

Conservation tillage in Zambia: Some technologies, indigenous methods and environmental issues

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1. Introduction

It is well documented that efforts over the past 2 decades to improve the performance of the traditional agricultural sector in Zambia have largely failed. Results of the 1995 IAS/UNZA Agricultural Sector Performance Analysis are particularly alarming as they point to a decline in both yields and gross area under production. Maize yields in Southern, Central and Eastern Provinces for example have declined by about 300,000 hectares from a peak of 1.2 million hectares in 1988. At the farm level, incomes have shrunk and families are generally less food security than previously. A recent World Bank Survey indicates an increase in poverty levels in the rural areas from 70% in 1994 to 90% in 1995.

At the institutional level, ineffective extension and research services and inappropriate agricultural policies, which have relied excessively on maize production, have been cited as contributory factors. However the recent sharp decline in the performance of agricultural sector is more likely to have arisen from major changes in climatic and economic circumstances. These changes include:-

- The severe droughts experienced recently, particularly in the southern regions characterised by both a decline in overall precipitation and increasingly erratic distribution patterns.
- The liberalisation of agricultural marketing under the Structural Adjustment Programme involving the withdrawal of subsidies for farm inputs and commodities
- the collapse of institutional credit organisations
- a sharp rise in interest rates on seasonal loans and a severe decline in lending operations.
- A severe decline in the availability of draft power in communal farming areas as a result of Corridor disease and the attrition of active farm labour through urban drift and widespread incidence of Aids.

The IAS/UNZA Agricultural Sector Performance Analysis Study identified these trends as the major cause of a reduction in smallholder cropped land.

Excessive soil erosion and a decline of fertility in the traditional cereal production regions of Zambia particularly, Southern, Central and Eastern Province was recorded.

1.1 The farm level

1.1.1 Coping strategies

At the farm level the picture has been particularly bleak. The decimation of draft oxen, the reduction in active farm labour, and recent disruptions in input supply and marketing arrangements have all had a negative impact on productivity, income and most importantly, food security. On the positive side there is evidence that farmers themselves are attempting to adopt strategies to cope with these problems. These include attempts, at crop diversification, the use of drought tolerant varieties, the adoption of reduced tillage methods and an increase in off farm income generating activities. It is also evident that farmers are more receptive than ever before to ideas that will increase their self reliance and reduce their susceptibility to the recent negative influences of the climate and the economy. Outgrower schemes in Zambia are also playing an increasingly significant role in the smallholder sector. In 1996 for example LONRHO had over 70,000 farmers producing cotton. The total number of farmers producing for small and corporate outgrower schemes is likely to rise beyond 120,000 in 1997 representing 18% of all small farmers.

1.1.2 Degradation of the agricultural resource base

Farmers are less aware that conventional farming systems are destroying the land upon which they depend. Most farmers notice the inexorable decline in the productivity of their fields, however they generally believe this is a

natural and irreversible process. 'My land is old and worn out'. Furthermore 'landuse' technologies which have up to now been advocated to protect their soils are extremely labour intensive, and farmers have therefore been unwilling to adopt them.

Overwhelming evidence from research in Zimbabwe and Malawi over the past 12 years has underlined the negative effects of conventional husbandry practices on the immediate, medium and long-term productivity of the smallholder sector. The statistics are alarming and can be applied equally to most of Zambia's agroecological Regions I and II. Furthermore, the extreme seasonality of agriculture in Central Africa and the consequent pressures placed upon small farmers who adhere to conventional practices has long been overlooked.

1.1.3 Immediate effects of conventional tillage and husbandry practices

- Smallholders who practice conventional tillage will always plant late because they have to wait for the rains before they can start. For each day of delay after the first planting rains have fallen, farmers will lose 1.3% of their yield. Subsequent husbandry practice, no matter how effective cannot compensate for this loss. Farmers who are 18 days late for example will lose 25% of their production.
- 'The rains always surprise us, everything has to be done at once, we cannot cope and so our work is done late, in a hurry and badly'. There is no better axiom than this farmers remark to describe problems all smallholders face with the onset of the rains. Activities such as land preparation, planting and weeding which should be sequential become concurrent and the farmers are driven by events, which overwhelm them.
- Unless farm land is contoured with bunds 30% of seasonal rainfall (300 mm in a normal year in Central Province) will be lost as runoff, and will be unavailable for crop growth.
- Unless farm land is perfectly flat up to 50 tons of top soil will be lost from each hectare annually.
- On conventionally tilled and exposed land, up to 50% of applied fertilisers are lost in storm flow.

