ECONOMICS ASPECTS OF CONSERVATION AGRICULTURE – A GLOBAL REVIEW OF THE PROFITABILITY, RISKS AND DYNAMICS FROM THE FARMERS PERSPECTIVE

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Key words: conservation, economics, risk, development

Introduction

At the turn of the Century, about 2.5 billion farm men, women and children produced some 1.9 billion tones of cereals for their own home consumption as well as sale to the urban population of 3.5 billion. Despite farmers' momentous past achievements — such as the increase of global cereal production by more than one-third since 1980 — by 2030 they will face a projected additional demand for cereals of around 1 billion tons; and an even larger increase in demand for livestock products (FAO 2003). On top of these production challenges, the prevalence of chronic hunger, famine, environmental and other development problems pose major challenges to scientists, policy makers and farmers. Following the establishment of measurable global development objectives in the Millennium Development Goals and the recognition of the close links between farm development and rural economic growth, the search for solutions to hunger and poverty has re-focused on agricultural and rural development. At least in some circumstances, Conservation Agriculture (CA) appears to be a "triple bottom line" type of farming, contributing simultaneously to farm income growth, reduced risk and positive secondary, off-farm effects, e.g., rural economic growth and environmental improvement.

Of the 1.2 billion people world-wide surviving on less than US $ 1 per day, two-thirds live in rural areas; and a high proportion of these rural poor are farmers (World Bank 2002). The growth of farmers' incomes directly reduces their hunger and poverty, as well as financing farm improvements to ensure continuing economic growth. However, the prevalence of famine and transient poverty caused by drought and other natural disasters, e.g., the current crisis in Southern Africa, underlines the vulnerability of farmers' livelihoods, which in turn depends on the down-side risks associated with production and the market. Unfortunately, many yield-enhancing production technologies, at least in rainfed cropping, increase production risk. There are obvious advantages of technologies that increase average productivity whilst simultaneously decreasing production risk.

In relation to the secondary benefits potentially stimulated by farm income growth, farmers' purchases of local goods and services[2] generate growth of the local non-farm economy: typically, every additional $ 1 of farm income generates about $ 2 of additional income in the non-farm economy. It is

[2] So-called "non-tradable" goods that are traded in local markets that are not linked to international markets.
[3] The environmental Kuznets curve, yet to be proven, posits a relationship between environmental conditions and national per capita income in an inverted U shape.

worth noting that this multiplier is higher for small farmers than large farmers: the former tend to spend a greater portion of their income on local goods and services than large farmers.

However, whether such agricultural development leads to resource enhancement or resource degradation has been a source of much debate. [3] In the 1980s it was generally assumed that national economic growth often occurred at the expense of the environment – see, for example, the debates in the Rio Earth Summit. During the early 1990s evidence emerged of successful rural economic growth along with environmental conservation, and donors invested heavily in the Global Environmental Fund and also in "integrated" conservation and development programmes; however, by the end of the decade it became apparent that only some of these programmes were successful. Lee and Barrett (2002) present an up-to-date and wide-ranging review and conclude that tradeoffs between agricultural intensification, rural economic growth and the environment are more common than synergies: however, CA was not among those topics that were reviewed.

CA is generally characterised by minimum soil disturbance and the presence of permanent soil cover and crop rotations (see FAO 2002). In fact, CA is emerging as a consensus term covering a variety of closely related types of farming, including minimum and no-till farming, mulch farming, resource management technology, conservation farming, sustainable land management and better land husbandry (Friedrich *pers comm.*) — this interpretation could be referred to as CA *sensu lata*, in contrast to the original concept of CA *sensu strictu*. The first component of CA *sensu strictu*, minimum soil disturbance, is achieved by minimum tillage or zero tillage – in fact zero tillage is the rubric for the highly successful CA movement in Brazil (Saturnino & Landers 2002). In the case of zero tillage, crops are sown directly into the stubble of the previous crop using special planting equipment, which very effectively reduces soil erosion (Baker *et al* 1996). In addition, minimum tillage and zero tillage lead to soil improvement and savings in field operational costs. In relation to the second component of CA, permanent ground cover, ideal residue management practices target at least 30 percent ground cover at any point in the season, eschewing the removal or burning of crop residues. Among the many advantages of good ground over, the increase in soil moisture and reduction of soil erosion leads to increased yields and maintenance of natural capital or land value. As part of the strategy to ensure permanent ground cover, a cover crop, often leguminous, is frequently grown during the off-season, which may generate saleable produce, provide fodder, or simply be slashed before sowing the next crop. These cover crops contribute to the third component of CA, crop rotation, with the concomitant advantages of reduced pressure on soils and reduced pest and disease pressure. There has been experiment station research on no-till since the 1940s in the USA, the 1960s in Europe and the 1970s in Latin America and Africa (Derpsch 1998, Lal 1998), and even earlier for mulchs and crop rotations[4]. However, research on the three components in combination has been limited, notwithstanding the emphasis in the CA literature on integrated management of soil, water and biological resources (FAO 2001). The paucity of research on the economics of CA is particularly striking, especially of on-farm performance.

