the term Conservation Agriculture be used by FAO in the future to describe sustainable agriculture systems.
• In 1998, FAO organized its first regional meeting on Conservation Agriculture in Harare where a code of practice was drafted describing the three interlinked principles of Conservation Agriculture and their practical application as we know them today.
• In 1999, the European Conservation Agriculture Federation and FAO organized the first World Congress on Conservation Agriculture in Madrid, Spain. The eight World Congress is being organized now and will be held in Bern, Switzerland from 29 June to 2 July 2020.
What is Conservation Agriculture?
Application of 3 Inter-linked Principles of ecological sustainability – FAO definition

• Continuous no or minimum mechanical soil disturbance by – seeding or planting directly into untilled soil & no-till weeding ......

• Permanent organic mulch cover on the soil surface – using crop biomass and cover crops to protect & feed soil life ..... 

• Diversification of species -- with annuals and/or perennials including legumes - in associations, sequences and rotations ..... 

Key element: Conservation Agriculture is a combination of resource conserving practices simultaneously creating synergies between them for optimization & sustainability.

Along with other complementary Good Agricultural Practices -- integrated crop, soil, nutrients, water, pest, energy management
Core Principles of CA: Achievable if we respect all 3 key interlinked principles which provide an ecological foundation to production systems

Conservation Agriculture

- No/min soil disturbance
- No-till seeding/weeding
- Soil mulch cover
- Biomass/cover crops
- Crop species diversity
- Rotations/associations

Applied with other context specific complementary crop, nutrient, water, pest, labour and energy management practices
CA works because ..... 

...It is regenerative, self-repairing & self-protecting production and livelihood system, and pays attention to maintaining:

- Ecological foundation of production systems
- Soil health and biology
- Healthy plant root system relationships
- Enhanced biodiversity above and below the ground
- Ecosystem societal services

- Aims at: Maximum efficiency & resilience (& profitability)
  & Maximum output with minimum input (optimization)
CA does not solve **ALL** problems (NO panacea) but complemented with other good practices, CA system allows for high production intensity and sustainable agriculture in all land-based production systems (rainfed & irrigated, annual, perennial, plantation, orchards, agroforestry, mixed systems, rice systems, organic systems ....... all crops ....).

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**CA principles operate as ecological foundation to CA Systems along with complementary GAPS**

- Sustainable agriculture
  - Pollinator/Biodiversity management
  - Good seed
    - Genetic potential
    - Genetic resources mgmt
- No/Minimum soil disturbance
- Soil Cover
- Crop Diversity
- Integrated Water management
- Compaction management, CTF
- Integrated Pest Management
- Permanent Bed and Furrow Systems
- System of Rice Intensification
- Integrated Weed Management
- Good seed
  - Genetic potential
  - Genetic resources mgmt
- Sustainable mechanization
  - Integrated Pest Management
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Soil productive capacity is derived from several components which interact dynamically in space and time:

- **Physical**: architecture - pore structure, space & aeration
- **Hydrological**: moisture storage - infiltration
- **Chemical**: nutrients, CEC, dynamics
- **Biological**: soil life & non living fractions
- **Thermal**: rates of biochemical processes
- **Gravity**: retention & flows of liquids
- **Cropping system**: rotation/association/sequences

A productive soil is a living system & its health & productivity depends on managing it as a ‘complex’ biological system, not as a geological entity.
Multifunctional objectives of CA

- Agricultural **land productivity**
- Natural capital and flow of **ecosystems services** *Simultaneously*
- Enhanced input-use **efficiency**
- Build farming system **resilience** (biotic and abiotic), also being climate-smart
- Contribute to multiple-outcome objectives at farm, community & landscape, and national scales
  e.g. climate change mitigation *And*
- Capable of rehabilitating land productivity and ecosystem services in degraded and abandoned lands

These objectives can be and are being met with No-Till Conservation Agriculture globally
What does CA do

Integrated CA systems

Spiral of Regeneration & Enhancement

Soil structure & biota

Nutrient & water cycling

Crop Diversity

Plant Insect pests & diseases

Integrated CA systems

Nutrient & water cycling

No-Till plus OM Management (soil biodiversity)

Weed management

Anderson, R.L. 2005
Worldwide History and Adoption of CA (2015/16). Since 2008/09 increasing at 10.5 M ha annually, 50% in the North, 50% in the South