- The surface layers of soils exposed to the energy of rain drops are pulverised and soon become crusted and sealed. This affects crop germination and further accelerates runoff and erosion.
- Hoeing and ploughing each year produces hard pans, which restrict crop root volume and make crops more susceptible to dry periods.

1.1.4 Medium to long term effects

Conventional tillage, coupled with monocropping and bad husbandry practises lead to degradation and to a situation where the soil can no longer support crops. In Zimbabwe it is estimated that 30% of smallholder farmland is now totally degraded. In the densely populated areas of Malawi such as the Lilongwe plains, the situation is worse. Recent statistics gathered from a visit by the CFU to Malawi underline the problem in stark terms:

1. annual loss of topsoil 35 tons/ha or 160 million tons in total.
2. annual loss of nutrients 339,000 tons of nitrogen and 25,000 tons of phosphate valued at USD300,000 million; and
3. average maize yields declined by 4% to 11% annually. Present yields average 1.0 to 1.2 tons/ha.

The pattern of decline is similar in both Zimbabwe and Zambia, and there is no doubt that the accumulative effects of inappropriate and unsustainable farming methods have exacerbated the effects of recent droughts in southern Zambia.

2. Agro-ecological zones of Zambia

2.1 Climatic overview

The Zambian climate is sub-tropical and strongly seasonal, characterised by three distinct seasons:

Mean annual temperatures are between 19-22°C reaching their maximum annual range in the extreme south-west (14-26°C in Sesheke). The mean annual rainfall decreases from over 1000mm in the North to less than 700mm in the South.

2.2 Agro-ecological regions

Zambia has been classified into 4 broad agro-ecological region zones:

1. Region I The Luangwa - Zambezi River valley zone.
2. Region IIA The Central, Southern and Eastern Plateau
3. Region IIB The Western, semi-arid plains
4. Region III The Northern, Northwestern high rainfall zone.

Sometimes the zones are referred to as:

- a) low rainfall areas (Zones I and IIB);
- b) medium rainfall (high agricultural potential) areas (Zone IIA); and
- c) high rainfall area (Zone III).

3. The benefits of conservation farming

Production, not soil conservation as such, is the priority for small-scale farmers. They do not deliberately set to degrade their land resources, but in their struggle to survive, they often have to concentrate on immediate short-term needs at the expense of sustainable soil use. Farmers give priority to those practices that best meet their family's immediate needs for food, fuel, shelter and cash as well as to meet their social and cultural obligations to the community in which they live.

The benefits of Conservation Farming methods are proven and they offer smallholders the opportunity to increase their productivity, safeguard their land and reduce the risks of total crop failure in drought years. Sustainable agriculture means a series of farming operations that take care of the "whole" system in such a manner that farming can be sustained over a long period of time.

3.1 Conservation farming definitions

Minimum Tillage (MT) refers to reducing tillage operations to the minimum required for crop development. For hoe and animal draft farmers producing cotton for Lonrho for example it usually means scratching or ploughing out the row where the crop is to be established and leaving the rest of the land untouched before planting. MT is not a new concept and has always been a traditional way of planting for hoe-farmers in many parts of Zambia. Any farmer who waits for the rain then makes planting holes with a hoe to plant a crop is an MT farmer. However ox-draft MT is a new concept and came as a survival tactic by farmers to cope with the effect of Corridor Disease on their cattle.

The main benefits of MT are that farmers can plant a larger area and can plant early.

Conservation Tillage (CT) are all operations which: (a) protect the soil from the damaging effects of rain splash; (b) reduce runoff and keep more of the rain on the fields (rain harvesting), (c) make the best use of costly fertiliser and seed and (d), allow farmers to finish land preparation well before the rains.