From the perspective of economic evaluation, management-intensive biological processes of CA[5] are substituted for conventional manual and mechanised field operations, leading to on-farm and wider secondary off-farm effects, and to short and long run effects. The cross-over success of CA in both temperate OECD large-scale commercial farming systems and Latin American sub-tropical smallholder farming systems is unusual and warrants closer inspection. In this connection, Fresco (2001) challenged CA to achieve "successes in Africa and other poor, ecologically marginal areas in the humid tropics". The focus of this paper lies on farm level benefits and costs of CA practice in developing regions. Four aspects are examined: adoption, profitability, risk and secondary, off-farm, impacts.

[4] For example, Rothamsted Farm in the UK and the Morrow Plots in Illinois, USA date back more than a Century.
[5] Although many CA farmers use herbicides especially during the transition from conventional tillage, on average herbicide use tends to be less than in conventional farming (Friedrich *pers comm*).

Adoption

In this section three aspects of adoption are discussed: global coverage; distribution by farming system; and dynamics of farm-level adoption. Farmers began to adopt CA relatively quickly when a variety of herbicides became readily available in the late 1980s, especially in parts of North and South America and Australia. The indications suggest that the uptake has been much slower, so far, in Africa and elsewhere in Asia (although hard data are not available because CA is not separately recorded by agricultural statistical systems in many countries). In the absence of comparative statistics on CA, Table 1 shows the expansion of no-till farming, the best available proxy for CA *sensu lata*, since 1980. CA covered a small area during the 1980s but expanded rapidly during the 1990s. In 2002 the global area of no-till farming was approximately 70 m ha, equivalent to about 5 percent of cultivated land world-wide.

Table 1: Growth of no-till farming world-wide

Year	Global area (m ha)
1973/4	2.8
1983/4	6.3
1996/7	38.7
1999/2000	59.9
2000/2001	70.4

Source: Derpsch (2003)

The distribution of no-till farming across countries is shown in Table 2. Of the 70 m ha world-wide, more than 60 m is found in four countries: U.S.A., Brazil, Argentina and Australia. The largest area of under no-till is found in the U.S.A., but a large proportion does not have year-round ground cover and further expansion appears to be stagnating. Conversely, the proportion of cultivated land under no-till in Brazil, Argentina and Paraguay, most of which corresponds to the above definition of CA, is substantially greater than that of the U.S.A. and continues to increase. Although the uptake has been limited to date, it is considered that there is substantial potential for CA *sensu lata* in Eastern European countries (Derpsch 2001) and in African countries (GTZ 1998).

Table 2: Distribution of no-till farming by country 2000/2001 (million ha)

Country	Arable land (m ha)	No-till area (m ha)	Proportion (%)	Principal Type of Farming System
U.S.A.	177.0	22.4	13	Large scale commercial
Brazil	53.2	17.4	33	Cereal-livestock (Campos); Extensive mixed (Cerrados)
Argentina	25.0	13.0	52	Temperate mixed; Cereal-livestock (Campos)
Australia	50.3	9.0	18	Large scale commercial
Canada	45.6	4.1	9	Large scale commercial
Paraguay	2.3	1.3	52	Cereal-livestock (Campos); Extensive dryland mixed (Gran Chaco)
Mexico	24.8	0.65	< 5	Maize-beans (Mesoamerican)
Bolivia	1.9	0.42	22	Extensive dryland mixed (Gran Chaco)
South Africa	15.7	0.40	< 3	Dualistic
India, Pakistan	191.7	0.35	< 1	Rice-wheat
Venezuela	2.4	0.15	6	Extensive mixed (Llanos)
Chile	2.0	0.13	5	Moist temperate mixed
Colombia	2.8	0.07	< 3	Extensive mixed (Llanos); Intensive highland mixed (North Andes)
Uruguay	1.3	0.05	< 5	Cereal-livestock (Campos)
Ghana	5.8	0.045	< 1	Cereal root crop mixed; Root crop
European Union	73.5	neg	< 1	Large scale commercial
Others	-	1.0+	neg	-
Total	1,364.2	70.4	5.2	-

Source: Source: Derpsch (2003) for no-till areas, Dixon *et al* 2001 for farming systems, FAOSTAT (August 2002) for country areas (note that country arable areas include permanent crops, refer to the year 2000).

