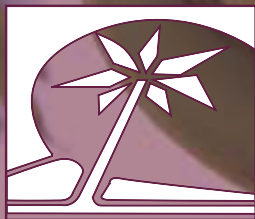
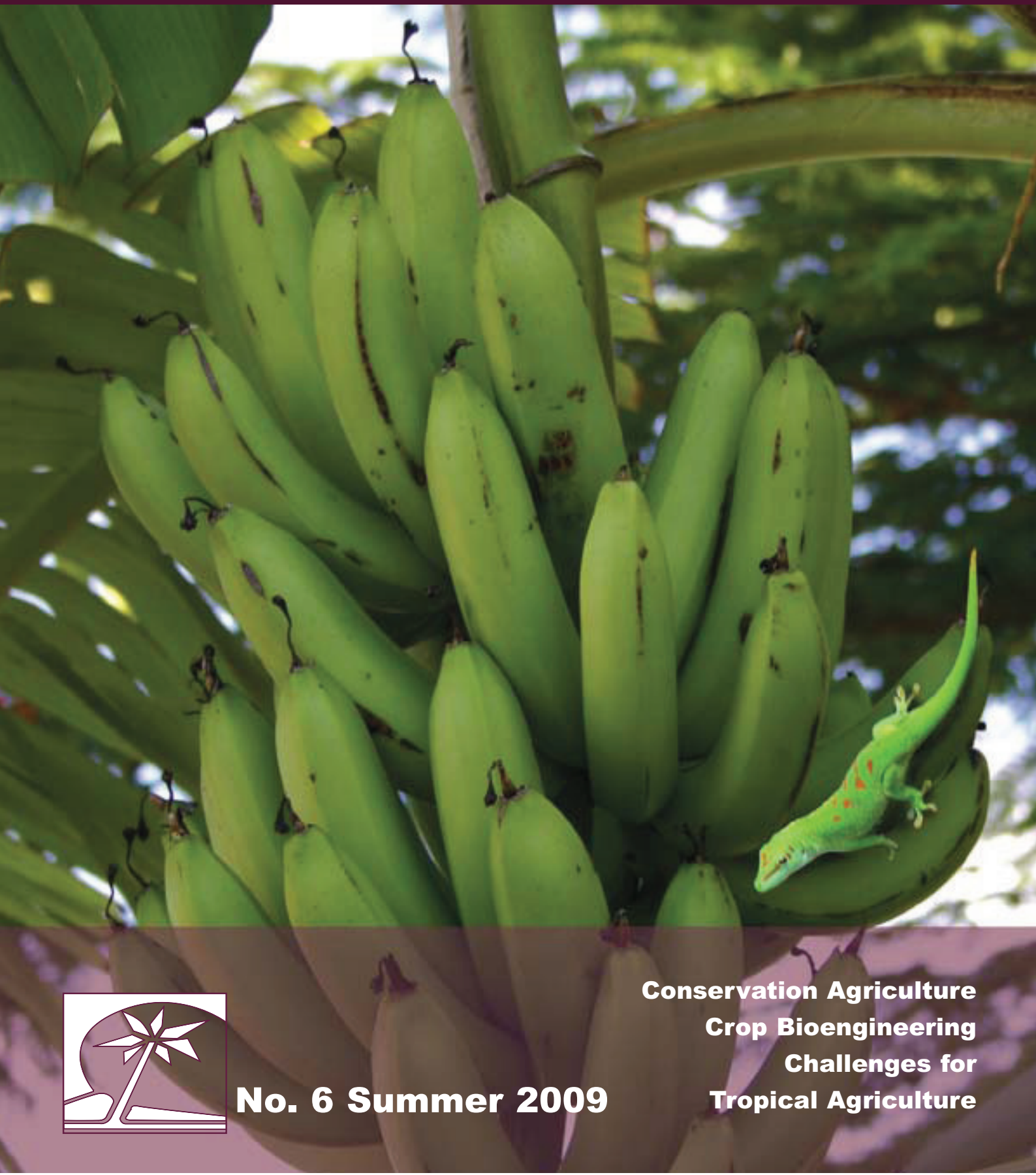


Agriculture *for* Development



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**Conservation Agriculture
Crop Bioengineering
Challenges for
Tropical Agriculture**



Conservation Agriculture

Characteristics of Conservation Agriculture (CA)

The objective of this paper is to provide an overview of the characteristics of CA, its development, current relevance and global distribution, the restricting framing conditions, its potential for improvements in productivity and sustainability, its relevance to small-scale farmers, the favourable settings for the promotion of CA in the developing regions, and areas of action for the future.