Conservation Farming (CF) incorporates MT and CT and is a term used to describe a range of husbandry and conservation practices which when used in combination bring about the benefits already mentioned. Conservation Farming also means crop diversification and rotations so that at least 30% of the land is occupied each year by a legume. Farmers who do Conservation Tillage and also use rotations are doing Conservation Farming. Essentially, CF combines sound husbandry and management practices, which arrest soil exhaustion, increase productivity, and enable farmers to spread out labour demand and get their work done on time. The technology can be applied to a wide range of farming groups from resource poor to commercial with good results.

3.2 Key conservation farming and tillage practices

- Crop residues are retained on the land and not burned. If residues are scarce they are raked into 'trash lines' across the slope to capture rainfall and reduce run off. Ideally a minimum ground cover of 30% residue is recommended. Residues reduce soil temperatures, protect the soil, minimise runoff and improve fertility.
- Land preparation commences in August or even earlier. The labour requirement can be spread over a period of 3 to 4 months. In this way the farmer is ready to plant his/her crop as soon as the first planting rains fall. Planting is quick and early weeding can commence as soon as weeds emerge.
- Planting basins of 30cms x15cms x15cms are dug with the hoe (these may be smaller in higher rainfall areas). These basins are permanent and are never moved.. Successive crops are planted in the same basins each season. Carefully measured applications of basal dressing and/or manure are applied in these basins well before the onset of the rains. The crop inter-rows are never cultivated and apart from weeding operations the inter-row is

not disturbed. This approach has many advantages. The basins remain concave after planting and concentrate the early rain around the seed and help to reduce runoff. Fertiliser and manure are placed where needed and wastage is minimised. Successive crops can take advantage of the root channels and residual fertiliser applied the previous season. Because the inter-row is not ploughed and weeds are not allowed to seed, the weed bank diminishes in time.

- Basins are spaced so inter-row weeding can be done by hand or oxen.
- Ox farmers using the new low draft, Shaka tine rip in the dry season and then establish their basins over the rip lines using the hoe. Alternatively they can use the Palabana Furrower to open planting furrow over the rip lines as soon as the first planting rains have fallen. Ripping reduces compaction, breaks plough pans and reduces the crop susceptibility to poor rain distribution.
- In the drier areas of Zambia, farmers use the hoe to make potholes in the inter-row during the first weeding. This technique harvests rainfall, improves infiltration, and reduces crop stress during dry periods.
- Legumes occupy 30% of the cropped area and are rotated with cash crops such as maize, cotton and sunflower. The legumes fix nitrogen and reduce the requirement for synthetic fertilisers. Deep rooting crops such as pigeon pea benefit successive weaker rooting crops by penetrating pans.

3.3 Establishment of the conservation farming unit

It is now commonly agreed that Conservation Farming (CF) systems provide the best opportunity for farmers to reduce their costs, increase their productivity, ameliorate the effects of drought, improve their food security, and protect the agricultural resource base from further degradation.

Accordingly, discussions between Donors, the Ministry of Agriculture, the National Farmers Union and the Golden Valley Agricultural Research Trust (GART) in late 1995 centred on the need to establish a cost effective and proactive unit to co-ordinate and promote the adoption of Conservation Farming Systems

(CF) among smallholders initially in the more drought prone regions of Zambia. In November 1995 with interim support from the World Bank and the EU a Conservation Farming Unit and Conservation Farming Liaison Committee was established under the Zambia National Farmers Union.

The Committee has representatives from ZNFU, Palabana ADP, MAFF, SCAFE, GART, and LONRHO. The Committee meets every two months and has the following responsibilities:

- a) ensure standardisation of technical messages, methods and approach;
- b) act as a forum for exchange of ideas and experiences;
- c) recommend priorities for research and seasonal demonstration programmes;
- d) maintain liaison with all local and international research organisations involved in CF and summarise latest findings for end users;
- e) assist and summarise latest findings for end users;
- f) publicise and promote the conservation "effort" through the media; and
- g) identify potential sources of finance to support the Conservation Farming effort.

