Overview of conservation tillage practises in East and Southern Africa

by

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Abstract

Smallholder agriculture in East and Southern Africa (ESA) has special gains to gather from the agricultural mechanization endeavour, which is at different levels in different countries and which remains a major challenge for governments and farmers alike. While tractorization programmes in the region have hardly served the power supply needs of smallholders, animal traction has proved itself as a dependable and versatile source of agricultural power for tillage and transport. While soil and water conservation efforts in the region are not new, tillage for soil and water conservation has seen many shortcomings, ranging from profession redress to technological limitations, institutional support and socio-economic bottlenecks. Conservation tillage has been practised in largescale farms of the region for a while and is now receiving new focus for smallholder agriculture, within a new re-awakening in the interest of soil, water and general environmental preservation. The region is losing as much as 290 metric tonnes of soil per hectare per year and faces an average population growth rate of 3.2%. This situation does not augur well in a region which is facing agrarian stagnation though endowed with a wide range of economically utilizable, but derapidating natural resources. Various research, extension and development work has proved the gains of conservation tillage. The gains are however yet to become common knowledge and translated to utilizable techniques adopted en masse. The traditional ways revolving around tedious and high drudgery manual operations persist. New, specialized and relatively simple conservation tillage equipment is yet to challenge the common and destructive mouldboard plough which is used as a multipurpose tool by smallholders. For real and fast progress, future efforts must cehtre around end user led, aggressive promotional, networked activities that avoid the low impact and duplicated top-down efforts of the past. A culture of environmental consciousness needs to be developed as a way of getting conservation tillage to the fore. The issue to be addressed is how to balance the inputs required so as to maximize efficiency and cost-effectiveness of inputs, reduce risks of soil and environmental degradation, maximize the per capita productivity, and maintain or sustain an increasing trend in productivity. With regard to technology output, the range of equipment including simple light-weight tools which can be used with donkeys (preferred by women) as well as capacity to package them for completeness needs to be explored. Packages will make it possible to exploit the complementary capacities of animal traction. Such packages will bring about the much needed entreprenurial creativity to make farmers implements serviceable as well as available for hire by those who cannot afford to own them. Among the recommendations made are farmer-centered, on-farm, participatory promotion methods and publicity, for sensitization, and environmental education; marrying traditional knowledge, ideas and practice, while addressing accompanying fears of users; farmer exchange visits; identifying suitable equipment and promoting the same nationally and regionally; field testing by farmers in multi-disciplinary and multi-sectoral research, geared towards quantifying the real gains of conservation tillage. Technology transfer efforts need to capture environmental protection through gender-sensitve soil management techniques and planning. Other complementary approaches like agro-forestry and water harvesting practices need to be brought on board if the socio-economic well-being of all parties is to be fully supported. Back-up support will includeappropriate level capacity building at institutional and small industry level.

1, This paper is published in: Kaumbutho P G and Simalenga T E (eds), 1999. *Conservation tillage with animal traction.* A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Harare. Zimbabwe. 173p. Publication supported by French Cooperation, Namibia.
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1. Introduction

1.1 Conservation tillage: an important worldly subject

The problem of soil water losses through surface runoff and evaporation is one of the major limiting factors in agricultural production today. Especially in arid and semi-arid lands, short intense storms coupled with prolonged dry spells make crop production difficult, if not impossible. A rainstorm brings about soil water conservation considerations, within the context of the surface storage, infiltration and water holding capacity of the soil and the capacity to minimise evaporation losses especially through the dry periods.

Tillage is defined as the mechanical manipulation of soil for any purpose. Manipulation involves soil disturbance and this can have great deteriorative consequences if not carefully or adequately incorporated. Tillage modifies the soil surface where the complex and crucial partitioning of rainfall into runoff, infiltration and subsequent evaporation. Tillage modifies soil surface structure, total porosity, macro-porosity, pore continuity and pore size distribution and therefore has great influence on the hydrology of an agricultural catchment (Mwendera, 1992).

Tillage influences the upward movement of moisture to the soil surface, vapour transfer from the surface to the atmosphere and heat transfer to the soil. Tillage therefore affects soil water evaporation and will do so differently in arid and humid environments. The properties of the plough layer and particularly the surface characteristics are time variant. Models of soil water transport can and have been used to help understand the effects of tillage (Klute, 1982).

Conservation tillage (Contil) is but one aspect of global, regional and national interest and importance in environmental conservation. For East and Southern Africa (ESA) the subject has special importance, considering that it touches directly on agricultural production and more so, in the majority semi-arid and arid tropics, which carry over 50% of the population. Additionally, ESA has about 80% of the population involved in smallholder agricultural production, utilizing traditional means of land preparation. The region also has some of the world's poorest population and it is unlikely that such people can have time for environmental preservation among other pressing needs, in a life of uncertain food security.

This situation makes Contil work and development in ESA to be incomplete, unless it addresses somewhat unusual or extra-thematic issues which are non-technical, economic and socio-political. Compared to the mechanized high input agriculture of the western world, conservation tillage in the tropics of sub-saharan Africa must be considered much more broadly, even if just to accommodate the highly variable eco-system.

Between the semiarid and arid planes of Namibia and the highly humid highlands of Cameroon and every climate and soil condition in-between, ESA is indeed a region of contrast. The region presents a highly defined ethnic and loosely structured and variable socio-political and other development scenario, which is highly influenced by practices or issues such as land tenure, pastoralism, shift-cultivation and others. Like the rest of Africa, ESA presents a complex system in which to address the Contil challenge. Indeed, in ESA the environment has become everybody's concern as well as frustration. Urban migration, movement to lower potential land in lower altitude locations, among other tendencies has brought in many factors of environmental sustainability, which have placed the region under great threat of total destruction.

In the region, environmental degradation is most likely to be associated with urban areas, while the erosion of large straits of idle semi-arid and arid lands goes un-addressed. High potential land is not spared as can be observed in streams and rivers which remain dark brown, throughout the rain season. Pollution by factories and motor vehicles which have recently been associated with subsequent global warming are small subjects in this region where there always seems to be more urgent problems in economically suppressed political economies.

In the agricultural sector soil and water conservationists have mostly addressed soil erosion and how mechanical approaches such as terracing, can be the answer. More recently, agroforestry efforts and promotion have brought in the tree as a structural aid and a source of biological wealth to the otherwise degraded land. The agroforestry approach has progressed a step into multi-disciplinary and multi-sector approach to agricultural land management. It also built on the indigenous techniques of soil conservation practiced for centuries by smalholder farmers in humid areas.

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Box 1: **Soil degradation or declining fertility**

"Soil erosion, widespread in all areas of Sub-Saharan Africa, is perhaps most serious in Ethiopia, where topsoil losses of up to 290metric tons a hectare/yr have been reported for steep slopes. In West Africa, losses of 10 to 20 metric tons of soil per hectare/yr have been reported even for very gentle slopes. Wind erosion is significant in drier areas. There are numerous reports of a decline in the fertility of cultivated land in many parts of the region. A common feature of degradation is the removal of weakening of vegetative cover by overgrazing, over-cultivation, or deforestation, which exposes the soil to rain and wind. With several notable exceptions government efforts to combat soil degradation have failed because soil conservation usually requires the farmer to provide extra labour – labour that is often unavailable. Moreover low prices for produce coupled with uncertain land tenure make conservation financially unattractive." [IBRD (1989)]

"The grave erosion which occurs on ploughland from time to time has often induced an "old-timer" to say ruefully that we should never have put a plough into Africa. However, the relatively unscarred Africa which carried a small population on the basis of shifting cultivation remained curiously unprogressive in a world which was advancing in scientific knowledge by leaps and bounds. Western interference caused the population to increase while accelerating the rate of deterioration of the soil. The biggest problem is not the soil directly but the people on the soil. Soil must be used by good farmers to remain productive. The emphasis must always be on the people who care for the land, not directly on the land. A poverty-ridden people pass their suffering to the soil" (Maher, 1950).

