DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

WORKING PAPER

An Analysis of Crop Diversification, Food Security and Adoption of Sustainable Soil and Moisture Conservation Tillage Practices by Smallholder Farmers in Zimbabwe: A Case Study of Kandeya Communal Land

Godfrey Mudimu, L. Rugube and J A MacMillan

Working Paper AEE 6/98

AN ANALYSIS OF CROP DIVERSIFICATION, FOOD SECURITY AND ADOPTION OF SUSTAINABLE SOIL AND MOISTURE CONSERVATION TILLAGE PRACTICES BY SMALLHOLDER FARMERS IN ZIMBABWE: A CASE STUDY OF KANDEYA COMMUNAL LAND

Working Paper AEE 6/98

by

Godfrey D. Mudimu[*], Lovemore Rugube[**] and Jim A. MacMillan[***]

Department of Agricultural Economics and Extension
Faculty of Agriculture
University of Zimbabwe
P O Box MP167
Mount Pleasant
Harare
ZIMBABWE

JULY 1998

---

* Godfrey Mudimu is a Senior Lecturer and Chairman in the Department of Agricultural Economics and Extension, Faculty of Agriculture, University of Zimbabwe.

** Lovemore Rugube is a Lecturer in the Department of Agricultural Economics and Extension, Faculty of Agriculture, University of Zimbabwe.

*** Jim A. MacMillan is Professor of Agricultural Economics in the Department of Agricultural Economics and Farm Management, University of Manitoba, Canada.

AN ANALYSIS OF CROP DIVERSIFICATION, FOOD SECURITY AND ADOPTION OF SUSTAINABLE SOIL AND MOISTURE CONSERVATION TILLAGE PRACTICES BY SMALLHOLDER FARMERS IN ZIMBABWE:
A Case Study of Kandeya Communal Land

ABSTRACT
This paper is based on an empirical case study quantifying the relationship between soil and moisture conservation practices, food and cash crop production and farm household welfare-food security and household income. The study tests the hypothesis that intensive agricultural production on the basis of cash crop production and application of soil and moisture conservation practices increase the land/labour productivity with positive effects on household food output and income. The results confirm that sustainable cropping systems and management practices are profitable and improve household food security and incomes at the farm level. This provides a basis for wide spread adoption by the small farmers.

INTRODUCTION

Improving household food security, incomes and growth in the small farming sector was a primary goal of Zimbabwe's agricultural strategies in the 1980s. The strategies adopted and their outcome are discussed by Rohrbach, (1988), Stack, (1994b), Mudimu, (1993), Eicher and Rukuni, (1994), and Eicher, (1995). The success, particularly the increase in smallholder maize and cotton, is mainly attributed to availability of high yielding varieties, favourable prices, availability of credit for fertilizers, and an improved marketing system and confined to the high rainfall agro-ecological zones. Unfortunately, degradation attributable to past land use is a threat to sustainability of the land resources (soil, natural pasturelands, and woodlands) on which arable agriculture is dependent.

The future prospect for improving rural incomes and food security is dependent on intensification of agricultural production. This would lead to more degradation through soil erosion and overgrazing if current trends continue. There would also be need for greater application of chemical fertilizers to maintain soil fertility. A cropping system based on continuous cropping with intensive use of chemical fertilizer may not be sustainable on a long term basis. This is because fertilizer prices having increased by 50% with the onset of economic reforms in 1991, there has been a noticeable decline in the quantity of fertilizers purchased by the smallholder farmers. Given that the soils are sandy and inherently of low fertility with low nutrient and water holding capacities reduced nutrient replacement will have a negative impact on productivity.

Environmentally suitable cropping systems and appropriate farming practices that make better use of land, rainfall and other resources at lower costs both to the environment and the farmers would be ideal to maintain sustainability of the environment and agriculture. Several options are a) crop diversification to shift from mono-cropping and b) adoption of soil and moisture conservation practices. The latter include winter ploughing, crop rotations, intercropping, mulching, tied ridging, planting in holes, tied ridges, and cattle manure application. Some smallholder farmers in Zimbabwe have adopted these practices. There is need to assess whether there are incentives for their wide adoption. For wide spread adoption, the strategies should not compromise on farmers' ability to

1

maintain food security and income. This paper analyses the productivity of smallholder farmers who have invested in low cost soil and moisture conservation tillage practices.