The Committee is chaired by the Conservation Farming Unit (CFU) Co-ordinator. The Unit works with private sector outgrower companies such as Lonrho and with NGO's by training staff and demonstrating CF practices with farmers. Such agencies provide the necessary services (extension, input supply and marketing) that enable farmers to exploit new CF technologies.

3.4 Conservation farming for ox farmers

Ox farmers cannot maintain the accuracy of planting in the same holes every year like hoe farmers, however weeding is easier for these farmers because they can use ox drawn cultivators. The advice to ox farmers to adopt Conservation farming include the following:

- keep residues in the field
- use minimum tillage; and
- train oxen to move in very straight lines so that the planting rows can be maintained year after year.

The common ox-plough is not a good implement to use for Conservation Tillage. Ox farmers therefore need an implement that can break up pans and not clog during land preparation.

The *Shaka Tine* is a ripping implement that can easily be fitted to a standard plough beam. It requires low draft and two small oxen (350kg each) can easily pull the tool. The tool is best used during the dry season to maximise shattering of the soil. The idea is to rip out the lines where the seeds will later be sown so that plant roots can penetrate the pan. The rip lines help enhance infiltration and they should be applied across the slope.

From work done by Conservation Farming Unit it has been found that a farmer can rip 2 acres per day as compared to ploughing one acre per day in the wet season. When farmers use *Shaka tines* they have at least 3 months in which to rip. The increased work pace allows larger areas to be cultivated. If the rip lines are made 90 cm apart, the farmer can even use oxen with a cultivator to remove weeds later.

The CFU is promoting the use of this tine with their demonstration farmers. So far, LOHNRO and CLUSA have ordered 200 tines each to give their farmers for the 1998-99 season.

The Palabana Subsoiler is a new implement to break up dry soil. It digs deep into the soil (25cm) and therefore breaks the plough pan. This will help improve the infiltration.

The attachment can easily be fitted to any standard plough or ridger frame found in Zambia. Depending on the soil type and depth of work, animal drawn sub soiler can work with satisfactory results at different times of the year.

The Magoye Ripper and furrower is used for minimum tillage in the preparation of land for planting. It has advantages over the standard plough of low draft requirement, and it produces a furrow of even depth. The Magoye Furrower can be used to open a planting furrow as soon as the first planting rains have fallen. If the *Shaka tine* has been used, the furrower should follow the rip line.

The Palabana Ripper is becoming the most widely accepted implement. The ripper is used to make planting furrows either in dry or moist soil. Only along such furrow is the soil disturbed. Such an operation makes it possible to do dry planting and ripping with reduced draft while leaving the ground undisturbed.

The Palabana Ripper Planter Attachment saves time and labour. It is a planter unit added to the Magoye Ripper which makes it possible to rip, plant and cover the furrow in a single pass.

Planting in this case is done even faster and much earlier than is done with just ripping.

In lighter soils, dry planting can be done before the onset of the rains. For heavier soils this equipment can only be used soon after the onset of the rains. Inter-row weeding can be done using an inter-row with a cultivator immediately after planting.

The Ridger body used on plough bodies or ridger beams has a clear point for good penetration. The wings turn soil upwards (like a plough) to form well shaped ridges. When a farmer needs to make ridges before planting e.g. sweet potatoes this implement can be used. This ridger can be used for tillage, weeding, split ridging and most important, conservation tillage, ripping.

4. Traditional methods

4.1 Hand hoe

Since time immemorial the hand hoe has remained the predominant method for crop establishment in most parts of Regions I and II with the exceptions of Eastern Province. At the onset of planting rains farmers dig random holes into which they plant their cereals. Interplanting of pumpkins, okra, cowpeas and other crops may be undertaken later using the same method. Since the introduction of cotton and soyabeans in Central and Southern Province by the Lint Company (LINTCO) in the late 1970's, farmers have been obliged to modify this approach to achieve the required plant population by scratching continuous planting lines with the hoe prior to or at the onset of planting rains.