Mrema (1996)

In less obvious ways, agricultural soil degradation and water losses have hardly been associated with tillage, its drudgery and power requirements. Tillage however remains, a great contributor if not the prime cause of soil degradation and erosion. In some ways the absence of special consideration for tillage as a prime issue may be associated with the young agricultural engineering profession in the region.

Traditional manual tillage or higher level, animal draft technologies have remained void of common-knowledge awareness of the importance of tillage and its practice. Technologically, neither the common hoe, nor the animal drawn mouldboard plough have offered much choice or creativity with regard to tillage. In largescale farming and especially so for wheat farmers, modern tractor based tillage has seen a wider level of choice, knowledge and creativity as these farming systems have borrowed directly from the developments of the Western World. In this regard, tine implements and single pass, minimum or no-till pneumatic seeders and other implements such as the prickle harrow have been introduced.

For example, in Kenya it is common to see a large scale wheat farmer in Timau area with a bumper wheat harvest when all the smallholders around them have a total crop failure especially in seasons when rainfall is scanty. The large farmers are able to use technology to break their hard pans and, in doing so build giant natural water "tanks", in which they store enough water for the season. At the same time the smallholder farmers, using the hand hoe or traditional animal drawn mouldboard ploughs find themselves busy expelling the little moisture that has been received to the thirsty sunshine. They do this by the traditional heavy soil manipulation in primary or secondary tillage operations.

1.2 The concept of sustainability

The concept of sustainable development emanated from the document developed by three international agencies: World Conservation Union, United Nations Environmental Programme (UNEP), and the World Wildlife Fund (WWF) in 1980 (Dieren, 1995). Later in 1983 the World Commission on Environment and Development (WCED) was established by UN General Assembly "to undertake a global enquiry on the prospect of combining social and economic development with environmental protection". It was anticipated that the Commission would work out proposals for long-term environmental strategies which would stimulate a sustainable development in the foreseeable future. The Commission compiled an important document (WCED, 1987) where the concept of sustainable development was formulated as were legal principles for environmental protection and

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sustainable development. The Commission defined sustainable development as:

"...development that meets the needs of the present without compromising the ability of future generations to meet their own needs…"

physically and biologically. Two main problems are associated with soil erosion:

i) the very fertile top soil is washed away to rivers while,
ii) deposition of erosion is a major source of air and water pollution.

Box 2: **Sustainable agriculture**

The enthusiastic response to "sustainable agriculture" by scientific community and policy makers is due to severe problems of soil and environmental degradation, pollution of water and environment, and over-dependence on non-renewable sources of energy. However, sustainability is often perceived as a moral or an ethical issue which has taken on an emotional air. Consequently, the topic of sustainability has become a political issue rather than a practical science, a religious myth rather than a generalizable concept, and an interesting theme to discuss and debate rather than a measurable system to evaluate and quantify.

In view of perpetual food deficit and severe problems of soil and environmental degradation in sub-Saharan Africa, sustainable agriculture is not necessarily synonymous with low-input organic or regenerative agriculture in this region. Scientifically speaking, ecosystems utilized by human societies are only sustainable in the long-term if the outputs of the components produced balance the input into the system. Because demand for output from agricultural ecosystems is greater now than ever before, and it is rapidly increasing due to high demographic pressure, no-input or even low-input agriculture is a non-solution. The issue to be addressed, however, is how to balance the inputs required so as to maximize efficiency and cost effectiveness of inputs, reduce risks of soil and environmental degradation, maximize the per capita productivity, and maintain or sustain an increasing trend in productivity.

Lal (1993b)

It should be emphasised that the concept has "needs" as the key issue and particularly reaching the poorest parts of the world by eradicating poverty and planning for the needs of future generations by preserving natural resources and protecting the environment.

Following the Commission's work, a series of international conferences on environmental issues have been held: the UN Conferences of Rio de Janeiro in 1992 and Kyoto (Japan) in 1997 on environment and the development. They were both meant to advance Agenda 21 whose content covers eradication of poverty and protection of environment, with emphasis on sustainable development in developing countries.

Soil conservation is important among global environmental and resource concerns. Sustainability in terms of soil conservation implies utilisation of soil without wastage or depletion, so that it is possible to have a continuous high level of crop production (Schwab et al. 1995). Soil and water resources of our planet are finite and are under already intensive use and misuse. Soil is being eroded at an extreme rate. Cultivated fields, overgrazed pastures, and deforested lands are suffering from erosion. An eroded soil is degraded chemically,

Soil erosion is therefore a potential environmental problem and erosion control is essential in maintenance of crop productivity of the soil as well as to control sedimentation and water pollution.

2. Background

2.1 The sub-Saharan Africa situation

Sub-Saharan Africa (SSA) has a population estimated at about 382 million in 1982, 433 million in 1986, and 490 million in 1990. At an annual rate of increase of 3.2% per year, the population is expected to approximately triple from 433 million in 1986 to 1263 million by the year 2000. The population may eventually stabilize at 10 times its present number (Table 1).

The region is characterized by a huge diversity of climate, soils, geology, hydrology, topography, ethnic groups and cultural heritage. Using Thornwaite's classification, about 37% of Africa is arid, 13% is semiarid, 23% is sub-humid, and another 13% is humid. Arid and semiarid regions are characterized by low, erratic and highly variable rainfall. Depending on these ecological regions, the climax vegetation varies widely depending on the amount and distribution of rainfall.

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Total arable land area of SSA is estimated at 131 million hectares (Table 2). The average per capita land area of 0.27 ha is only slightly lower than the world average of 0.33 ha. However, for the expected population of 1478 million by the year 2025, the per capita land area may be as low as 0.09 ha with no additional land brought under cultivation (Table 2), and 0.18 ha if new land is cleared at the rate of 0.6% per year of the existing rainforest (Lal 1993b).

Sub-Saharan Africa (SSA), is undergoing agrarian stagnation, becoming world famous as a region where natural resources are stressed to the limit and the place where food relief efforts have become routine. Concerns of accelerated erosion, desertification, deforestation and other human-driven destruction phenomena have placed SSA under recurrent threat of starvation and malnutrition.

Waterways and reservoirs continue to silt-up as rivers and lakes get polluted. From the agriculture perspective, and when tillage is given the broader meaning of "soil manipulation for any purpose" it is realizable that inappropriate tillage methods remain the major contributors to this trend.

Though loaded with high natural and economic diversity, SSA has 2231 million hectares of land, of which only 6% is arable. Annual rainfall amounts range from zero in the deserts to 5000mm in the highlands and all major soils are present.

