Criteria for Adoption of Conservation Agriculture and Zero Tillage in Developing Countries

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Summary
Land degradation impacts seriously on land productivity, food security, poverty reduction, and environmental services in many developing countries. Conservation agriculture and zero tillage have considerable potential to mitigate the effects of land degradation, but apart from North and South America and Australia, adoption rates have been very low. In promoting these technologies, the approaches and procedures have to be tailored to the changing conditions in developing countries, and in most cases linked to technologies of Sustainable Land Management, so as to concomitantly improve land quality, improve food security, and reduce rural poverty. This paper discusses the successes achieved with zero tillage in Latin America, and some recent evidence from Sub-Saharan Africa. Recommendations for improved promotion are provided, including technical, institutional, and policy support.

Introduction

The human footprint on global ecosystems is large and growing exponentially. Currently, fully 83% of the world's land area is directly influenced by human interventions (Karieva, P. et al. 2007); 50% of the terrestrial earth's surface has been converted to grazing land and cultivated cropland, and 25% is intensively managed in agriculture, natural and plantation forests, or managed nature preserves (UNEP, 2005). Estimates are that by early in the next century, all land will be under some degree of management (Vitousek 1994).

Land degradation, including erosion, nutrient depletion, and desertification, is recognized as a major global environment and sustainable development challenge (GEF, 2002), particularly for croplands and grazing lands. About two-thirds of global agricultural land has been degraded to some extent during the last 50 years, and about 25% is severely degraded. It is estimated that the cumulative crop productivity losses due to land degradation are about 5 % worldwide (about 8.2 % for Africa), and the annual loss of agricultural land due to degradation is about 5 – 12 M ha. This has impacts on the livelihoods, economic wellbeing, and the nutritional status of almost 1 billion people in developing countries (UNEP, 2005).

Land degradation is especially serious in Africa and South America where there are direct negative impacts on agricultural productivity and rural poverty. It also impacts negatively on ecological services, such as water quality, sedimentation control, biological diversity, and soil sinks for greenhouse gases.

The Changing Status of "Developing Countries"

The terms "Developing Countries or Emerging Economies" are often used loosely to denote populations with lower per capita incomes than those enjoyed in North America and Europe. Although there are some common characteristics among them, the

production systems, economic conditions, and ecosystems of these countries are highly diverse. Also, conditions are changing very rapidly, with the adoption of new marketing structures, new technologies, and new knowledge.

The World Bank (WDR, 2008) characterizes "Developing Countries" into three categories:

a. *Agriculture-based countries* (Mostly Sub-Saharan Africa). The agricultural sector is the engine for economic growth, poverty reduction, and food security; it generates 32 % of GDP, and employs 65 % of the labor force. Women make up a major portion of the agricultural workforce.

b. *Transforming countries* (examples China, India, North Africa, etc). Major issues are reduction of rural poverty (600 M) and narrowing the rural-urban income gap. Agriculture contributes about 7 % to GDP; a major concern is to avoid falling into subsidy and protection traps that stymie growth and tax poor consumers.

c. *Urbanized countries* (mainly Latin America, the Caribbean, Eastern Europe, Central Asia). The broad goal is to link smallholders to modern food markets and provide remunerative jobs in rural areas. However, rural areas are still home to 45 % of the poor. Agriculture contributes just 5 % of GDP growth, but agribusiness and food services account for as much as 35 % of GDP.

The WDR notes that major driving forces on global food supplies include competing demands for food, feed, and biofuels; the rising price of energy; increasing land and water scarcity; and climate change. Developing country producers are disadvantaged due to the protectionist policies and subsidies in developed countries, the result of which is to limit export oopportunities, depress prices, and restrict the evolution of a neutral international market, including biofuels. Also, the report asserts that industrialized countries urgently need to do more to help poor farmers adapt their production systems to climate change.

In summary, developing countries have evolved considerably over the past decades, except for sub-Saharan Africa. Thus the promotion of any new technologies, such as zero tillage, requires that the approach be sufficiently flexible to fit within the range of conditions currently present in these countries. The challenge is to make the technology sufficiently appealing to capture a particular niche in the systems.

Conservation Agriculture and Zero Tillage[1]

The term "Zero Tillage" and "Conservation Agriculture" are often used synonymously in the literature, but the concepts behind each are different. Conservation Agriculture is a paradigm involving a combination of principles, procedures and technologies which, when used in combination, promote healthy soil environments and sustainable agricultural production. Zero Tillage, on the other hand, is a technology for planting with minimal disturbance of the soil surface. It is the most important technology in Conservation Agriculture. "Integrated Zero Tillage" is sometimes equated with Conservation Agriculture in Brazil.