The distribution of no-till across farming systems (see Table 3) shows the geographic pattern of adoption, with a concentration in large scale fully commercial temperate farming systems in OECD countries and in medium scale sub-tropical/temperate farming systems of various types in Latin America. Adoption is just taking off in a number of irrigated and rice based systems, for example in Northern India and Pakistan. To date there has been limited adoption in hill or mountain systems (except for the intensive highland farming system in Columbia, where expansion has been rapid).

Table 3: Distribution of CA by Global Farming System Type

Global Farming System Type	Total cultivated land (m ha)	Proportion under CA	Example Farming Systems by Region
Smallholder irrigated schemes	15	Negligible, < 0.5 %	
Wetland rice based	155	Low, < 1 %	Asia: Rice-wheat
Rainfed humid	160	Low, < 1 %	AF: Cereal-Root Crop Mixed; Maize Mixed LA: Maize-beans (Mesoamerican)
Rainfed highland	150	Negligible, < 0.5 %	LA: Intensive Highland Mixed (North Andes)
Rainfed dry/cold	231	Low, < 1%	LA: Dryland Mixed, Brazil Asia: Temperate Mixed, Mongolia
Dualistic (large/ small)	414	Substantial, < 20%	AF: Large Commercial&Smallholder. Asia: Extensive Cereal-Livestock, Kazakhstan. LA: Cereal-livestock (Campos); Extensive mixed (Cerrados&Llanos); Extensive dryland mixed (Gran Chaco); Temperate Mixed (Pampas).
Coastal artisanal fishing	11	Negligible, < 0.5%	
Large-scale commercial – Aus, USA, Canada	273	Substantial, < 20%	Various
Total	c. 1400+	Low, approx 5%	

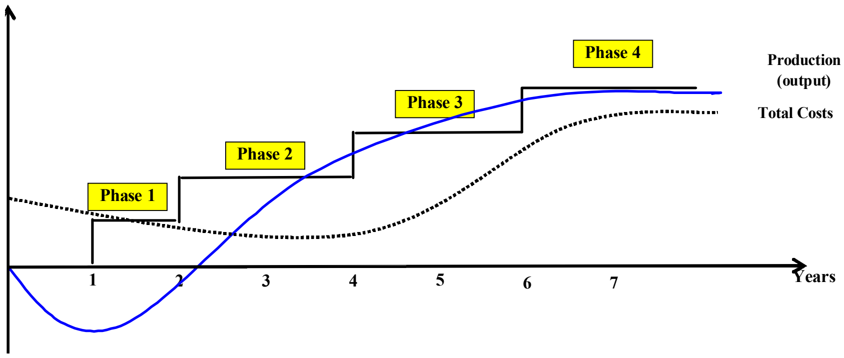
Notes: AF: sub-Saharan Africa. LA: Latin America.

Unlike some single component technologies, CA is relatively complex and farmers require time to fully understand and integrate CA into their existing farming systems. Dixon and de Oliviera conceptualised four phases of the individual farm adoption process. During the initial Phase, investment is required for new equipment and sometimes liming, operational costs may also rise and yields may even fall. During Phase 2 operational costs remain fairly high (e.g., herbicides may still be required and farmers may be operating CA on only part of their land) but yields begin to rise as farmers adjust crop management in line with personal experience. In Phase 3 crop yields have reached the expected levels and operational costs have reduced. By this stage farmers have usually learnt to manage CA adequately, expanded CA to most or all of their suitable land, thus benefiting from economies of scale with machinery; and have found productive use for resources freed up by CA, especially labour and machinery. In Phase 4 the benefits and costs approach plateaus, as the medium term benefits of CA are realised including better soil moisture holding capacity, increased soil organic matter, reduced weed and pest pressure and productive use of freed resources especially labour and machinery. Figure 2 illustrates hypothetical trends in key variables during the four phases. The significance of this progression is that farmers only experience the full benefits of CA (the benefits listed in promotional materials) after a significant period, in some settings as much as 10 years — some estimates are provided by Derpsch (2003). In this sense, CA should be viewed as a medium to long-term investment.

