Indigenous soil conservation tillage systems and risks of animal traction on land degradation in Eastern and Southern Africa

by

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Abstract

Traditional agriculture in the past was compatible with the level of population, ecological environment and intensity of cropping. Long bush fallow periods restored soil fertility effectively while tillage practices such as pit cultivation; mounding, ridging, mulching and earth-bunding successfully conserved the soil. The indigenous soil conservation systems evolved over the course of time to suit certain environments. They are usually location specific and have designs that reflect their multiple functions such as fertility management, erosion control, drainage and water harvesting. Moreover, most indigenous soil conservation tillage systems are labour intensive and are difficult to mechanise, thus severely limiting the cropped land. In some areas they have been replaced with conventional flat cultivation. Conventional flat cultivation whether done by the hand hoe, draft animals or tractors, needs to be accompanied by appropriate soil conservation measures, or it will encourage soil degradation. The adoption of the ox-plough is usually associated with extension of cultivated land which may need clearing. Plough pans may form with continuous cultivation and the extensive use of sledges increases risks of soil erosion. Therefore in order to protect the soil for sustainable agricultural production, land conservation should be integrated in the normal crop and livestock husbandry practices. Smallholder farmers can relate to the land husbandry concept, which should be emphasized. In areas where animal traction is on the increase, minimum tillage using animal drawn ripper tines and wheeled cart transportation should be encouraged to reduce risks of soil erosion. Participatory community based approaches should be used to create a more ownership attitude and the "free for all" livestock range management system should be revisited to increase personal responsibility on the land and increased investment on soil conservation activities.

1. Introduction

Agriculture is the dominant sector in the economies of Eastern and Southern Africa providing up to 75% of the total export earnings. Agriculture contributes between 15 and 50% of the Gross Domestic Product (GDP) and provides employment to 80% of the over 150 million people living in the region (FAO, 1991). Moreover agricultural production is predominantly subsistence and the productivity of the smallholder farmer is generally low. The potential for lateral agricultural expansion, to meet the food security needs of the growing population is mainly constrained by a combination of low soil fertility, poor production systems and erratic, unreliable rainfall. Most soils have high acidity, poor structure, low water holding capacity and low organic matter (Ofori, 1993), quality constraints that have to be overcome in order to improve productivity for sustainable agriculture.

Traditional agriculture in the past was compatible with the level of population and ecological environment. Long bush fallow periods were effective in restoring soil fertility for the prevailing level of crop yields and intensity of cropping. Pressure on land has resulted in drastic reduction of the fallow periods and in some countries they have disappeared completely. Intensive land cultivation – albeit with low use of inputs due to the farmers' inability to purchase what is necessary has set in. This leads to nutrient "mining of the soils" which is manifested in degraded soils and reduced crop yields.

Indigenous tillage practices such as pitting, mounding, ridging, mulching, earth and stone bunding successfully conserved the soil but in recent years, conventional flat cultivation, which is associated with modern agriculture has set in. Mechanized conventional tillage encourages splash and sheet erosion as it leaves the soil surface bare, under sporadic tropical downpours.

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This paper briefly reviews the indigenous soil conservation tillage systems and discusses the risks of animal traction on land degradation. It also looks at the challenges of soil conservation in the region.

2. Tillage systems and land husbandry

2.1 Tillage and land degradation

Land degradation is the process that leads to the loss of biodiversity and productive capacity of the land (Box 1). Land degradation is therefore a major environmental concern for sustainable agriculture in Africa.

> Box 1: Land degradation
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> Land degradation starts with the impoverishment of, and reduction in vegetative cover, exposing the soil surface to accelerated erosion and leading to reduction in soil organic matter and nutrient content (IFAD, 1992).

2.2 Conventional tillage practices

Tillage is defined as physical, chemical or biological soil manipulation to optimise conditions for germination, seedling establishment and crop growth (FAO, 1993). The primary objectives of tillage are seedbed preparation, provision of a good medium for plant roots, water infiltration and retention, erosion and weed control.