[1] In this paper, the term "Zero Tillage" is used synonymously with Conservation Tillage and No Till.

The principles of CA are the following (developed by an international working group; Dumanski et al., 2006):

- *Maintaining permanent soil cover and promoting minimal mechanical disturbance of soil through zero tillage systems, to ensure sufficient living and/or residual biomass to enhance soil and water conservation and control soil erosion.*
- *Promoting a healthy, living soil through crop rotations, cover crops, and the use of integrated pest management technologies.*
- *Promoting the application of fertilizers, pesticides, herbicides, and fungicides in balance with crop requirements.*
- *Promoting precision placement of crop inputs to reduce input costs, optimize efficiency of operations, and prevent environmental damage.*
- *Promoting legume fallows (including herbaceous and tree fallows where suitable), as well as promoting composting and the use of manures and other organic soil amendments.*
- *Promoting agroforestry for fiber, fruit and medicinal purposes.*

Conservation agriculture emphasizes that the soil is a living body, essential to sustain quality of life on the planet. Zero tillage is a "cornerstone" of CA, and it can be practiced in both large and small farming systems.

Adoption of Conservation Agriculture and Zero Tillage

Zero-tillage is now being practiced on more than 95 million ha world wide[2]. Approximately 47 % of the zero-tillage technology is practiced in South America, 39 % is practiced in the United States and Canada[3], 9 % in Australia and about 3.9 % in the rest of the world, including Europe, Africa and Asia. Adoption rates are faster in South America than in other parts of the world, and these areas are more consistent with permanent soil cover and permanently not tilling the soil. Adoption rates are very low in Europe, Africa and most parts of Asia, despite good and long lasting research.

Table 1: Adoption of zero-tillage worldwide, 2004/2005 (ha) (Derpsch, 2008)

USA	25.304.000	South Africa	300.000
Brazil	23.600.000	Spain	300.000
Argentina	18.269.000	Venezuela	300.000
Canada	12.522.000	Uruguay	263.000
Australia	9.000.000	France	150.000
Paraguay	1.700.000	Chile	120.000
Indo-Gangetic-Plains	1.900.000	Colombia	102.000
Bolivia	550.000	China	100.000
		Others (Estimate)	1.000.000
Total	**95.480.000**		

[2] This represents about 7 % of global cultivated land

[3] This represents about 22 % and 27 % of cultivated land in the US and Canada respectively.

Adoption of Zero Tillage in Latin America

On a global basis, zero till expanded most rapidly in Latin America, especially, Brazil, Argentina, and Paraguay, starting effectively from the early 1990's. This expansion was from necessity, due to very serious issues of soil erosion, soil compaction, and soil nutrient depletion, with serious concerns on the future sustainability of agriculture in these tropical regions. Traditional engineering techniques had failed, and zero till was initiated as a viable alternative. Initially, it was promoted through pioneering efforts by enterprising and far seeing farmers in each country, supported by national research institutions. The common learning experiences which evolved were the basis for formation of an international farmer association for zero tillage, CAAPAS, currently with ten member countries, including Canada and the USA, and two observer countries.

The most important lesson learned from Latin America was the importance of integrating zero tillage with other principles of Conservation Agriculture. In fact, without this, successes would not have been possible. Over time, some common models of sustainable agriculture emerged, called "MOSHPA" in Argentina (Peiretti, R.A., 2003) and "Integrated Zero Till" in Brazil (Machado and Freitas, 2004). These approaches include zero tillage but also maintenance of crop rotations, integrated pest and weed management, use of modern varieties and cultivars, careful and selective crop fertilization systems, and many other conservation technologies. These combined approaches have proven to be the main technologies to improve the economic sustainability of both large and small holder agriculture in Latin America. Some estimates for Brazil show that through the integration of crop and cattle enterprises under combined zero till and conservation principles, it may be possible to increase grain, fibre and meat production in Brazil to meet market demand for the next 20 years or more without further deforestation in frontier areas (Landers & Freitas, 2001).

The MOSHPA and integrated zero till models have also been shown to considerably reduce off-farm externalities, such as reduced soil erosion and silt control, reduced public expenditures for infrastructure maintenance, improved water filtration and aquifer recharge, improved local biodiversity, and improved mitigation of drought. The environmental impacts of these technologies has been increased soil carbon sequestration, reduced emission of non-CO_2 gases, and improved economic and environmental sustainability of agriculture in the tropics and sub-tropics.