<table>
<thead>
<tr>
<th>Region</th>
<th>Adoption in 2015/16 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South America</td>
<td>69.9 (41.0%)</td>
</tr>
<tr>
<td>North America</td>
<td>63.2 (57.9%)</td>
</tr>
<tr>
<td>Australia &amp; NZ</td>
<td>22.7 (86.1%)</td>
</tr>
<tr>
<td>Asia</td>
<td>13.9 (430%)</td>
</tr>
<tr>
<td>Russia &amp; Ukraine</td>
<td>5.7 (5000%)</td>
</tr>
<tr>
<td>Europe</td>
<td>3.6 (127%)</td>
</tr>
<tr>
<td>Africa</td>
<td>1.5 (211%)</td>
</tr>
<tr>
<td>Global total</td>
<td>180.4 (69.4%)</td>
</tr>
</tbody>
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- **US Soil Conservation Service conservation tillage**
- **First no-till in the US**
- **Dustbowl Siberia/USSR**
- **First no-till farmers in USA**
- **First no-till demonstration in Brazil**
- **Oldrieve/Zimbabwe**
- **IITA no-till research**
- **First no-till in the US**
- **Falkiner (US) – Fukuoka (Japan)**
- **Experiments in China, Indogangetic Plains**
- **Adoption Brazil plantio direto na palha**
- **New boost: Canada, Australia, Kazakhstan, China, India, Pakistan, Russia, Ukraine, Europe...; Africa**
- **First WCCA in Madrid**

- **Mill. ha**
  - 180 M ha
  - 150
  - 100
  - 50

- **1930**
- **1950**
- **1970**
- **1980**
- **1990**
- **2000**
- **2010**
- **2015**
Drivers for adoption & spread of CA

- **Erosion**: North America, Brazil, China
- **Drought**: China, Australia, Kazakhstan, Zambia
- **Cost of production**: global
- **Land degradation**: global
- **Ecosystem services**: global
- **Climate change A&M**: global
- **Sustainable intensification**: global
- **Pro-poor**: developing regions

Spread is farmer-led but needs policy & institutional support, specially for smallholders, for **mainstreaming** CA
Patterns of deliverable benefits with CA – small or big farms

**AGRICULTURE, FARMER & SOCIETY**

- Increased & stable yields, higher productivity & profit (depending on level and degradation)
- Less agrochemicals: less fertilizer (up to 50%+) & pesticides (up to 20-50%+)
- Less machinery, energy & labour cost (50-70%+)
- Less water needs (30-40%+)

**LAND, ENVIRONMENT & SOCIETY**

- Can feed more people & animals (carrying capacity)
- Lower impact of climate change – adaptation & resilience to drought, floods, heat, cold
- Climate change mitigation – carbon sequestration & lower GHG emissions
- Environmental services and lower environmental cost (water, infrastructure)
- Rehabilitation of degraded lands & ecosystem services
Sustainable Land Preparation - smallholders

Planting holes, ripping or mulching, direct drill
CA is applicable to all crops & cropping systems:

- soya
- wheat
- rice
- vegetable
- potato
- corn
- perennials
- agroforestry
Example 1-- Canada: Carbon offset scheme in Alberta

Sequestering soil Carbon with CA and trading offsets with regulated companies to offset their emissions by purchasing verified tonnes (from ag and non-ag sectors) Source: Tom Goddard et al.
Water resources are threatened by conventional tillage agricultural practices. Conservation Agriculture is an alternative to reduce impacts on river’s quality and to maintain a higher level of productivity and sustainability.

Cultivating Good Water Programme

Itaipu reservoir dam today (source: Itaipu Binacional)
Conservation Agriculture

Smaller scale -- Paraguay, Tanzania, Zimbabwe, Zambia, Mozambique, Italy, India, Bangladesh, Iran ........

Larger scale – Canada, USA, Brazil, Argentina, Australia, Kazakhstan, china, UK, Spain, South Africa, ........

Many books & papers

Documented benefits of CA paradigm for food security, livelihoods, environment, sustainability, climate change, rehabilitation, pro-poor development ...........

Two volumes of Advances in CA by Burleigh Dodds Science Publishing soon to be released - Francs Dodds (Editorial Director) & Katherine Lister (Marketing Executive) at the booth set up in the Seminar Barn with promotional material.
Broad conclusions

• CA now represents a global agricultural revolution at the paradigm level transforming mind-sets about farming.

• CA is now seen globally as a basis for truly sustainable crop agriculture for plant-based products.

• Originally a farmer’s driven process, but attention increasingly paid by donors, national and international development organizations, and increasingly by governments – becoming a structural response.

• But this is not enough – we need to support the farmers to continue to lead with their biological and ecological innovations based on what they already know about Conservation Agriculture and its regenerative ecological capability at the farm, landscape and regional levels.
Thank you!

CA - Future of farming and farming for the future

Tony Reynolds farm, UK, June 2011

SOC% vs. Clay Content

- 2.1%, 2003
- 4.59%, 2007
- 6.26%, 2013

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