Farm profitability

Garcia *et al* (2001) record, in the Proceedings of the First World Congress in Madrid, numerous positive assessments of CA by both farmers and scientists in many countries, who highlight simultaneous micro-economic benefits (e.g., increased farm incomes and reduced risk), social and environmental benefits (e.g., enhancement of soil resources). However, the widespread perception of the profitability of CA is in marked contrast to the scarcity of rigorous data on enterprise or farm income effects, especially in low-income countries. Table 4 illustrates typical effects of CA on several components of farm economics, based on a survey of literature and project reports (see Annex Table 1).

Fig 1 - Theoretical Transition Phases - Conventional to Conservation Agriculture



For large-scale commercial farming systems in North America and Australia, there exists a significant positive income effect in a majority of cases (ranging from 8% to 42% in the observations recorded in the Annex Table 1), stemming largely from a reduction in field operational costs, supplemented by modest productivity increases. The reduction of costs can vary substantially across locations, scales of adoption (partial adoption can increase average machinery costs), time frames (increased short run costs cf. reduced long run costs when capital costs are fully taken into account) and fuel prices (the cost advantage of CA increases with increasing fuel prices).

Table 4: Illustrative effects of CA on farm economics in selected farming systems

Farming system and region	Reduced machinery use	Reduced labour use	Reduced costs	Increased yield	Increased profit
Large scale fully commercialised	-	-	-	+	+
Cereal-livestock (Campos) & Intensive mixed, Latin America	-	- -	-	+	+
Maize mixed, Africa		- -	-	++	++
Cereal root crop mixed, Africa		-	+	+++	+++
Intensive highland mixed (North Andes), Latin America		-	-	+	+++
Rice-wheat (irrigated), South Asia	-	-	-	+	+
Temperature Mixed FS & Extensive Crop-Livestock, Central Asia	-	-	- -	+++	+++

Souces: refer to Appendix Table for details. Notes: Increases indicated by + for 1-20%, ++ for 21-80%, +++ more than 81%. Decreases indicated by – following a similar pattern.

Although data on farm profitability of CA is even more scarce for farming systems in low and middle-income countries, indications are that yield increases and cost reductions can be substantial. In Latin America, a majority of observations occur in the Cereal-livestock (Campos) or Intensive mixed farming systems. Positive farm income effects, from reduced operational costs and increased yields, can be presumed where adoption has been fast, e.g., Brazil and Paraguay, which is confirmed by the limited farm data available. The yield and income increases can be quite substantial in some farming systems, especially where management systems are improved at the same time that CA is introduced, e.g., in Central Asia.

Typical reductions in machinery requirements are 19 - 29% for several crops in Santa Catarina, Brazil (see Annex Table 1). The reduction in labour requirements is cited as the main reason for the widespread adoption of CA in Southern Brazil[6]. The reduction in labour and machinery requirements frees resources which can lead to an increase in cultivated land. On many farms which lack land to expand area cultivated, surplus resources are allocated to off-farm activities. A majority of studies indicate greater use of inputs, especially herbicides and inorganic fertiliser, in CA. Investment costs vary with the type of farming. In hand hoe cultivation a jab planter is required, costing about US $ 10-20 (Friedrich *pers comm.*). Animal draft equipment for CA costs of the order of US $ 100-500. However, the vast majority of existing CA is mechanised, for which investment costs are substantial but vary widely depending on the area operated under CA.

A number of economic evaluations include additional benefits stemming from diversification towards high income crops associated with CA, for example in Paraguay (Sorrenson 1997). Where farmers have access to markets for organic produce and where herbicide use has declined to low levels or has ceased (under some situations of well established CA), there may be a progression from conventional products towards Organic Agriculture. Although not quantified in the literature, extra farm household income arises from the increase in off-farm work allowed by the reduced labour requirements of CA.

A number of surveys of CA in Africa, e.g., in Ghana, identify income increases stemming from yield increases and field cost reductions. The limited information from South Asia points to similar conclusions. However, the pervasive effects of globalisation can alter the comparative advantage of CA in the future.

Risk and vulnerability

The perceived riskiness of a technology is an important determinant of adoption by small farmers; and the actual riskiness of enterprises or livelihoods is an important determinant of household vulnerability and exposure to transient poverty. Generally most profitable production technologies for rainfed cropping carry with them concomitantly higher risks, necessitating the trade-offs between higher profits and higher risks. Therefore, it is not surprising to find that many farmers perceive that CA increases their farm business compared with conventional tillage (Baker et al 2001).