Definition of CA

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes.

CA is characterized by three principles which are linked to each other in a mutually reinforcing manner, namely:

1. Continuous no- or minimal mechanical soil disturbance (i.e., direct sowing or broadcasting of crop seeds, and direct placing of planting material in the soil) (Figure 1);



Figure 1. Direct seeding into mulch and moist soil by hand with jab planter, animal drawn seeder, and tractor mounted seeder

2. Permanent organic-matter soil cover, especially by crop residues and cover crops (Figure 2); and



Figure 2. No-till maize with permanent mulch, Brazil

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- 3. Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops, including legumes.

Translation of CA principles into technologies and farmer practices

CA systems utilize soils for the production of crops with the aim of reducing to a minimum the excessive mixing of the soil that is characteristic of tillage-based farming. CA maintains crop residues on the soil surface to minimize damage to the environment, and deploys diverse crop rotations and associations for enhancing soil and crop health. This produces more biomass of higher quality, assists integrated insect pest, disease and weed control, and improves nutrient uptake.

As a consequence, CA:

- Provides and maintains an optimum environment in the root-zone to a maximum possible depth.
- Ensures that water enters the soil so that (a) plants seldom suffer water stress that will limit the expression of their potential growth; and (b) residual water passes down to groundwater rather than over the surface as runoff.

- Favours beneficial biological activity in the soil in order to (a) maintain and rebuild soil architecture, (b) compete with potential in situ soil pathogens, (c) contribute to soil organic matter and various grades of humus, and (d) contribute to capture, retention, chelation and slow release of plant nutrients (Figure 3).
- Avoids physical or chemical damage to roots that disrupts their effective functioning or limits their maximum potential for nutrient uptake.

CA can be practiced in all sizes of farms and ecologies. Machinery, tools and equipment have been developed to cater for three levels of power usage: manual power, animal traction, and motorized equipment. The success of CA depends on the effective management of operations dealing with: (a) land preparation, (b) cover crops and weeds, (c) direct seeding, and (d) harvest and residues.

Involved knowledge: integrating CA principles into production practices

At the production level, CA cannot be reduced to a simple standard technology package because of the diversity and variability in agro-ecological and socio-economic condi-



Figure 3. Comparing soil in a farmer's trial – clods of top soil from adjacent plots, Parana, Brazil (credit: Shaxson 2007)

PRO-BIOTIC
Topsoil after 5 years with retention of crop residues and no-till seeding

ANTI-BIOTIC
Topsoil after regularly-repeated disk-tillage, without retention of residues



tions of farming. Thus, the interactions between the possible recommended technological components and the location-specific conditions of farming must be adequately considered. The standardised “best bet” production technologies approach tend to be of limited relevance and value for many farmers because CA practices tend to be knowledge intensive; farmers themselves must become involved in fine-tuning the transformation and application of the principles into site- and farm-specific practices.

International cooperation

International cooperation has become stronger recently as illustrated by the biennial process of the World Congress on CA, and increasing numbers of regional workshops. An international multi-stakeholder meeting organized by the UK Tropical Agriculture Association (TAA) and hosted by Newcastle University in March 2007 was followed by a larger meeting hosted by FAO with technical support from TAA. The outcome of the latter meeting has been the emergence of the concept of ‘Community of Practice’ (CoP) within development communities to formalize and strengthen the connections among like-minded persons who work in a variety of circumstances and seek collectively to improve both knowledge and practice of CA.

Potential advantages from CA

The potential for CA systems in 21st century agriculture development is based on the large amount of field-based evidence from all continents regarding the benefits of CA systems.

These can be grouped as:

- Economic benefits that improve production efficiency.
- Agronomic benefits that improve soil productivity.

- Environmental and social benefits that protect the soil and make agriculture more sustainable.

CA concepts and practices have a wide range of compatibility and complementarity with other resource conserving approaches and technologies, and applicability in rainfed and irrigated farming systems, including ‘organic’ farming. It is suitable for different crop types such as grain crops including rice, roots and tubers, vegetables, perennials, and agro-forestry systems.