Several papers have recently reported on the economics of soil conservation practices and factors important for their adoption in developing countries. Lopez-Pereira, et al (1994) showed that fertilizer use complemented by yield-increasing varieties would promote adoption of soil conservation practices through crop diversification among the fragile hill side landholdings of Honduras. But, the increase in income was not sufficient to pay for the cost of adoption. Continued price support was required to provide a stable environment that would facilitate adoption of intensive and sustainable production systems.

Hwang, et al (1994) simulated various least cost strategies for farmers to meet various soil loss tolerances in the Dominican Republic. The results indicated that a) adoption of common erosion control practices and adjustment in the crop mix would reduce the costs; b) the costs to the farmer, measured as loss in income, were substantial; and c) meeting higher soil loss tolerance levels required substantial increase in crop yields or compensation for farmers to make the adjustments. Higher costs of food commodities (maize and beans), low returns to cash crops (coffee) and insecurity in land tenure inhibited the farmer from making the adjustments. Carcamo et al. (1994) examined the economic incentives for farmers to use alternative tillage practices in order to reduce soil loss in a watershed region in Honduras. The findings were that investing in soil erosion control and altering cropping patterns reduced soil loss at significant costs to the farmers in terms of lower income. Mausolff and Farber (1995) compared the costs and benefits of chemical and low-purchased-input ecological technologies (cover crops, live barriers, minimum tillage). Both increased yield but the ecological technologies increased yield at lower costs (of fertilizer use) to the environment.

The above studies are consistent with other observations in Sri Lanka (Gunatilake and Abeygunawardena, 1993) and in Central America and the Caribbean (Lutz et al, 1993) and in India (Chopra,1993) that given that the investment costs are high and benefits of most soil conservation practices are long term while farmers' preferences are for short-term benefits, incentives have to be provided for the farmers to adopt. For the small farmers to adopt sustainable practices, the practices should be profitable and improve household income and food security in the short run.

This paper discusses the incentives for widespread adoption of soil and moisture conservation practices by smallholder farmers in a high rainfall zone in Zimbabwe. The study quantifies the relationship between soil and moisture conservation practices, improved maize varieties, food and cash crop production and farm household welfare-food security and household income. The study tests the hypothesis that intensive agricultural production on the basis of cash crop production and application of soil and moisture conservation practices increases the land/labour productivity with positive effects on household food output and income. This would provide a basis for wide spread

2

adoption by the small farmers.

SETTING FOR THE STUDY

The setting of the study is important for studying sustainabilty of the smallholder farming, in the Communal Lands of Zimbabwe. These provide livelihood, that is food, income and employment to 1.5 million households which make up 6.5 million people of 70 percent of Zimbabwe's population. Sustainable agriculture is therefore vital for increased output of both food and cash crops. Sustainable agriculture in the Communal lands could be defined as use of land resources (arable, grazing, wood lands and rainfall) that meets the current needs of food security, improved incomes, and employment without reducing the ability of these land resources to meet the need of future generations.

There is growing shortage of cultivable land due to population pressure. The results are: a) cultivation in marginal land and communal pasturelands, b) intensification of arable land use that has caused the shortening or disappearance of fallowing periods; c) converting wooded lands into arable lands. d) continuous intensive cropping with limited application of fertilizers and manure. Reduced fallowing periods in the long run will lead to depletion of nutrients and organic matter. Cultivation of marginal lands, in converted grazing lands and woodlands, exercerbates soil erosion. Reduction in grazing lands puts pressure on the remaining grazing lands leading to over-grazing. These are exerting a significant impact on arable and livestock productivity in some parts of the country. Recurrent droughts have created another dimension to the problem. The loss of vegetative cover and concentration of livestock on remaining viable pasture have exercerbate soil loss in pasture lands. The same applies to heavy rain in arable lands.