Despite various but non-comprehensive efforts put in place at national and regional level ESA gains have been more in terms of economic and political togetherness and less so, by way of communally or regionally arresting environmental degradation. Environment preservation needs to be addressed across the borders as solitary efforts of individual nations simply do not do. It is noteworthy that, in ESA, human capacity is no longer as limiting as a few decades ago. Africa has the human capital needed to develop physical resources. Recent decades have seen the development of manpower with all the skills needed for the broad range of human needs. Technical manpower is especially strong in populous countries, like, Nigeria, Ghana, Kenya and Zimbabwe. In fact, unemployment and under-employment of trained personnel has contributed to mass exodus to European, North America and the Middle East (Lal, 1992).

The greater shortcoming is probably the general sense of environmental sustainability. With the potential adequately exploited, soil resources of Africa are adequate to support an acceptable standard of living for the current and future populations of SSA. FAO (1984) reported (see Table 3) that SSA could support 1120 million people at low levels of input, 4608 million at intermediate levels and 12930 million at high levels of input. The report was written at a time when the SSA population was only 400 million.

Table 1: **Projected population of sub-Saharan Africa+**

Region	1986	1990	2000	2025	2050
	Millions				
Western Africa	189.7	215.2	294.9	648.1	1357.0
Eastern Africa	133.5	151.4	207.5	456.0	954.8
Central Africa	48.1	54.6	74.8	164.4	344.2
Southern Africa	61.3	69.5	95.2	209.2	438.0
Sub-Saharan Africa	432.6	490.7	672.4	1477.7	3094.2

+ Rate of increase : (i) 1986 to 2000, 3.2% yr (ii) 2000 to 2025, 3.2% yr; and (iii) 2025 to 2050, 3.0 % yr.

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Table 2: **Arable land resources of tropical Africa assuming no further deforestation (calculated from FAO, 1986).**

Region	Total arable land in 1990	Per Capita arable land+ 1990	2000	2025
	10^6 ha		ha	
Western Africa	62.0	0.29	0.21	0.10
Eastern Africa	37.7	0.25	0.18	0.08
Central Africa	10.8	0.20	0.14	0.07
Southern Africa	20.5	0.29	0.22	0.10
Sub-Saharan Africa	131.0	0.27	0.19	0.09

+ Assuming no additional land is brought under cultivation, and that population continues to increase at 3.2% yr^{-1}.

Table 3: **Population carrying capacity of Africa for different scenarios (FAO, 1984).**

Carrying capacity at different input levels	People	Ratio to population of 1975*
	Millions	
Low input	1120	3
Intermediate input	4608	12
High input	12930	24

* Actual population in 1975 was 380 million.

Despite the high potential and vast resources, it is ironic that the extent of soil and water degradation in Africa is equally alarming. Natural resources are severely degraded because of mismanagement, exploitation for short-term gains and widespread practice of low input subsistence farming (Lal, 1988, 1990). Resource-based continuous cropping, even at low levels of productivity can lead to an average nutrient loss of 10 kg N, 1.8 kg P and 7.1 kg K ha^{-1} yr^{-1}. The rate of nutrient loss is about twice as much in Eastern Africa, and is likely to increase because of the increase in demographic pressure and intense cropping.

Despite common belief, Africa has an impressive history of high-quality research data. Some of this research was initiated in early 1930s. History of research in soil and water management and crop improvement was summarised by Lal (1992).

2.2 The Conservation Tillage System:

The conservation tillage system can be viewed as composed of natural factors, which influence the various human and other capacities to manage soil. In this respect, soil is viewed as a small part of a larger system, made up of natural and management factors. Management factors are strongly influenced by various capacities, which in turn are dependent on the natural factors. Of essence, soil has to accommodate all and various needs imposed on it by both nature and humans.

For example, a soil in say, southern Sudan has certain natural qualities which will determine its conservation input level and needs. The manager may have strengths or weaknesses in capacity to manage soil and may for example need animal traction input and conservation tillage implements which may or may not be available. The same farmer may have the animals and equipment but have shortcomings in design, training, maintenance and other capacities. These capacities may be limited due to natural, technological or socio-economic factors. This vicious cycle may explain why conservation tillage is such a complex and multi-sectoral involvement.

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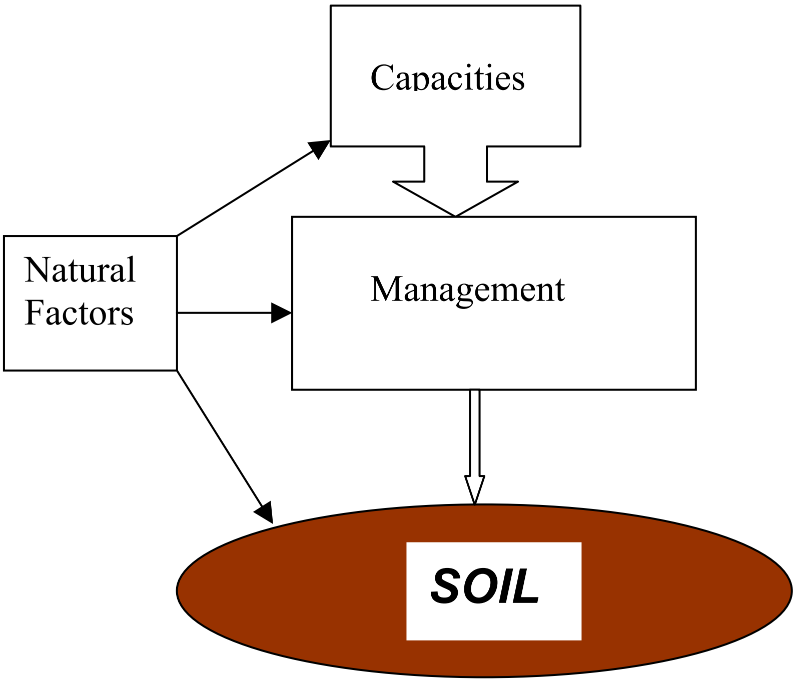

Figure 1. **The conservation tillage system**

Natural factors can be visualized as:

- History and trends,
- Cultural complexities such as values, societal and gender-based roles,
- Weather and climate,
- Topography and cover,
- Soil type and distribution and
- Other phenomena such as global warming.

Capacities can be visualized to be:

- Experience and information,
- Training (formal and informal),
- Socio-economic well-being,
- Technology quality and accessibility,
- Research and extension and
- Government and non-Governmental institutional support including policy.

Management factors are such as:

- Role of people and their involvement,
- Natural resources, their place and rights,
- Land tenure, ownership and settlement,
- Leadership and natural resource policy,
- Legal base and establishment,
- Dynamic capacity to adjust to and address changes within development trends and
- Action and not reaction: where the tendency is to cure other than prevent environmental degradation.

Soil factors are such as:

- Basement material, structure and texture,
- Microbial capacity, profile and cover,
- Manipulation and compaction dynamics as well as sitting operational condition,
- Erosion stability, penetration resistance and water retention capacity and
- Tillage energy and other requirements.

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2.3 Conservation tillage questions for East and Southern Africa

2.3.1 Crop yields and potential

Potential yield of most crops in SSA can be increased two to four times by judicious use of off-farm inputs such as chemical fertilizers, appropriate farm tools, improved varieties, etc. (FAO, 1978; see Table 4). With traditional systems of resource-based agriculture, agronomic yields of most crops are low. An important reason for low yields is the widespread system of no-input, resource-based, subsistence farming. For example, the average fertilizer use in SSA, although more than doubled over the decade ending 1987, was merely 8kg ha^{-1} of major nutrients. There is a potential for irrigation to mitigate the drought. However, currently only 5 million hectares of land is being irrigated. Furthermore, use of improved cultivators and of high production systems is currently limited to merely 5 to 6% of the arable land (Lal, 1993b).