Although data pertaining to the actual riskiness of CA are scarce, the limited evidence points to the contrary conclusion, namely, that inter-seasonal variability of yield is lower under CA compared with conventional tillage (especially under conditions of good management). CA reduces inter-seasonal yield variability in low rainfall areas, principally by limiting yield reductions in dry years. In principle, this feature distinguishes CA from many other modern production technologies that increase yield variability. Typical results capturing spatial and temporal yield variability under small farmer conditions in Zimbabwe are shown in Table 5.

Table 5: Variability of maize yields under no-till tied ridging and farmer conventional tillage (t/ha)

	Conventional till (mulboard)	No-till with tied ridging
Overall average yield (four sites, five years)	5.08	5.22
Minimum yield	0.33	0.98
Average yield - lowest quintile	0.65	1.08
Ratio of lowest quintile yield to overall average	13 %	21%

Notes: Recalculated from data presented by (Nyagumbo 1998) for on-farm trails in four communal land sites in Zimbabwe (Kapita, Chinamhora; Basikoro N, Musana; Marewo J., Chiweshe; and Bulawayo P., Chiweshe) over five years 1991/2-1995/6

However, in some cases yield variability increases, perhaps as a consequence of poor management, weeds and pests. Further to the annual yield variability, many farmers perceive increased risks in the conversion from conventional to conservation agriculture, associated with the significant initial investment in specialised equipment. The evaluation of CA in Ghana (Ekboir et al, 2001) also indicated reduced risk of crop failure in bad years. In the 2000 season, with drought in the study areas, yield reduction attributed to drought was only 24% among those using no-till as compared to 30% among the non-adopters. In Zambia, with a serious drought in the southern parts of the country during the 2001-02 season, farmers who had applied pot-holing or minimum tillage (ripped planting furrows) obtained some harvest as compared to complete crop failure among those who had conventionally ploughed their fields (Dutch, 2002).

Secondary Non-Farm Impacts

A wide variety of other benefits is attributed to CA and has been well reviewed in Garcia *et al* (2001) and Saturnino & Landers (2002). These include reduced erosion, improved soil fertility, carbon sequestration, improved watershed condition, etc. In addition, there are wider economic benefits of CA such as the stimulus to the growth of the rural economy. In Southern Brazil the labour released from farming by CA has stimulated the local rural economy (Saturnino & Landers (2002). A full discussion of these is beyond the scope of this paper.

Conclusion

Considerable evidence suggests that CA is delivering “triple bottom line” development in Latin America, summed for CA in Paraguay: ‘no other farming techniques have been shown to have such a high impact on farmers' incomes, reduce their production costs and risks, and at the same time be environmentally sustainable and generate very considerable net social gains to society' (Sorrenson 1998). During the last few decades there has been rapid adoption of CA *sensu lata* in temperate and sub-tropical farming systems in Latin America (now more than 50 % of cultivated land in Paraguay) and recently in Intensive highland mixed systems in Columbia, cereal-root crop and maize mixed systems in Africa and irrigated rice-wheat systems in South Asia, although expansion in large scale fully commercialised systems in North America has slowed down. CA has been successfully introduced into large scale crop livestock systems in Central Asia. However, considerable innovation and adaptation of practices will be required before CA is widespread in Africa and Asia.

Whilst there is an obvious *prima facie* case to presume positive farm income effects where adoption has been widespread, the limited amount of data from farm surveys points to increases in farm profits, sometimes substantial; and to substantial secondary benefits. The limited evidence on variability points to a reduction in farm risk (contrary to many farmers' perceptions).

Nevertheless, the scarcity of information on farm productivity and risk handicaps the evaluation and promotion of CA, especially in marginal risk-prone farming systems in Africa where CA could, in principle, play a significant role in reducing vulnerability. Therefore, the collection and analysis of technical and economic productivity data on CA is a high priority, especially in farming systems characterised by low yields, poor economic growth and severe poverty.