Current relevance of CA and basic data on use worldwide

Global area and regional distribution

Worldwide, there are now some 100 million ha of arable crops which are grown each year without tillage in CA systems (Figure 4). The total area under CA is still very small (about 6-7%) relative to areas farmed using tillage.

No-till agriculture in the modern sense originated in the USA in the 1950s, and the USA has always had the biggest area under no-till in the world although it accounts for only 22.6% of all cropland area. In contrast, in the Southern Cone of Latin America no-till became the majority agricultural system over 60% of the surface. Canada shows the fourth biggest area under no-till with 12.5 million ha. CA exists in Europe but it is not really widely spread. In Australia CA has been widely and quickly embraced by farmers.

Asian and African countries have begun to take up CA practices only in the last 10-15 years, but have already acquired many useful lessons with respect to adapting the principles of CA to a vast diversity of conditions and constraints. Among the most encouraging experiences has been the CA work developed in dry environments such as Tunisia and Kazakhstan.

CA is practiced in all climate zones of the world where annual and perennial crops can



be grown and its concept and principles are applicable to any size farm subject to availability of equipment.

Restricting farming conditions

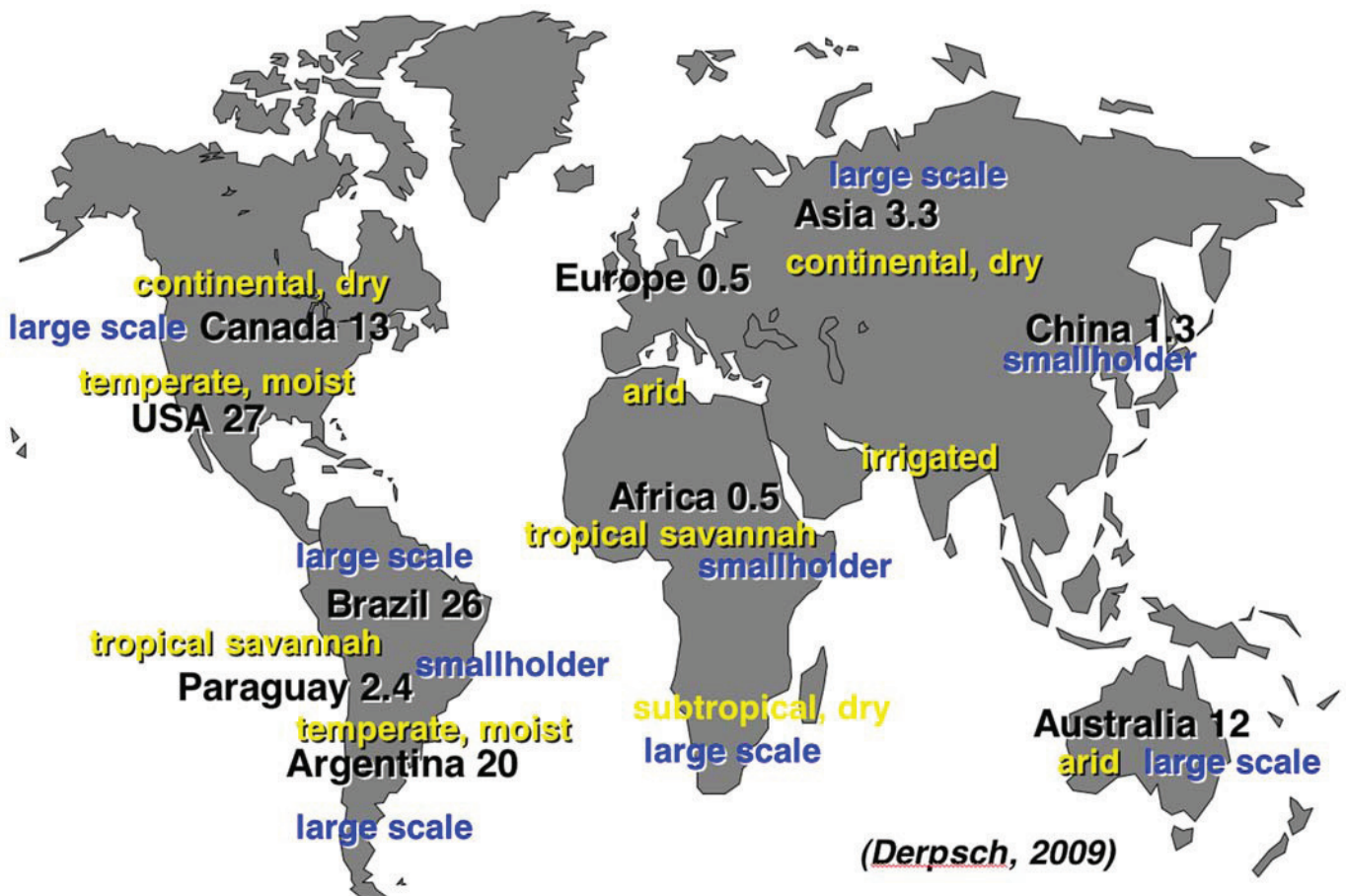
The initial and primary restriction to adoption of CA is the assumption that tillage is essential for agricultural production. Subsequent hindrances to its adoption include, variously, those of intellectual, social, technical, environmental and political characteristics. Key restrictions with mainstreaming CA systems relate to problems with up-scaling which is largely based on the lack of knowledge, lack of expertise, lack of inputs (especially equipment), inadequate financial resources and infrastructure, and poor policy support.