2.3.2 Contil questions

In addressing the conservation tillage problems and progress in ESA, three basic questions need to be addressed:

1. What are the complexities of the general Contil effort and what are the real or specialized challenges the region and individual countries must contend with?

2. Are there adequate technologies and techniques available to manage soil and water resources for the much needed enhanced agricultural productivity?

3. Are the available conservation tillage technologies being adopted and what further action is needed to arrest the prevailing deteriorating situation and destruction of fauna and flora?

2.4 Why conservation tillage?

Conventional tillage practice is one where the hand hoe is used each season to dig and turn the soil over, with an effort placed to break the clods and leave a fine tilth. When animal power is used farmers make several runs with the mouldboard plough, while they remain unaware of other equipment like harrows and ridgers. Where these

Box 3: **Technology adoption in SSA**

An important question that has repeatedly been asked is whether technically viable and station – proven technologies are being adopted. The answer to this question is no. Most technological innovations have proven successful in on-station experimentation and in research-managed on-farm trials. However, farmers of SSA have not abandoned the age-old traditional systems based on hoe, machete, and the match box. The absence of poor adoption of improved and apparently high-yielding technologies deserves the attention of sociologists, anthropologists, policy makers, and extension specialists. One of the principal reasons for the low rate of adoption is the topdown approach of research, without the participation of the farmer in prioritizing critical issues, defining research methods, and in validating and adopting the technology by fine tuning it to local conditions. Researchers often perceive a research problem according to their assessment of the farmer's constraints to enhancing production. Researchers design methodology for on-station or on-farm experimentation, develop a hyphothesis, collect and analyze data and publish results without interaction with farmers. It is not surprising, therefore, that the so called "improved technology" is often rejected by the farmers of SSA. Agricultural sustainability is extricably linked with recognition of the farmer being the premier research client and with the farmer's effective participation. Has response by donor agencies been timely, adequate and effective in providing financial assistance to overcome the crisis and alleviate sufferings? An answer to this question is vividly presented by Lele (1991). It is argued that over the three decades ending in 1990, billions of dollars have been transferred from developed countries to Africa. It seems, however, that most of this aid has been rather ineffective in stimulating growth, breaking the vicious cycle, and alleviating poverty and human suffering. The problem lies both with national policies and donor perception. Furthermore, donors need to coordinate their assistance with regard to long-term development strategies and institutional building.

Overall, the success rate was about 25% for projects initiated in 1970s and 56% for those initiated in 1980s. Similar conclusions of low success rate (12-40%) were arrived at by a survey conducted by the World Bank (1984; 1985, p.38-43; 1986). He concluded that technology should be appropriate and tested locally; offer short-term, on-site benefits, and large increments (50-100%); require affordable inputs, especially labour; not include foregone benefits, e.g., giving up land; not include any increased risk; and be in tune with existing social factors, e.g., the separate roles of men and women in agriculture.

(Lal 1996)

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equipment are known they remain out of reach due to supply shortcomings or cost. These farmers however still work to achieve the traditional fine tilth, which in most cases is unnecessary. With ongoing shortages hitting tillage, weeding and other labour needs, animal traction will continue to have a place in the smallholder farming system.

Table 4: **Yield potential of crops**+

Land capability	Input	Millet	Sorghum	Maize	Soybean	Bean	Sweet Potato	Cassava
		Mg ha^{-1}						
Very suitable	Low	0.9	1.1	1.6	0.7	0.7	2.2	2.0
	High	3.5	4.6	6.4	3.0	3.0	9.1	12.2
Suitable	Low	0.6	0.8	1.0	0.4	0.4	1.5	1.0
	High	1.8	3.0	4.2	2.0	2.0	6.0	8.1
Marginal	Low	0.3	0.4	0.5	0.2	0.2	0.7	0.3
	High	1.2	1.5	2.1	1.0	1.0	3.0	4.0

+From FAO (1978)

Conservation tillage has been defined in various ways which all capture the need for less soil manipulation, hence reduced energy requirement and capacity to leave crop residue on the soil surface during all tillage operations (primary or secondary). The common theme is one of reduced soil and water losses.

Due to continued use of traditional manual, animal drawn and even tractor drawn mouldboard ploughing, many farms in ESA have lost large amounts of soil to erosion. Especially where disc and mouldboard ploughs (both animal and tractor drawn) have been used consistently, hard pans have formed and soils no longer have capacity to allow easy percolation of rain or irrigation water. This situation is as bad for humid, as it is for semi- and arid areas. Reduced percolation leads to deprivation of water and nutrients from plants as roots are unable to dig into lower soil zones. Overall, a case of increased runoff results. Traditional tillage systems generally are energy intensive and leave behind overly pervourized soils with destroyed soil structure. The high energy tropical rain storms easily carry away soil from the desirable but vulnerable fine tilth seedbeds, which farmers insist on having.

Oldreive, (1993), a practising farmer helped show clearly the gains of higher input agriculture as well as conservation tillage. Chart 1 below shows how a higher investment in better farming standards can easily translate into higher profits per unit of land.

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Fewer hectares with higher standards mean more profits

Example 1:

2 ha @ 2 t/ha	= 4 t @ $900/t	= $3600
Costs	= 2 ha @ $1578/ha	= $3156
Gross Margin		= $444 profit

Example 2:

1 ha @ 4 t/ha	= 4 t @ $900/t	= $3600
Costs	= 1 ha @ $1876/ha	= $1876
Gross Margin		= $1742 profit

Example 3:

1 ha @ 6 t/ha	= 6 t @ $900/t	= $5400
Costs	= 1 ha @ $2175/ha	= $2175
Gross Margin		= $3225 profit

The areas here are only representative and will vary according to the situation.

Chart1: **Examples of the gains brought by higher input agriculture (Oldreive, 1993)**

The effect of two simulated storm trials on water run off and soil loss

a) 63mm rain in 1 hour on 4% slope

Treatment	Water Runoff %	Soil Loss t/ha
Deep ploughed and disced	90	28.5
Ripped and disced, 10% stover cover	70	6.7
Chisel ploughed and cultivated 30% stover cover	34	1.6
Zero-tilled, 80% stover cover	6	1.0

b) Two consecutive day treatments; total of 125 mm applied in 2 hours

Conventional till	- 52 mm infiltrated	Tractor could only get in after 2 to 2 days
Zero-till	- 122mm infiltrated	Tractor could get in after 4 hours

Chart 2: **The advantages of conservation tillage illustrated (Oldreive, 1993)**

Chart 2 however helps to show that even with higher inputs such as fertilizer, tillage is an important practice for enhanced machinery and crop performance. The information on Chart 2 helps show the gains of conservation tillage.

The case is reported where no-till practice, where 80% stover is left on the surface is compared to reduced tillage, chisel ploughing and conventional disc tillage. It is shown that the higher energy tillage methods led by conventional tillage, led to increased runoff, hence soil loss, with dramatic difference, though

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on only 4% slope land. Section b) of Chart 2 shows how, with less or no tillage, machinery was able to go into the field and work, much sooner following a storm, while at the same time much more rain water infiltrated into the soil for the less-tillage case. It is common knowledge that machinery can be highly destructive of soil structure when used especially under soil conditions that are beyond the liquid limit.