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Appendix Table 1

Table 1: Effects of CA technologies on farm economics by farming system (selected cases)

Farming System, location, study	**Reduced tractor/ animal draft use (%, units/ha)**	**Reduced labour use (%, units/ha)**	**Reduced variable costs (%, units/ha)**	**Increased yield (%, units/ha)**	**Increased profit (%, units/ha)**
Large scale fully commercialised, OECD countries					
Rainfed mechanised no-till maize, winter wheat, wheat straw, soy & hay, US (Kelly, Lu & Teasdale 1996)					+ 8% TGM US$ 306-331
Rainfed mechanised no-till spring wheat-fallow crop rotations, silt loam, Saskatchewan, Canada (Zentner et al 1991)					+ 29% NI, C$ 84 -108
Rainfed mechanised no-till sorghum, tropical northern Australia (Kirby et 1996)					+ 42% GM, US$ 190-271
Cereal-livestock (Campos) & Intensive mixed, Latin America					
Mechanised soya, Parana, Brazil (Pieri et al 2002, citing 1998 World Bank Implementation Completion Reports)	- 27%	- 10%		+ 27%, 2.44 -3.10 tons	
Mechanised maize, Parana, Brazil (Pieri et al 2002, citing 1998 World Bank Implementation Completion Reports)	- 19%	- 51 %		+ 30%, 4.50 - 5.84 tons	
Animal traction bean, Parana, Brazil (Pieri et al 2002, citing 1998 World Bank Implementation Completion Reports)	- 46%	- 59%		+ 37%, 1.46 - 2.00 tons	
Animal traction maize, Parana, Brazil (Pieri et al 2002, citing 1998 World Bank Implementation Completion Reports)	- 66%	- 55 %		+ 20%, 4.0 – 4.8 tons	
Rainfed animal traction soy, center-south, Parana, Brazil (Ribiero et al 1993)	- 26%, 189 - 139 hrs				
Rainfed maize, center-south Parana, Brazil (Ribiero et al 1993)					
Rainfed soy, south-western Parana, Brazil (Ribiero et al 1998)					
Rainfed maize, south-western Parana, Brazil (Ribiero et al 1998)	- 25%, 122 - 92 hrs				
Rainfed animal traction maize, Santa Catarina (Heiden, 1999)		- 55%			
Rainfed animal traction soy, Santa Catarina (Heiden, 1999)		- 59%			

Extensive dryland mixed (Gran Chaco), Latin America					
Rainfed mechanised mixed cropping, Edilera, Paraguay (Sorrenson et al 1998)					+ 76+ % NFI US$567 – (1000-2900)
Intensive highland mixed (North Andes), Latin America					
Rainfed direct planted beans, mountains (Borda 2000)		- 3%, 74.8 - 72.8 hrs	+ 1% inputs 659,500 - 661,900 pesos	+ 45%, 2.0 -2.9 tons	+ 746 %, 107,500 - 910,350 pesos
Rainfed direct planted potatoes, mountains (Borda 2000)	- 6% draft animals, 7-6.6 days	- 5%, 112.7-106.9 hrs	- 9% inputs 3,064,350 -2,798,220 pesos	+ 3%, 17.9 -18.5 tons	+ 350%, 134,650 - 606,680 pesos
Rice-wheat, South Asia					
Irrigated wheat, Pakistan (Farooq)			- (17-36)% tillage, Rs 1000 - 400	+ (15-20)%	
Temperature mixed FS & Extensive crop-livestock, Central Asia					
Rainfed mechanised wheat, 5 locations, Mongolia (FAO/GOM 2002)			- 40% (incl depreciatn), 30,380 - 18,118 tugric	+ 110+%, (0.11-1.14) -(0.64-2.4) tons	
Rainfed mechanised no-till wheat, Kazakhstan (Bissetaev 2002)			- 17%, US$ 44 - 36.50	+ (4 - 7) %, (1.1 - 2.1) - (1.1 - 2.2) tons	
Cereal-root crop mixed, West Africa					
Rainfed no-till maize, Ghana (Boa-Amponsem 1998)			+ 53%, 113 – 172 000cedis	+ 116%, 2.5 - 5.4 tons	+ 98% NB, 719 -1,426 000cedis
Rainfed no-till maize, Ghana (Ekboir et al 2002)		- 27%		+ 45%	
Maize mixed, East Africa					
Rainfed no-till tied ridges maize, Zimbabwe (Nyagumbo 1998)				+ 3%, 5.08 - 5.22 tons	
Rainfed no-till-mucuna cover crop maize, Tanzania (Mariki 2002)		- 41% planting 63-37 hrs		+ 47%, 1.89 - 2.78 tons	
Rainfed no-till-mucuna cover crop wheat, Tanzania (Mariki 2002)				+ 71%, 0.93 - 1.59 tons	
Rainfed basins-ripping-potholing-residue maize, Zambia (Muliokela 1998)				+ 50%, 4.86 - 7.27 tons	

Notes: Selected cases from the literature. Abbreviations: NI net income; NB net benefit; GM gross margin. Costs and profits have been reported using a variety of measures, as indicated in the table. Some figures have been rounded.