Several researchers have calculated the extent of the environmental degradation due to past agricultural activities. Elwell (1987) estimated soil loss due to sheet erosion in arable lands to be up to 50 t ha^{-1} per annum. Vogel (1992) estimated soil loss from cultivated lands under the conventional ox-ploughing tillage practice in an above average rainfall season at up to 9.5 t ha^{-1} per annum. Using aerial photography, Whitlow (1988) estimated that 26.9% and 32.5% of all Communal Lands as seriously and moderately eroded, respectively. Deforestation due to clearing land for arable use and firewood is estimated at 74 000 hectares per year.

Wide spread adoption of soil and moisture conservation tillage practices by small farmers could reduce the magnitude of soil losses and conserve moisture vital for agricultural production. The range of such tillage practices available to the smallholder farmers are outlined in Table 1. The potential for these tillage practices to reduce soil loss and conserve moisture can be inferred from the work of Vogel (1992). On the basis of an agronomic experiment, he estimated soil losses in cropped sandy soils under varying soil and moisture conservation practices and rainfall intensities over two seasons (1989/90 and 1990/91) in two agro-ecological zones. Soil losses were highest (up to 8 t ha^{-1}) under the current commonly practised conventional ox-ploughing with a single furrow mouldboard plough. The water-harvesting technique of tied ridging minimised runoff and sheet erosion. Soil losses were

3

estimated at 0.3 to 2.2 t ha^{-1}. Mulch ripping had the second least soil loss at 0.6 to 2.25 t ha^{-1}. Soil losses from cultivated lands kept free of weeds by either herbicides or multiple weeding was estimated at 50 to 90 t ha^{-1}. The latter implies that inter-cropping reduces soil loss. Vogel considered 5 t ha^{-1} as the sustainable soil loss level. Thus the adoption of these soil and moisture conservation tillage has the potential for reducing soil loss from the current estimates of 6 to 9.5 t ha^{-1} to the sustainable levels.

Soil moisture conservation enhances early development of the crop vegetative cover that provides added protection to the soil particularly during the most erosive rainfall (in terms of amounts received per unit time) in January and February (Vogel, 1992). Intercropping would have a similar effect of allowing different phases in the development of vegetative cover that provide protection later in the season.

DATA AND DESCRIPTION OF THE STUDY AREA

The paper draws from a larger study by the Department of Agricultural Economics and Extension, University of Zimbabwe. The study was set to analyze the economics of adoption of improved maize varieties and assess the returns to research and extension activities designed to increase maize production and income by smallholder farmers in a high rainfall area of Zimbabwe.

The data were obtained through a survey undertaken in Kandeya Communal Land, based, in Mashonaland Province in May and June, 1991. Seventy three (73) households were selected from 800 household in eight villages. The households were selected with the aid of the resident extension agent to obtain a sample representative of the types of farmers on the basis of technology use, agronomic practices, output in maize production. Maize was used as it is the staple grain crop of all households. It was also the target crop for the study. As the sample was not random, the sample statistics may not be generalised for the whole population. However, they are indicative of the prevailing situation.

The average farm household size was 8.8 persons with a landholding size of 2 ha. All household had access to adequate animal draft power: 56% of the households owned own oxen and 44% hired. Maize is grown both as a food and a cash crop. Their objective would be to produce maize in sufficient quantities to meet food needs and for marketing locally, or sell to local traders, or the Grain Marketing Board, the commercialized parastatal that is a buyer of last resort. For the sample population, the average total maize output was 4 320 kg, equivalent to 86.4 bags (50 kg bag). Household consumption was estimated at 2 bags per household member per year. The surplus for the market was 30 bags. All the farmers used hybrid short-season maize varieties. These are high yielding under conditions of fertilizer application and high and reliable rainfall. This explains the high yields achieved by the surveyed farmers. Use of moisture conservation strategies could also be a contributory factor.

The average areas allocated to the crops and the percentage of households growing each crop were: maize 1.25 ha; cotton 0.52; groundnuts 0.25; tobacco 0.4. Groundnuts were mainly a subsistence crop. Cotton was an established cash crop. The farmers were diversifying into tobacco production. Cowpeas, roundnuts and finger millets are grown mainly for home use and local marketing. Areas allocated to these are small. Cowpeas are intercropped with maize.