In Eastern and Southern Africa, conventional flat cultivation systems are commonly practised. In this practice, the soils are cut, inverted and pulverised, burying most of the crop residues underneath, leaving a clean fine seedbed. Under the impact of raindrops, the soils may cap or crust. This reduces infiltration and increases water runoff, accelerating sheet erosion.

> Box 2: Reduced yields due to plough pans
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> In Njombe district in the Southern Highlands of Tanzania, the grain yield in maize dropped from 5 tons/ha to 1.2 ton/ha in ten years. This was caused by the formation of plough pans. 2-10cm below the surface due to continuous conventional tillage, using 34 discs trailed harrows year in year out. (Shetto and Kwilingwa, 1989).

Conventional tillage is energy intensive and results in a limited rooting volume due to plough pans formed at shallow depths which restrict root growth and development (Box 2,). It also results in a decline in organic matter content and increased soil erodibility.

2.3 Conservation tillage

Conservation tillage can be defined as a crop planting system that allows minimum disturbance of the soil to allow seeds to be sown while ensuring maintenance of crop residues on the surface (FAO, 1995). The crop residue left on the surface, cushions rain drop impact and reduces water movement, hence soil erosion. As water runoff and evaporation are reduced, water penetration is improved. The crop residues and roots build up in the long term, improving soil structure. Draft power requirements are also minimised ensuring timely planting (Box 3).

In Eastern and Southern Africa, soil conservation measures have been undertaken since time immemorial. This indicates that, conservation tillage was probably among the major preoccupations of farmers in ensuring sustainable crop production.

> Box 3: No-primary tillage and animal power
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> Farmers in Chunyu district in Tanzania have trebled their area under cotton production (some up to 20 ha units) with the adoption of the ox-weeder. Ox-ploughing is now becoming a constraint to further expansion because of the short planting time. To hasten planting, the less energy no-till system is now practised where only planting holes are dug with the hand hoe, followed by very early weeding using the ox-weeders, a few days after the emergence of the cotton. (Shetto and Mkomwa, 1996).

2.4 Indigenous soil conservation tillage systems

These are mainly traditional soil conservation tillage systems evolved by farmers over the course of time to suit certain environmental conditions (Box 4). It appears that indigenous conservation knowledge has accumulated particularly in areas where the natural resource base is under severe pressure from local communities, the ecosystems are fragile and

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there is a long history of adaptation to adverse conditions.

Box 4: Indigenous technologies

Technologies evolved as a result of a gradual learning process and emerge from a knowledge base accumulated by rural people by observation, experimentation and a process of handing down across generations peoples' experiences and wisdom. Apparently the technology is dynamic and not static in nature, frozen in time or stuck in history (Hans-Joachim Kruger, et al. 1996; Reij, 1996)

Most local soil and water practices are location specific and accordingly vary in purpose. They may conserve soil in situ such as stone and earth bunds; conserve soil while simultaneously improving soil fertility such as mixed cropping, ridging or pitting; harvest water such as tied ridges; and dispose off excess water from crop lands such as traditional ditches or cut off drains. Thus indigenous soil conservation systems may be agronomic, vegetative or physical in nature and some of these are discussed in the following section.

2.5 Agronomic and vegetative techniques

Agronomic techniques may be biological or cultural. They include such practices as crop rotations, mixed cropping and trash lines. Crop rotations and mixed cropping are traditional systems that are widely practised in the region. Good crop rotations such as maize followed by legumes facilitate the conservation and addition of humus, restoration of soil structure and fertility and reduction of pests and diseases.

In mixed cropping, two or more crops are grown in the same field in the same season. In most cases grains and leguminous crops are mixed. The fast growing legumes provide soil cover early in season, shielding the impact of raindrops. They fix nitrogen too, and thus help to maintain soil fertility.

In slopping hillsides, maize stover is sometimes used to make trash lines, which help in slowing down the flow of runoff, and traps eroded soils. The technique is used both for erosion control and fertility improvement.