4.2 Hand hoe-ridge culture

The Hand hoe-Ridge Culture is common practice in Eastern Province and Malawi. Ridges are split each year usually before the onset of the rains and new ridges are formed in the previous season's furrows. Contour ridging was introduced by the colonial Government in Nyasaland as a measure to control erosion and to accommodate the production of hard fired tobacco. Unfortunately, the majority of farmers do not ridge on the contour.

4.3 Ox-ridging

Farmers in Eastern Province who grow tobacco or groundnuts wait until the onset of rains and then use ridger bodies to build up

ridges, often by splitting the previous seasons ridges. Alternatively, ridges are built up during the growing season after ploughing and crop establishment, by using ridger bodies to weed.

4.4 Ox ploughing minimum tillage

This is a relatively new method adopted by cotton farmers who have lost draft animals but wish to maintain their cropped area. A recent survey undertaken by the World Bank revealed that 18% of all farmers had converted to this method to establish their cotton. The plough shear is generally removed and the trek chain stoned. The plough point is then used to open planting furrows after the onset of the rains.

5. Achievement of the CFU over the past two seasons

In 1997/1998 the CFU undertook 881 demonstrations with smallholders, up from 395 in 1996/1997. There is no doubt that many farmers have recognised the benefits of the technologies demonstrated and adoption by non-assisted farmers is already picking up. Particularly, they have understood the opportunity it provides for early and rapid crop establishment, and the moisture retention benefits in seasons of poor rainfall. Ox farmers have already noticed the effect of dry season mulch ripping in cotton yields.

Conservation Farming is becoming well known in Zambia and some agencies like DAPP and CLUSA have adopted Conservation Farming as the recommended practice for all their farmers.

The demand for advice and support from the CFU from a wide range of agencies is extremely encouraging.

6. Problems and constraints

Despite the reported successes in Zambia with conservation farming, the following have been identified as the problems faced in the adoption of Conservation Farming.

6.1 The absence of farmer groups and associations

This is regarded as the biggest problem. In practise the vast majority of farmers are fragmented, disorganised and geographically dispersed. The absence of cohesive and well organised farm groups is the most significant constraint facing the development of

smallholder agriculture in Zambia. The transaction costs in dealing with a disorganised farming community is prohibitive whether it is for the provision of loans, extension services, markets, or the dissemination of appropriate technologies.

CLUSA's Rural Group Business Programme is currently facilitating the formation of farmer groups in Mazabuka, Monze, Mumbwa and Chibombo and the CFU is working with these groups with very good results. CLUSA's demonstration farmers in Mumbwa have achieved the best results in the 1997/98 season.

LONHRO remains a major CFU client and presently has about 90,000 smallholders producing cotton. The structures established by LONRHO are based on administrative priorities to enable the dissemination of extension and provision of inputs, loans and marketing services. Although LONRHO recognises the potential benefits of Conservation Farming, its major focus is the growing of cotton.

6.2 Continuity

CFU works with demonstration farmers for 3 years in order that the medium term benefits can be realised. Because of the high standard required by CFU, only 28% of the 395 demonstration farmers in the 1996/1997 achieved an adequate standard of management to warrant continued support. This means that with the drop of demonstration farmers, the inclusion of other farmers will mean a destruction in the demonstration programme.

6.3 Technology dilution and impact monitoring

Non-assisted farmers will not necessarily follow the complete package of measures. For example burning residues in a deeply entrenched practice, and in communal areas where cattle grazing is uncontrolled, residues are consumed well before the onset of the rains. Alternatively, the benefits of conservation farming are limited for farmers who cannot afford fertiliser and do not keep livestock.

The CFU does not have the capacity to assess uptake rates and the broader social, financial and environmental implications. Recently USAID has pledged support for a three-year independent monitoring and evaluation consultancy to undertake this work and it is hoped that this will be forthcoming.

6.4 Liming

The acidification of soil is a major problem in Zambia and is not only confined to the acid leached soils of Region III. A considerable amount of research has been conducted on this subject, including attempts to seek alternative means of arresting or reversing the acidity. These have largely failed and lime appears to be only short-term solution. Commercial farmers lime their land as a routine measure but due to the cost (application rates of 4 tonnes/ha), the vast majority of small holders cannot use lime.

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