2.5 Regional efforts towards conservation tillage and case studies

There have been several concentrated efforts towards eventual introduction of conservation tillage at farm level in the SSA region. These efforts have been in research stations and institutions while more recently, and on some cases they are reported to have moved to the farmers farms, adopting more participatory approaches. The efforts have seen various degrees of success. In turn the efforts have taken various forms of localized and national ventures with minimal regional integration for dissemination. Duplication of efforts has not been absent.

Work carried out in introducing conservation tillage research and management at both stations and farms includes that by: International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria; International Centre for Research in Semi-arid Tropics (ICRISAT) Sahelian Centre, Niamey, Niger; Zimbabwe's Agricultural and Technology Extension Services (AGRITEX) in collaboration with various European institutions such as Silsoe Research Institute; works of Kenya Agricultural Institute (KARI) and Regional Land Management Unit (RELMA), formerly Regional Soil Conservation Unit (RSCU) in Kenya, the Palabana, Zambia work on CONTIL equipment, the Improved Maresha prototype Contil project by University of Nairobi and Swedish University of Agricultural Sciences (Gebresenbet and Kaumbutho, 1997) among others.

At an FAO/FARMESA led meeting in Harare (June, 1998), the idea of forming a regional network on Contil was floated and intensely discussed. Where Contil studies have persisted in the ESA region and even better, gone from the research station to the farmers' fields, real progress has been recorded although mass adoption of technologies is yet to follow. Various technological advances have been made, with greatest impact where introduction of equipment has been backed by multi-disciplinary research teams looking at:

Box 4: **Striking the balance**

Although a comparatively large amount of research and development work has gone into various conservation tillage systems in Zimbabwe, farmers in both large and small scale sectors have been slow to adopt them. This reluctance can be attributed primarily to conservatism, rather than to technical or socio-economic factors, though the latter obviously play a part. It must be recognised that none of the currently available conservation tillage techniques are truly sustainable in terms of preserving soil, rainwater, nutrients, soil structure and the ecosystem. Nevertheless, some hesitant steps have been taken locally to reduce the environmental damage resulting from annual ploughing combined with mono-cropping and over-reliance on chemicals. Tine planting into residues has the potential to reduce losses of soil, rainwater and nutrients to levels close to sustainable ones, and significant improvements in soil structure have been recorded under this treatment; but the technology still depends on large inputs of chemicals and has been tested for only a limited number of crop rotations. The locally developed system called no-till tied-ridging is particularly suited to the communal areas as hardy residues are recommended to be fed to the cattle and would be a hindrance in land preparation if left on the surface. Losses of soil, rain and nutrients are reduced to very low levels under this system but no significant improvement in soil structure has been recorded. The experiment no-till strip-cropping system is the closest approximation to a sustainable low-external-input system yet devised locally. Negligible soil, rainwater and nutrient losses have been recorded with soil structure being maintained at levels similar to virgin ground.

Tillage increases water holding and transmitting properties of the soil. The more open the tillage-induced structure the greater are these increases. However, at high rainfall intensities the effect of tillage in enhancing these properties is undermined by the structural breakdown of the surface layer which results in greatly reduced water intake rates. The finer the tillage-induced surface structure, the more vulnerable it is to structural damage. The effect of tillage on evaporation depends on the surface structure and the level of atmospheric demand. At lower evaporation demands rougher than smoother surfaces. However, at high evaporativities, tillage tends to induce more evaporation losses. It appears that the argument that tillage reduces evaporation losses through the “soil mulch” theory tends to hold at relatively low evaporativities.

Elwell, (1993).

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- the equipment, its design quality, sustained production and marketing,
- farm level crop yields as affected by the introduction and use of Contil equipment or practice,
- participatory approaches where not just technological but also socio-cultural and economic constraints to adoption have been addressed.

It may be argued that the most successful programmes have been those of Zambia and Zimbabwe. From these, complete animal drawn equipment packages covering the range of primary as well as secondary tillage operations have come to existence. In no-till and minimum tillage systems energy saving direct seeding equipment have been manufactured. Due to high weed infestation in these systems animal drawn cultivators have also been developed.

Examples of equipment developed are such as the Mogoye ripper and its wing attachments which easily make it a Contil ridger and weeder; or its planter attachment which makes it a direct seeder. The animal drawn subsoiler, one version from Zambia and another from Zimbabwe are but a few examples of the range of equipment developed in the region. Others are such as the tie-ridger, a most useful light equipment which helps conserve moisture in the driest areas. Some efforts have attempted to modify the traditional Ethiopian Maresha among other efforts.

2.5.1 Farmer management, soil and micro-topography

Working in Botswana Harris et al (1992) analyzed farmers practices with regard to management and soils, micro-topography and tillage options. Farmers commonly grew a variety of crops with mixed stands of sorghum, maize, water melon, cowpeas and sweet sorghum. Most farmers broadcast their crops and this resulted in areas of high and low crop density. Row planting provided better control of plant population densities reducing the inter-plant competition and facilitating weeding.

The work in farmer's fields highlighted the importance of accessibility to draught animal power for timely cultivation and planting. Good crop establishment was clearly a key factor for good productivity. The spatial and temporal variability of the rainfall and the spatial variability of soil properties were confounding factors in comparing the influence of sites and soils on crop production.

Micro-topography (small differences in surface elevation, 0.2 –0.8m, over distances of 20-50m, not associated with the overall slope) was identified as a major scale of within field variability. The high areas were commonly associated with termite activity and the soils were generally more fertile with higher pH and clay content than low areas. However the high areas (despite greater available water holding capacities) were always drier than low areas where runoff landed.

Several tillage options were tried including tie ridging and strip tillage. Cultivation was shown to improve the infiltration into the soil. Despite the complications introduced by micro-topography, double cultivation appeared to improve crop establishment. This was attributed to better soil moisture conditions early in the season through improved infiltration and weed control.

For ***tie-ridging***, the system did have effect of preventing redistribution of water within fields, while concentrating water in the furrow bottom. The seed was sown in the base of the ridge and was close to the subsoil as most of the top soil had been used to form the ridge. This positioning of the seed avoided the potential water logging effects of the furrow bottom and the dry conditions in the ridge top. The early development of the plants was always slower than in the flat row planted control, due to soil compaction in the root zone. Planting in the ridge top was not a feasible option as this was the driest soil. Although such a system could not be recommended a modified wide-bed, tied ridge and furrow system appeared more promising.

Extensive research was conducted into ***strip tillage*** systems, where alternate bands of soil were cropped and kept bare, both under well controlled experimental conditions and in farmers fields. Water flowing through a series of such crop strips was likely to result in a cascade effect with consequent soil erosion problems.

2.5.2 Water harvesting and agronomic practice

Water harvesting from off-field sources was also explored. There was potential for such schemes to benefit other farmers. No specialist equipment was needed for construction of bunds. Each site would however have required specific investigation and design to fit socio-economic aspects.

Various ***agronomic and management factors*** were considered. The need for timely sowing

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with respect to rainfall was most important, more so for farmers who relied on contract cultivation. It was shown that even with optimum soil moisture conditions at sowing, subsequent conditions, if hot and dry, still reduced establishment. Seed soaking was shown to be one method of speeding up early growth and enhancing establishment and merits further investigation.