2.6 Physical tillage techniques

2.6.1 Pit cultivation

This is essentially a soil and water conservation system as well as a fertility restoration technique, through refuse decomposition. Grass is cut and laid out in strips forming square grids. Soil is then dug from the centre of the grid, covering the grass and leaving 30-60 cm deep and 100 cm in diameter pits. The pits, from a distance resemble a honeycomb or chessboard. The pits control runoff while conserving moisture simultaneously. The rainwater collected in the pits, percolates into the soil slowly while the incorporated crop residues improves soil fertility. The practice is fairly common in the Matengo highlands in southern Tanzania where they are popularly known as "*Ngoro*". Pits are laid even on steep slopes ranging from 10-60% (Temu and Bisanda, 1996).

2.6.2 Mound cultivation

Mound cultivation is essentially an in situ composting system for fertility management. Mounds are prepared by heaping soil and grass from an area of about one square metre, ensuring that the grass is covered completely. A leguminous crop is planted randomly on the mounds that are 40-60 cm high and 50-60 cm in diameter. In the following rainy season, the mounds are flattened and the main crop is grown. These mounds are locally known as "Fundikila" in Kenya while in Tanzania they are called "Ntumba".

2.6.3 Earth bunds

This is essentially a soil and water harvesting technique. Earth bunds are used mainly for water harvesting in rice production in the drier parts such as the lake zone in Tanzania. Earth bunds about 0.5m high are constructed around rice fields in order to collect runoff water from the higher slopes. In some other parts like Ethiopia, earth bunds are used for slowing down runoff in maize and sorghum fields where they are usually constructed along the contour after planting the crop. The bunds are constructed by digging a trench about 25cm deep with the scooped soil forming embankments or ridges.

2.6.4 Stone bunds

These are barriers of stones placed at regular intervals along the contour. They have been used for generations in Ethiopia where they are locally known as "dhagga" and in some parts of South Africa. The size of the stone bunds varies between 0.5-2m and may be 5 to 10m

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apart, depending on the availability of stones and the topography. Stone bunds retain or slow down run off and hence control erosion. They also allow the accumulation of soil, which may be redistributed after the bunds are dismantled.

2.6.5 Traditional ditches

Traditional ditches may be made to allow excess water to infiltrate easily and drain out of cultivated land, to the side of an artificial or natural waterway. A ditch may sometimes be dug on the upper side of the cultivated land to act as a cut off drain to protect the field from the runoff coming from the higher land. Thus traditional ditches drain excess water from the field, protect the soil from being washed away by runoff and reduces surface runoff generated within the cultivated land. They are commonly made throughout the region and in Ethiopia they are constructed using a ‘maresha’ ard plough pulled by oxen.

2.6.6 No primary till or pot holing

This is essentially a dry planting slashing and burn system. It involves slashing the vegetation or stover, leaving it on the ground to dry and burning it to leave a clean seedbed. Sowing is then done without disturbing the soil, except for the planting holes that may be made by using a digging stick or hoe. The practice is common in the central plateau of Tanzania where it is known as “kuberega”. In Zimbabwe, Zambia and Kenya it is known as “Muro”.

2.6.7 Ridges

Ridges have traditionally been associated with the growing of specific crops such as beans, groundnuts, sweet potatoes and cassava. Ordinary ridges are 20-50 cm high and are usually spaced between 60-80cm. When they are laid across the slope they control the soil erosion. Ridges also improve the soil fertility through in situ composting of vegetation that is buried under during ridge formation. In some areas, broad-based ridges have evolved, furthering more the concept of soil fertility restoration with the incorporation of more grass, and trash. The system is commonly practised in Tanzania and Zambia.

2.7 Mulching

Mulch farming maintains surface residues on tilled land. Crop residues are useful in conserving the soil, controlling water runoff, improving soil physical conditions and increasing soil fertility. In situ mulching was fairly commonly practised in the region. The practice has declined as a result of other competitive use of the crop residues such as feed for livestock, fuel and building materials. Mulching however is still practised in banana and coffee areas and in horticultural crops, in areas of high rainfall.