Technical potential for improvement

Conventional tillage-based ways of treating soils has resulted in damage to their inherent productive capacity and their biologically based sustainability as favourable rooting environments. CA is aimed at self-sustaining improvements of the overall health of the soil/plant ecosystem, and provides a more benign and beneficial alternative.

By avoiding tillage, the loss-rate of CO₂ from soil to atmosphere is greatly reduced. Permanent cover of mulch materials both sustains the soil biota, raises the soils' retention/release capacity for water and plant nutrients, and protects the surface from extremes of rainfall and temperature. Rotations limit pest build-up, favour nutrient-cycling in the soil, and increase levels of soil

Figure 4. Conservation Agriculture worldwide, 106 Million ha





organic matter at different depths. In these ways CA improves and sustains soil health on land already in good condition, can regenerate land in poor condition, and favours the self-repeating sustainability of soil processes. As such it furthers the aims of a number of international conventions on, for example, combating desertification, loss of biodiversity, and climate-change effects.

Relevance, availability and effects for small-scale farmers

Chances, risks, failures and discouragements

Land degradation is due primarily to a failure or inability to apply what is already known about the functioning of such systems. Even those rural poor who cannot fully meet their basic needs can benefit from application of CA's principles. Benefits cited are reduction in labour to produce greater crop yields per unit area, improvement in family members' health due to the inclusion of vegetables in the diet, greater food security throughout the year and chances to make off-farm sales of surplus produce. These benefits were initiated with near-nil investment through altered usage of already available materials and energy, and provided extra cash for re-investment in the enterprise next season.

There are growing risks to continuing with tillage agriculture, but entrenched insistence on its continuation (as by powerful voices of some input- and equipment-makers) could jeopardise firm encouragement and support by governments of CA's spread. Interested farmers risk becoming disillusioned if adequate practical advice, equipment or inputs are not available.

Desirable or necessary changes in farming conditions

A government needs to make firm and sustained commitment to encourage and support CA, expressed in policies which are consistent and mutually reinforcing across

the spectrum of government responsibilities and sufficiently flexible to accommodate variability in local characteristics. Facilitation should include tapered financial and logistical support for the number of years needed for farmers to make the changeover and become familiar with the functioning of CA. Formal recognition should be given to the public goods value of environmental benefits generated by adoption of CA. The education system should be permeated with understanding of well-managed CA as an optimum expression of sustainable productive agriculture.

Settings for the promotion and sustainability of CA systems in developing regions

Regional experiences with the promotion and sustainability of CA

A variety of CA cases are available from the three developing regions. Ample evidence now exists of the successes of CA under many diverse agro-ecological conditions to justify a major investment of human and financial resources in catalysing a shift, whenever and wherever conditions permit it, from tillage-based production systems to those based on minimal soil disturbance, organic residue retention, and crop rotations and combinations. This will lead to large and demonstrable benefits that have been detailed earlier in this article.

In Latin America CA was initially designed by farmers and by farmer organizations in the southern state of Paraná in Brazil. The very good environmental and economic performances of CA systems eventually led to the implementation of supporting policies and to a fast and wide adoption of this system. Subsequently, public research and extension system and even some private companies have been involved in CA expansion. This multi-stakeholder strategy has been really efficient and successful, as CA is now reaching



60% of the total agricultural surface at national level.