Agro-climatology studies were also conducted to provide an understanding of the spatial temporal variability of rainfall. While large differences in seasonal rainfall were evident between sites, the differences between years at a given site were much greater.

Among other points, the study concluded that:

1. Net runoff losses from cultivated fields were small and inconsequential in comparison with the effects on crops of inefficient management.
2. Runoff losses could be substantial from rangeland with sparse vegetation cover. Grazing could be managed to minimise runoff or to maximise runoff for use in a downslope crop area. The latter would however degrade the land.
3. Redistribution of rainfall within fields as a result of widespread micro-topography was a far more serious problem for arable agriculture. Large asymmetries in the system had important consequences for crop production because they reduced the level of control exercised by farmers over their operations.
4. Systematic variations in the micro-topography were associated with termite activity. These formed an environmental mosaic with large interactions between surface water mobility, available water-holding capacity, fertility and the destructive habits of the termites themselves. The system was extremely dynamic and relative cropping outcomes depended on a further interaction between rainfall pattern and sowing date.
5. Soils varied widely in the major components of available water holding capacity influenced by depth and texture. This variation was loosely correlated with position in the landscape, but also influenced by the nature of parent material.
6. Current cropping strategies involved minimal inputs by farmers who perceived arable farming to be a high-risk occupation. Crop production was not viewed as a high priority. Such an outlook was possible in Botswana because the buoyant economy offered alternative sources of income.
7. Levels of land management and crop husbandry were very low. Consequently, production was "sustainable" because off-takes were small. Improved management, which was a prerequisite for improving crop yields needed to be addressed.

2.5.3 Farmer-centred research

Working at Makoholi Experiment Station in semi-arid Zimbabwe Mashavira et al. (1997) described yield responses of commercial cotton to reduced tillage systems and the evaluation of innovative combinations of low-input tillage and weeding systems. The tillage practices adapted farmer practices and implements that were available to the communal area farmer, namely the mouldboard plough and the five-tine cultivator and ripper tine for maize production.

They concluded that open plough furrow planting (OPFP) with an ox-plough and ripping a planting line to a depth of 30 cm offered alternative crop establishment options that could be successfully implemented on ploughed or fallowed (reduced tillage) land without any yield reduction. In fact, for the scenarios they described, maize yield increased between 20 and 300% over hand planting. Although ripping to 30 cm required more labour than OPFP, the grain yield returns more than compensated.

2.5.4 Adding efficiency to current animal traction systems

Mbanje (1997) analyzed implement and selection factors with an aim of achieving practical opportunities to reduce draft demand. He did this by exploiting ways of having a multi-operation single pass, correct implement adjustment for right orientation, whereby, orientation referred to the position of implement in relation to the direction of movement of work animals (Gebresenbet, 1991). Other factors considered were ploughing speed and equipment hitching and harnessing, maintenance, and cleaning. Soil factors were such as choosing when and how to plough.

Caring for the soil, involved the way it was cultivated and the nutrients that were added to it. For example, addition of manure and organic matter helped reduce draught demand. The author however did not reach any quantifiable gains and recommended further work on this, much neglected subject of efficient tillage and use of animal traction.

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2.5.5 Conservation tillage and erodibility

Chuma (1993) applied mulch ripping, clean ripping, no-till tied ridging and hand hoeing. No-till tied ridging and mulch ripping showed lower total soil loss than the other treatments. Checking the tillage effects five years (measured annually) after the treatments were applied, erosion and penetration resistance were evaluated by determining organic carbon content, percent clay in the upper root zone structural stability, infiltration and soil strength.

Conservation tillage treatments showed lower organic carbon reductions than conventional tillage, mulch ripping treatment however, showed slightly better structural stability than conventional tillage. Hand hoe treatment showed high soil strengths likely to inhibit root penetration.

Chuma (1993) concluded that minimal soil disturbance as by ripping operation combined with improved soil fertility and ground cover could contribute to improved erosion resistance. He confirmed fears that present tillage practices were depleting (maybe upto 2.5m tonnes/annum) organic carbon leading to increased erodibility.

2.5.6 Weeding, labour use and returns

Weeding is an important consideration in conservation tillage systems and can be a major shortcoming to the promotion and eventual adoption of Contil technologies. Riches et al. (1997) reported that weeding accounts for upto 60% of the labour used in maize production in semi-arid Zimbabwe (MLARR, 1992). Because of poor returns from cropping and an acute shortage of labour in many households, conservation tillage and weed control systems should be based on low cost, labour-saving technologies (Ellis-Jones and Mudhara, 1995). While 76% of households in southern Zimbabwe own a plough, only 23% own an inter-row cultivator (MLARR, 1992). Weeding is undertaken by plough, cultivator, hand hoe or a combination of methods depending upon implement ownership, draught power and labour availability. If a plough is used, farmers usually remove the body (mouldboard) leaving the share as the operational weeding blade. They recognise that timely inter-row cultivation is important for weed control and for maintaining a rough soil surface which can retain subsequent rainfall (Ellis-Jones and Riches, 1992).

Table 5: **Maize grain yields (kg ha^{-1}) labour requirements for weeding (h) and return to weeding labour (kg yield h^{-1}) for four weeding systems at the Makoholi Experiment Station.**

		Labour requirement for weeding			Return to weeding
		Manual	Mechanical	Total	
			1992/93		
Hand weeding	5195	132.5	0	132.5	39.3
Cultivator	4552	52.2	16.2	68.3	66.7
Plough with body	4345	26.8	28.3	55.2	78.7
Plough less body	2766	45.4	40.4	85.8	32.5
			1993/94*		
Hand weeding	2251	126	0	126	17.9
Cultivator	2092	45.3	15.1	60	35.0
Plough w/ body**	3047	20.3	36.8	57	53.5
Plough less body	1636	45.3	36.3	82	20
			1994/95		
Hand weeding	3670	155.6	0	155.6	23.6
Cultivator	3990	42.6	13.5	56.1	71.1
Plough w/ body**	3896	0	34.6	34.6	112.6
Plough less body	2590	41.4	34.7	76.1	34.0

*labour for hand weeding estimated from on-farm records;
** ridges were tied after weeding in 1993/94 and 1994/95.

Weeding by mechanical systems required less labour than hand hoeing (Table 5). With the body removed the plough had an effective working width of only 25cm so three passes were needed to weed each inter-row. The plough with body system gave the greatest return in terms of maize grain yield per weeding hour (Table 5), even when the plough system resulted

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in lower yields than hand weeding or the cultivator system.

Mid-season ridging at the time of weeding, which could be used in combination with widely used plough and planting systems, was a versatile method of preparing a water conserving landform. It could also provide timely weed control following tine tillage, that is planting along a rip line (Shumba et al., 1992). Farmers would then have a low draft system of plant establishment without the requirement for additional weeding labour caused by early weed growth in the untilled interrows. This approach to reduced seed-bed preparation may allow conservation tillage to be introduced where other systems such as mulch ripping (for example, Anazodo et al., 1991) are impractical because the crop residues are used for livestock feed. Other potential benefits, as yet unquantified, were the effects of the previous season's tied ridges on the conservation of early spring rainfall, prior to spring tillage.