Adoption of Zero Tillage in Sub-Saharan Africa

Adoption of zero tillage in African agriculture has not been highly successful, even though soil erosion and soil nutrient depletion has degraded almost 70 % of the region's land between 1945 and 1990, and 20 % of total agricultural land has been severely degraded. This extensive degradation is seriously threatening the progress of economic growth and poverty reduction in Africa.

Many approaches to improve on this situation have been tried, with limited success. However, a recent study in Uganda provides some guidance on how to proceed (Ephraim, et al., 2009). The most significant finding in the study were that combined investments in land improvement, such as soil and water conservation, agroforestry, and technologies of

sustainable land management provided collective impacts beyond those available through financial, infrastructure, or market stimuli alone. On the other hand, investments in financial services, such as access to credit, resulted in improved productivity and higher incomes, but had neither positive nor negative relationships with good land management or mitigation of land degradation. Access to roads, certain other physical assets, and improved land tenure were also positively associated with higher income, but had minimal relationship with good land management.

The study concluded that integrated investments in sustainable land management, including soil conservation, high value crops, and improved market development, can achieve "win-win-win" outcomes, simultaneously increasing productivity, improving household incomes and reducing poverty, and reducing land degradation. Zero tillage can be a component of this integrated set of investments, but needs to be presented as part of a combined approach with a focus on poverty reduction and mitigation of land degradation.

The Top Ten Criteria for Adoption of Zero Tillage

Experience from Latin America and elsewhere has identified a set of criteria for adoption of zero tillage (Derpsch, 2008):

- *Improved knowledge about the system, especially weed control*
- *Maintaining crop rotations and green manure cover crops*
- *Producing high levels of mulch*
- *Soil testing to ensure balanced fertilization and soil acidity*
- *A level soil surface*
- *Avoiding soils with poor drainage*
- *Eliminating soil compaction*
- *Proper zero till equipment, including seeders, knife rollers, etc*
- *Starting small (10% rule)*
- *Continual learning and adaptation*

The most important among these is the desire for change on the part of adopters, and the knowledge on how to effect the change. This can be driven by the need to control soil erosion, reduce input and operating costs, or for environmental services. In Brazil, the imperative was to mitigate extensive soil erosion and land degradation; in Africa the driving motivation will be it poverty reduction; in other regions it will be linked with improved market opportunities. The growing evidence is that linking zero tillage with the broader objectives of soil and water conservation and the income generating objectives of sustainable land management are the best options.

Conclusions

Zero tillage is currently concentrated in South and North America, with minimal adoption elsewhere, and globally it represents less than 7 % of global cultivated land. There is potential for considerable expansion, but this technology has to be presented in combination with Conservation Agriculture and Sustainable Land Management. The benefits of zero tillage, including reduced labour and input costs, have to be promoted in the context of reducing rural poverty, improving rural livelihoods, capturing new market opportunities, and providing environmental benefits. Expansion will occur only if these

technologies can fit into the range of farming systems currently evolving in developing countries, and if they find a particular operational niche.

Expansion in the agricultural and transforming economies will require improved institutional and policy support, improved knowledge base, and a new mind set for small farmers. Efforts must be made to create enabling policy environments, including removal of obstacles such as perverse legislation, subsidies, and other policies that impact negatively on poor land management, as well as mainstreaming of soil conservation and sustainable land management into national and regional policies and programs. Increased emphasis must be placed on economic instruments and international markets, and incorporation of non-market values in ecosystem investment, such as payment for ecosystem services, certification schemes, etc. In addition, these initiatives have to be matched with targeted technological innovations, which concurrently improve on-farm productivity, reduce rural poverty, and improve the health of the soil and the global environment.

In most cases, expansion of technological innovations, such as conservation agriculture and zero tillage, is based on farmer driven initiatives. The early successes in Latin America were met with high enthusiasm and expectations, and resulted in the formation of farmer associations such as CAAPAS. Greater support for the continued growth of CAAPAS and similar farmer associations, as central players, is needed.

In addition, agreements and partnerships with other, major players in soil conservation, such as the nature-based NGOs, are needed to promote rapid adoption. Under the right conditions, such partnerships can raise a new dynamic in soil conservation, and ensure a more balanced focus on production, economic, and environmental goods and services.

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