In Asia, where most national economies are in transition and there is growing effective demand for food and agricultural products, much of the promotion work is being done through the normal extension services with backing from the public sector research organizations. There is also collaboration with international research.

In Africa, efforts such as Farmer Field School (FFS) that rely on participatory approaches to learning and adaptation at the grassroots level, and farmer-discovery processes at on-farm benchmark sites enable farmers themselves to decide how to put concepts and principles. In several cases the international assistance arriving for recovery after natural disasters and emergencies could in Africa successfully be harnessed to introduce CA.

Areas and options for action

Focus on CA technology development, adaptation and introduction

Technologies that can help put CA principles into practice are mostly available but require their local adaptation to specific cropping systems and cultures across diverse agro-ecological and socio-economic situations. In many places, the introduction of CA technologies and practices will be from scratch, calling for mechanisms such as FFS that would enable empowering farmers through phased learning and discovery processes.

Collective knowledge and experience must be shared in introducing CA approaches to new countries and in supporting the accelerated adaptation and uptake of CA practices in countries in which they have already been introduced.

Agronomic strategies for CA aim at harnessing the abundant and diverse life forms that exist within soils to enhance their

long term productivity. They include various combinations of:

- minimal or zero tillage;
- continuous soil cover often including green manure and cover crops;
- crop rotations, sequences and combinations;
- non-inversion weed control, including the use of allelopathy and smother crops;
- crop-livestock integration in farming systems;
- increase in biomass inputs to soil systems;
- optimization between organic and inorganic nutrient amendments;
- ecosystem-based and integrated management methods to control weeds, pests and diseases; and
- erosion control infrastructure where needed.

Organizational strategies include:

- participatory farmer-centred research and development;
- greater assumption of responsibilities for agricultural innovation by farmer organizations;
- capacity building within such organizations;
- engaging scientific expertise for understanding of below-ground processes;
- incentives and certification of sustainable agriculture practices to recognize societal benefits; and
- establishment of a network of Communities of Practice (CoPs) bringing together diverse stakeholders around the world to give concerted support.

Summaries of critical issues, goals for what might be done about them, and proposed actions that could be considered in the three broad stakeholder areas are set out in the full report of the FAO workshop. The participants in the workshop in July 2008 proposed establishing a number of interconnected CoPs



that can further the objectives of CA as discussed above. Participants also decided to establish and sustain a *multi-stakeholder knowledge management system* that will be suited to the needs of diverse users, and in particular of farmers who can benefit from more appropriate and effective CA practices.

Focus on European Cooperation policy on CA, and framing conditions for CA in the EU

European agricultural development policy for sustainable production in Europe and in the developing regions should have a clear approach to sustainable farming which in tropical conditions is not possible with tillage-based agriculture; hence all development activities dealing with crop production intensification should be assessed for their compatibility with CA. Environmental management custodian schemes in Europe do not promote the principles and practices of CA. This is because CA practices do not attract special rewards in the single farm payments to European farmers. On the contrary, commodity related subsidies or payment for set-aside land work against the adoption of CA. Thus environmental costs arising from the negative impacts from intensive agriculture in Europe continue to be externalised and shifted to the society at large. Consequently, the degradation of soil, biodiversity and environment continue largely unabated.

It is perfectly feasible to meet food security needs in Europe and in the developing regions at lower economic and environmental costs through CA systems but the transformation to such systems will require effective political will and commitment. Currently, these policy provisions are lacking in Europe.

The proposed Soil Framework Directive, resulting from the Soil Thematic Strategy, for example, would have facilitated national policies in support of CA. Unfortunately it was not adopted. However, the new EU Water

Framework Directive includes permissible levels for pollutants in water such as nitrates, phosphates or pesticides, and only under permanent no-till systems (CA) can the erosion and leaching of agrochemicals into surface and subsurface water bodies be reduced to a level compatible with the new directive.

Within Europe there is an increasing concern about the sustainability of farming and organizations promoting CA in Europe, such as ECAF (European Conservation Agriculture Federation). CA principles, knowledge, skills and practices as well as the associated learning and dissemination processes are of a 'public goods' nature and are effective in reducing purchased exogenous input requirements while enhancing the natural endogenous biotic and ecological productivity enhancing processes. European governments and European Commission will have to take responsibility of promoting the transformation through the EU's Common Agricultural Policy (CAP) which has been generally rather effective in managing agricultural change over the past several decades.