2.6 Technology advancement

Conservation tillage and technology needs to be defined in the broad sense. Contil technology is much more than animals and their care, implements and equipment, crop varieties and their management and even soil and water management techniques. In recent days the broader approach to technology and its transfer calling for multi-disciplinary and multi-sector approach has become necessary.

The need for systems approach to conservation tillage and management needs emphasis. Technology includes sustainable soil and crop management options available to farmers in the region. Among the various equipment that have been introduced in ESA, the range of practices include technology for seedbed preparation, planting and erosion control. Biological conservation technologies are such as agroforestry, mulch farming, contour and strip cropping, legume-based crop rotations, cover crops and green manures, mixed farming practices based on controlled grazing, use of farm-yard manure and others.

Conservation tillage technology needs to be seen and defined to include these and what may be called physical technologies such as no-till, minimum-till, vegetative hedges, sod-seeding, contour ridges, tie ridges, mulch farming, terracing, rough-ploughing, deep sowing and pot-holes, among others (see Chart 3). Time when these various technologies, or accompanying operations are applied is of prime importance. Time determines not only what is possible when, but also the energy requirements, operational efficiency and yields.

Dry-planting and pre-season hard pan breaking are some of the practices which are of great significance especially in areas of limited rainfall amounts.

Generally, physical technologies involve implements and tools which, in many applications add work and energy efficiency towards applying the biological technologies.

2.6.1 Research Findings versus traditional practice

Most field operations particularly by small-holder farmers are performed manually thereby limiting the area cultivated per person. The fact that most operations are performed by hand limits the extent to which farmers can adopt certain conservation tillage practices as draught power or mechanisation is almost always a requirement.

Thus the development of mechanical power has been related to scales of production associated with the colonial history of the respective countries. The adoption of conservation tillage systems is related to the resource ownership of the farmers particularly draught power. In Zimbabwe for instance it is estimated that 5-10% of the commercial farms are under true conservation tillage whilst the use of conservation tillage in the small-holder farming sector is estimated to be below 1% (Nyagumbo, 1998).

Assessing the potential for adoption of advancing technology and specifically on weed control in the region Nygumbo (1998) reported that weeding effort which accounted for more than 60% of the labour used for maize production, was greatly eased by animal drawn cultivators and ploughs used to control weeds. The efficiency of weed control was also found to greatly improve where farmers used re-ridging with the plough as a weed control measure under no-till tied ridging in the sub-humid north of Zimbabwe (Nyagumbo, 1993). The technology utilization remained low. Comparatively in the larger scale commercial farming sectors of Zimbabwe, Zambia and South Africa the spread of Contil technologies could be attributed to the availability of suitable machinery and the herbicides which have tended to be unaffordable to small-holder farmers in Zimbabwe.

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Operation	Sustainable Management Option
Land clearing	Manual, chain saw, shear blade
Biomas disposal	In-situ burning
Fertility maintenance	Cover crop, residue mulching, vegetative hedges, agroforestry, farmyard manure, cover crops, supplemental dose of N and P, rotations, kralling, organic ammendements, banding
Seedbed preparation, planting or erosion control measure (technology)	No till, Minimum till, vegetative hedges, sod seeding, contour ridges, tied ridges, early sowing with onset of rains, mulch farming, soil inversion in dry season, terracing, rough ploughing at end of rains, high seed rate, deep sowing, diggets/stone lines, water harvesting, supplemental irrigation, micro-catchments, ridge-furrow system, potholes, pre- or post-planting ridges

Converted from Lal 1993a

Chart 3: **The broad definition and aspects of conservation tillage technology**

Table 6: Sources of power for primary land preparation in 5 SADC countries

Country	% of cultivated land Human muscle power	Draught animal power	Mechanical power
Botswana	20	40	40
Kenya	84	12	4
South Africa	10	20	70
Tanzania	80	14	6
Zimbabwe	15	30	55

Source: Ellis-Jones, 1997

Farmer management capabilities will remain an issue in gauging possible progress as conservation tillage systems call for higher levels of management and this has tended to contribute towards low adoption rates. Small-holder farmers own less than 5 ha of land in most countries in the region and because of this they do not want to risk crop failure by using technologies they are unfamiliar with, especially considering their labour and resource limitations.

2.6.2 Contil initiatives and efforts by nations in the ESA region

Nyagumbo (1998) summarized some of the Contil activities of selected countries in the ESA region:

In ***Zambia*** the currently practised soil conservation measures include contour ridges and grass strips across the main slopes. The lack of effective enforcement laws after independence led to a complete collapse and abandonment of conservation measures particularly by smallholder farmers. The traditional CHITEMENE system of shifting cultivation also contributed to accelerated rates of soil erosion due to shorter fallow periods and longer cropping cycles caused by increased population pressures (Mukanda, 1993). Some research work on tied ridging has been undertaken at Lusitu Research Station with some encouraging results.

The use of conservation tillage systems in Zambia has mainly been spearheaded in the last

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3 years by efforts of the Zambia National Farmers Union (ZNFU) Conservation Farming Unit in the Southern province of Mazabuka as reported by Aagard and Gibson, (1996). Zambian links with Hinton Estates in Zimbabwe culminated in ten commercial farmers establishing 20-70 ha under conservation tillage with encouraging results. Since December 1995, the conservation farming unit was established to promote conservation tillage in both large and small scale farming sectors. Some work on the promotion of various animal drawn rippers which have been extensively tested with farmers through extension brochures is in progress through a programme known as Smallholder Agricultural Mechanisation Promotions (SAMeP).

In ***Botswana*** it was reported (Nyagumbo, 1998) that tillage research has been undertaken since 1970s. However up to the present the most common form of tillage practise is mouldboard ploughing carried out on the day of planting. More recent research on different tillage methods (Persuad et al., 1990) recommends two methods namely double ploughing i.e. spring ploughing followed by another ploughing at planting and spring ploughing followed by tine cultivation at planting. Some work was also carried out on strip tillage on sandy loam soils and shallow tillage or herbicides on vertisols as reported by Willcocks and Twomlow (1991).

In Malawi the ridging constructed by handhoes is the most common practise used by about 95% of the smallholder farmers (Mwinjilo, 1992). Zero tillage or no-till are not used at all due to cost of herbicides and lack of draught and labour resources (Kumwenda, 1990). Some effort is being made to reduce labour requirements for construction of ridges by the use of permanent ridges as compared to annual ones. Other forms of conservation practices include maize-legume inter-crops and rotations.

In Southern highlands of ***Tanzania*** 95% of the farms are less than 5 ha in size. Land preparation is mostly manual (Ley, 1990). In addition to standard mechanical structures such as channel terraces conservation tillage systems are in use with implements capable or retaining 70% crop residues on the surface after tillage operation. Weed control is achieved with the use of herbicides such as round-up. Problems cited included lack of appropriate machinery, experience and grazing of stover by livestock.

Traditional techniques locally developed in the southern highlands of Tanzania and suitable for use on steep slopes include the Matengo pit or Ngoros (a series of pits 2.4m long x 2.1m wide x 0.14 – 0.30m deep) and the Matuta ridge systems (vegetation slashed and aligned across the hillsides and buried with soil thrown down-slope (Temu and Bisanda, 1996). These techniques have shown immense benefits in terms of soil and moisture conservation for crops as well as fertility improvements.