Ox-draft power is used for land preparation, weeding with an ox-drawn cultivator and transport. The farmers applied recommended maize fertilizers, ammonium nitrate (AN = 34.5% nitrogen) and Compound D (Nitrogen=8%; phosphate=14%; potassium=7%) at around the recommended rates of 170.43kg per ha. Compound D is for basal application while AN is applied as top-dressing at around six weeks post germination.

Soil and Moisture Conservation Tillage Practices

Table 1 Soil and Moisture Conservation Practices and Number of Households Practising

Practice	Description	No[1]
Contours	drainage ditches for protection of arable lands by controlling rainfall runaway, prevents rill and gully soil erosion	71
Gulley protection	filling up gulleys and taking prevented measures against gulley formation within and around the lands.	4
Winter ploughing	cultivation soon after harvest to conserve soil moisture and incorporate crop residues into soil	53
Tied ridges	Perpendicular ridges made to create depressions to capture and preserve rainfall runoff within the field	8
Ridging	Ridges made within the land to capture rainfall runoff with planting either on the ridge or the fallow	46
Planting holes	Planted holes not levelled so as to leave depression for retention of rain directly in the planting station	2
Crop rotation	Mostly maize and groundnuts; maize and roundnuts. Generally all sole cropped	73

Note 1: Number refers to a number of farmers adopting in the study sample

The number of farmers who have adopted the various soil and moisture conservation in the study area are given in Table 1. The widely adopted were crop rotation, contours, winter ploughing, and

5

ridge cultivation. Crop rotation is advocated by the extension service as a pest and disease control strategy and for improving soil fertility in the case of a rotation with groundnuts and roundnuts. Contour ridging is a mandatory requirement by the extension service. Contours are a long-term investment. Once properly constructed, as per the land use plan of the extension agent, they last up to 25-30 years with minimum maintenance.

Winter ploughing is done immediately after harvesting when there is still soil moisture. It is a soil moisture conservation strategy with short-term benefits in the following season as it maintains soil moisture that is critical for germination and early establishment of the crop. The resultant incorporation of crop and plant residues has both short and long-term benefits. It raises organic matter content of the soil and nutrient availability. Soil moisture conservation allows effective use of early rains for crop establishment. It is vital in the event of delays in onset of rainfall or low rainfall at the start of the season. Winter ploughing is by ox-ploughing and is therefore not labour demanding.

Tied ridging and planting holes have immediate payoff as they retain rainfall runoff within the fields for immediate use by the growing crops. Both slow the runoff thereby retarding soil erosion. The practice of planting holes is not widely used to forestall birds and baboons from easily identifying the planting stations and picking the planted seed. Tied ridging was not widely practised in the survey area. It is mostly used in parts of the country where the rainfall is low and erratic. It is more human and ox labour demanding than row ridging. The latter allows easier weeding.

THE EMPIRICAL MODEL

The relationship between sustainable agricultural practices and farm welfare-food security, and income can be expressed in the framework of a profit maximising behaviour of smallholder farm household. The household will allocate resources to meet the goal of maximising the welfare of the family. This welfare is defined as meeting adequate food security for the family and generating surplus for marketing to obtain cash. Food security would be determined by the total output of the food crop. In the case of Zimbabwe, the food security crop is maize. It is grown by all the smallholder farmers. Thus maize output per household is used as the dependent variable. The functional relationship can be expressed as:

Maize Output = *f (maize variety, maize area, landholding size, planting population, planting date, fertilizer applied, cattle manure applied, number of weedings, soil and moisture conservation practised, access to draft oxen, area allocated to other crops, rainfall quantity, household size, household head age, years farming, extension contact, remittances)*

Number of resident household members is proxy for available labour resources. Access to animal draft to important to implement various soil and moisture conservation practices. A dummy is used for access through ownership or renting (1), or (0) for none. Application of AN and D fertilizers, cattle

6

manure, pesticide for maize stalk borer control are expected to increase output. Area allocated to other crops, tobacco, cotton and groundnuts is expected to draw resources from maize and therefore have a negative impact on output. Total area allocated to maize is expected to increase total output but have a negative impact on yield due to competition for resource use.