2.8 The iraqw system

This is an intensive crop management system practised by the Iraqw tribe in northern Tanzania. In this hilly area, all the crop residues in the field and manure from stall fed cattle is incorporated into cultivated ridges. Terraces are made to control soil erosion, and fodder is cropped on the edges of the terraces for the cattle, being supplemented by grass from fallow fields. Trash lines and cut off drains are also used to slow down surface runoff and to increase infiltration.

3. Animal traction and land degradation

3.1 Historical perspective

With the exception of Ethiopia and South Africa, the history of animal traction in Eastern and Southern Africa started with the introduction of ox-ploughs by the missionaries and white settlers in the early 1920s. Whereas in Ethiopia, animal power has been used for thousands of years, in South Africa it dates back to the 1600s (Starkey 1995).

Apart from the initial efforts by the then colonial governments, increased utilisation of animal power before the 1960s has been more or less spontaneous, being closely associated with the commercialisation of crop production to serve the then mushrooming trading centres, the mines and the export market to Europe. However, with the coming of independence, most countries moved to tractorisation in the hope of increasing crop production to meet their domestic food needs; and raising the much needed foreign exchange through export of cash crops.

As a result animal traction was completely neglected and its development stagnated. Moreover, new interests cropped up again in the early 1980s following the failure of many tractor mechanisation schemes. Animal traction is now increasingly becoming important throughout Eastern and Southern Africa, with the number of draft animals increasing, complementing both hand labour

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and tractor power. For example, the number of draft animals has almost doubled in Tanzania and Zambia in the last twenty years.

Animal power is mostly utilised in the fairly extensive systems of grass fallow cultivation and semi-arid areas in the region. These include southern Kenya, the cotton zone of northern Tanzania and the southern highlands, the maize belts of southern Zambia and central Malawi, the communal areas of Zimbabwe, southern Mozambique and northern Namibia (Starkey, 1994).

3.2 Risks of animal traction on land degradation

There is very little documented information concerning the environmental implications of animal traction. However, like any other conventional flat cultivation, whether by hand or tractor, animal power has the potential of promoting land degradation. For smallholder farming in many countries in the region, proper soil conservation measures are rarely practised, leaving the tilled land at the mercy of the weather.

3.3 Area expansion and deforestation

The adoption of the ox-plough is usually associated with extension of cultivated land. With the possession of more farm power, more woodlands are cleared and put under cultivation, thus increasing deforestation. This exposes more land to the hazards of soil erosion. An increase of cropped land of 100-300% has been observed in Tanzania and Zambia with the adoption of animal draft technology (Francis, 1988; Harder, 1989).

As more farmers move to animal traction, traditional soil conservation practices such as mound farming, ridge and zero cultivation give way to flat cultivation with the ox-mouldboard plough which is potentially disastrous especially in the semi arid areas (Shetto and Mkomwa, 1996).

3.4 Conventional flat cultivation

Traditionally in Eastern and Southern Africa, tillage by draft animals is done by using the single furrow mouldboard Victorian plough. It is in Ethiopia only where the non-inverting 'maresha' plough is used. The mouldboard plough cuts, inverts and pulverises the soil burying most of the crop residue. The practise might not be appropriate especially in the semi arid areas, as the tilled land is left fairly exposed, making it more vulnerable to splash, sheet and wind erosion.

Also when ploughing is repeatedly done on the same land, plough pans a few centimetres below the top-soil. Plough pans hinder good development of roots, resulting in declining yields. In many cases, ploughing is done parallel to the slope and not along the contours. Some farmers claim that it is faster to work the animals up and down the slope rather than across the slope especially when the configuration of the field is difficult (BACAs, 1996; Shetto and Mkomwa, 1996). Sometimes in ploughing, width adjustment on the plough is not done properly, leading to many plough furrows being left in the field. When it rains, water runs in the plough furrows accelerating rill erosion especially in sloping fields.