In ***Kenya*** the traditional conservation technique is the *fanya juu* terrace. In a recent study on traditional techniques mobile trash lines at 1.5-7.5m spacings significantly out-yielded (maize and cow pea) and reduced soil loss and run-off levels compared to the control (Okoba et al., 1998). The use of these trash lines in combination with static structures such *as fanya juus* and stone bunds is a recommended system especially for lower Embu in eastern province.

3. Socio-economic issues of conservation tillage

Apart from the many technological concerns and proven gains of conservation tillage, the few exposed farmers in the region are still not adopting the techniques *en masse.* The non-technical reasons for the low adoption rates range from costs of equipment when they are available to the socio-cultural features such as fear of change and weaknesses in promotion and qualities of extension services.

Socio-economic issues of conservation tillage in ESA centre around the traditional African customary approach to issues revolving around land its use and ownership. The value attached to land as a sign of worth and wealth can be a major source of caution, if not conflict in development.

Nyagumbo (1997) analyzed the socio-cultural constraints of smallholder technological dissemination and their impact on development projects. The observations were centred around the Contil project in Zimbabwe, which had faced varying degrees of success. It was observed that:

- Farmers were victims of a receiver mentality, brought about by previous government and donor subsidized projects. They immediately lost interest each time they were told that the project had nothing to offer materially or financially. Longer term gains were more difficult to comprehend. Previous subsidies had been such as interest-free money to commence projects, with little contribution from the locals themselves.

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- Emanating from the receiver attitudes highlighted above, was suspicion between participating and non-participating farmers, with those not participating feeling those participating had certain material or financial gains. This caused tension between them, resulting in jealousy, envy and even hatred.

- In Zimbabwean customary law following the death of a member of a family, close relatives of the deceased get a small share of the deceased's belongings, such as clothing. Contil research equipment quickly became wealth to be shared, following the death of participating farmers. Issues and concerns of witchcraft soon set in.

- Many farmers indicated that they spent as many as 30 days (25% of their working time), attending funerals and were therefore unavailable for participatory research.

It was therefore clear that development of new technologies in small-holder farming areas was affected by serious non-technical problems and constraints. Awareness of these constraints led to farmers being adequately informed and accommodated to feel true ownership of research projects. It was noticed that when farmers knew the objectives of the research, they were more co-operative and useful.

3.1 Gender issues in conservation tillage and technology transfer

Hagmann et al. (1997) reported on an assessment of socio-cultural constraints in agricultural research and extension. They noted that this is often a male-dominated domain and that the introduction of the gender perspective was frequently taken as a fashion rather than as a substantial contribution to rural development. They highlighted the reality that, in many societies in Africa south of the Sahara, male labour migration into towns had resulted in a situation where more female than male-headed households prevailed in the rural areas.

Among the many facets of gender weaknesses and as they affected efficiency in development the following points were put forward:

- ***Weak communication between the Actors*****:** where communication within the families, within the communities and between farmers and extension workers turned out to be weak.

- ***Communication in the families*****:** where extension workers chose male farmers who often were also members of the farmers' club and extension training programmes. The male head of household was not obliged to inform the other household members, whereas the wives and the children etc. were accountable to the male head and therefore information flowed smoothly in this other direction. The same applied to communities, where farmers complained that their leaders never report back from meetings and courses they attended. It was also realised that communication among female members of the household was better than the flow between the sexes.

- ***Problems of a Male****-Dominated Extension*: where male domination in extension limited the attraction of extension for women.

- ***Decision making***: where men and women stressed that the husband makes most of the

Box 5: **Gender roles in conservation tillage and technology transfer**

The implication for extension would be to facilitate the problem and needs identification with the presence of both, men and women, rank the priorities together and according to gender and then develop the extension programme together. A choice of technological options should be developed together in order to correspond to farmers (male and female) criteria which are very diverse and situation specific.

In a time of rapid socio-cultural change gender roles and relations are highly dynamic. Therefore, it is important to build a platform on which rural people themselves can negotiate for new roles, functions, norms and for new power relations. It is more favourable to negotiate roles via technical issues rather than via discussions on gender as the advantages of any changes must be concrete and obvious in real life-situations. The process requires skilled facilitators at various-levels. This new competence is a real challenge to the conventional agricultural research and extension institutions.

Hagmann et al. (1997)

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decisions in the family, but it turned out to be the opposite.

The study concluded that:

- Training for Transformation (TFT) was a method to be recommended as it empowers local people to control their lives through active participation in their own development and sharing of ideas and knowledge. TFT stresses the importance of participation and co-operation of both, male and female members in organisational development in order to build institutions which enable people to become self-reliant.

4. Conclusion and the way forward

In conclusion it is noted that many efforts towards conservation tillage practice in ESA has been put in place although impact is yet to be felt. A wide variety of factors have worked against research and extension efforts for technology transfer, and traditional practice has continued to persist and dominate. In many cases poor technology transfer techniques have been tried and farmers are yet to adopt conservation tillage practices *en masse.*

For progress to be attained, the definition of the path to be followed can only be based around the wide range of literature items cited, the experiences therein and that of these authors. The appropriate approach for Contil promotion in the region can therefore be defined and subscribed as one to include the following components:

i. Farmer-centered, aggressive, on-farm, participatory methodologies in demonstration and practice as well as publicity for sensitization, with all parties (researchers, extensionists, farmers, support service providers, government and non-government operators) applying their appropriate and adequate roles.

ii. Marrying traditional knowledge, ideas and practice, while accommodating fears and experiences about technologies, with socio-economic and other concerns of end-users. Farmer exchange visits will be most important in this endeavour.

iii. Identifying suitable equipment and promoting the same nationally and regionally while merging resources and eliminating duplication of efforts within and between nations.

iv. Applied field testing with farmers as more research findings are made, especially to quantify the real gains of the use of various equipment while accommodating the natural and other development trends and narrowing the gap between research & end-users

v. A systems approach, to multi-disciplinary and multi-sector research and technology transfer efforts which capture environmental protection and soil management techniques, agro-forestry practices and economic well-being of all parties involved, and especially smallholder farmers.

vi. Formal Contil networking, collaboration and co-ordination backed by training, support for equipment supply, including simplification for local manufacture and other support.

vii. Shortcomings in technology and equipment development is not unique to conservation tillage but subject to the many general as well as specific shortcomings and gaps in agricultural mechanization endeavour.

viii. Efforts towards capacity building in terms of institutional back-up, training, personnel, equipment and other support are faced with shortcomings in disciplinary commitment & time allocation, which calls for adequate remuneration of professionals.

Improved agricultural technologies should be directed to alleviating soil-related constraints of accelerated soil erosion, rapid fertility depletion, nutrient imbalance, and drought stress. Furthermore, essential inputs must be made available at affordable prices and on time. Beyond these, farmers must be adequately rewarded for their produce and be assured of returns.

Work with farmers – especially to build on their traditional ways to give real meaning and confirm indicators brought about by research is recommended. For example, mulch ripping has shown great promise for soil structural stability while the hand hoeing has shown soil strengths that could inhibit root penetration but probably hand-hoeing and no mulch ripping will continue to be the practice in reality.

Africa is endowed with a wide diversity of climate, vegetation, geography, terrain and soils. Yet the range of species grown is rather narrow. Introduction of new species could spread risks and increase options. There is no justification for ignoring cash crops.

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