3.5 Sledges

A sledge is a "V" or "Y" shaped wooden plank cut from a forked tree branch or trunk. The two trailing planks are joined with short pieces of timber to form a loading platform. The single end of the "Y" trunk is then hitched to the animals by means of a chain. Sledges slide on the soil surface as the animal pull, leaving rutted tracks on the ground. These sledge tracks act as waterways when it rains, accelerating soil erosion. Sledges are a common sight in most rural areas especially in Tanzania where, almost every household owning a pair of oxen, owns a sledge too. In some SADC countries such as Botswana and Zimbabwe, sledges have been banned completely as they are considered an erosion risk.

4. Other sources of land degradation

Apart from inappropriate tillage practices, deforestation and overgrazing have been identified as the other major causes of land degradation in Eastern and Southern Africa.

Deforestation is mainly a result of agricultural land expansion and provision of building materials and fuel wood for domestic requirements. It is estimated that 90% of the domestic energy used in the region is from fuel-wood (Box 5). Bush fires are also rampant in the area, especially in the dry season reducing further the forest cover. The long-term consequences are changed rainfall pattern, decline in soil fertility and increased surface runoff.

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On the other hand, the number of livestock has also been increasing, almost doubling in the last three decades. The "free for all" extensive free range grazing system of livestock encourages soil degradation. Overgrazing depletes the land of its vegetation cover exposing the soil to water and wind erosion. Excessive trampling by the animals destroys the soil structure, reducing infiltration rates, thus increasing run-off that accelerates soil erosion. Free grazing of crop residues makes conservation tillage difficult even for those who would have liked to practice it.

> Box 5:Fuelwood and land degradation
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> About 300,000 – 400,000 ha of forest and woodlands disappear each year in Tanzania. Iringa town alone with a population of 85,000 people in the Southern highlands requires approximately 79,000 tonnes of fuel-wood annually that equals clear felling of approximately 3,000 ha of natural standing miombo woodlands each year [De Pauw 1994; HIMA, 1994].

5. Constraints and challenges

Traditional or indigenous conservation tillage has been a major pre-occupation of subsistence farmers since time immemorial. During the pre-independence era, the colonial governments instituted wide mechanical soil conservation measures in the region. However, they became unpopular with the farming community as they were implemented by force. After independence, most of these measures were ignored, leading to severe land degradation in some countries.

While indigenous soil conservation methods still play an important role, they are highly location specific. Some of these measures are labour intensive and are difficult to mechanise, thus severely limiting the cropped land. Agronomic and vegetative measures alone have not been very effective where marginal lands like steep slopes are put under cultivation as a result of land pressure.

Where animal traction is becoming important, some indigenous soil conservation systems have been replaced with conventional flat cultivation that increases the risks of soil degradation. As the use of animal traction is on the increase in the region, then the incorporation of appropriate soil conservation measures in such systems is important so as to ensure sustainable crop production. These measures should be integrated into the normal crop-livestock husbandry concept, where care and improvement of land resources comes first and control of degradation is part of the caring and improvement process. Minimum tillage using animal drawn ripper tines should be encouraged to protect the soil from hazards of erosion especially in the semi arid areas.

Transport on the wheel using animal drawn carts should be promoted to reduce risks of soil erosion with the extensive use of sledges that trail on the ground.

Participatory community based approaches involving the stakeholders in planning and implementation are necessary in order to create a higher ownership attitude. Clear messages on conservation tillage should be included in the normal extension packages and training of both village extension workers and farmers should be emphasised so as to improve their understanding and skills.

The livestock "free for all" range management system should be revisited so as to increase personal responsibility on the land and increase investment on soil conservation activities. Conservation measures tend to be more acceptable to farmers if they serve multiple objectives and help to increase production. Indeed, to many smallholder farmers, resource conservation cannot be an end in itself, but it is an integral part of efforts to improve and sustain livelihoods. Improving productivity is the underlying rationale.

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