Adoption of soil and moisture conservation practices measured as an index of winter ploughing, contours, and row ridging would have a positive functional relationship with maize output. Early planting date should have a positive impact by lengthening the crop growing season. However, the effect of the planting date is influenced by the onset and availability of effective rainfall. The onset of rainfall determines planting date and the overall cropping season length and the early vegetative cover development phases of the crops. Soil conservation strategies would reinforce the positive effect of early planting date as determined by the rainfall onset. There is also an interaction effect between variety, rainfall onset, planting date and winter ploughing. An early maturing variety would allow early harvesting and hence early winter ploughing when soil moisture is high. Inter-cropping with cowpeas would have positive effect through nitrogen fixation.

Age of household head and years of farming are expected to have a positive effect on output through the accumulated experience on knowledge and handling of local conditions. Remittances in cash and in-kind from non-farm work would provide some working capital for purchase of inputs. This together with access to agricultural credit would contribute positively to output. Number of non-resident household members could be used as a proxy for remittances. Extension contact has positive effect. A dummy is used for membership and extension contact group as proxy for extension contact.

Linear and quadratic models were applied in order to choose the best fit equation for estimating the effects of varying the various inputs, management practices and household socio-economic characteristics on total maize output. Several steps were used in building the model. First a model including all variables for which there were data was estimated. Subsequently, all non-significant variables were dropped. The choice of variables was based on minimum C_p, high R_2, small mean square error and stability:

$$C_p \quad = \quad [\text{SSE}(p)/(\text{MSE}(k)]-[n-2(p+1)]$$

where p = possible number of variables,

k = maximum number of variables,

n = number of observation

Variables found statistically insignificant and omitted from the equation were household size as proxy for labour, access to oxen, pesticide application for stalk borer control, plant population, and maize area.

RESULTS AND DISCUSSION

The following equation was found to be the best and most functional for the purpose of this study:

$$TOTMZEOUT = A + B_1AN - B_2D + B_3COTTON + B_4GROUNDNUT^2 + B_5WINTPLOUGH + B_6MAIZE^2$$

$$- B_7WINTPLOUGH \times GROUNDNUT + B_8WINTPLOUGH \times TOB + B_9PLANTDATE \times D$$

$$+ B_{10}AN \times GROUNDNUT$$

where

TOTMZEOUT	Total maize production in 90kg bags per household
AN	Top-dressing 34.5% Ammonium Nitrate (kg/ha)
D	Basal application of Compound D(8% N, 14% P, 7% K) kg/ha
COTTON	Cotton production per household (ha)
GROUNDNUT^2	Groundnut production per household squared (ha$^{2)}$)
TOB	Tobacco production per household (ha)
WINTPLOUGH	Winter ploughing with a value of 1 for if done or 0 if not done
MAIZE^2	Maize production per household squared (ha^2)
PLANTDATE	Planting date in days from 28 October the first date of planting in the sample

The estimated coefficients are given in Table 2. The variables with positive impact on per household maize output are fertilizer application, crop rotations and intercropping, winter ploughing, planting date and maize area squared (representing economies of scale).

Table 2 Results of Estimated Equation

Variable	Co-efficient	Std Error	t
Constant	-28.8063	7.22	-3.99
Ammonium Nitrate (AN)	0.1297	0.026	4.97
Compound D	- 0.0695	0.029	-2.38
Cotton	8.5774	4.78	1.79
Groundnut Area^2	148.6619	30.40	4.89
Soil & Moisture Conservation	24.7815	6.16	4.02
Maize area^2	12.8032	0.88	14.47
Soil & Moisture x Groundnuts interaction	-105.398	29.22	-3.61
Soil & Moisture x Tobacco interaction	31.6089	11.27	2.80
Planting Date x Compound D interaction	0.002137	0.0006	3.40
AN x Groundnut interaction	-0.4484	0.10	-4.28

$R^2 = 0.827$

Winter ploughing on its own and in an interaction with tobacco have the largest positive impact. Tobacco is ideally planted in mid-October to early November. This would be well before onset of the rainfall. Tobacco growing farmers are most likely to winter plough to conserve moisture for planting tobacco early. Either the winter ploughing is extended to all the arable lands or maize lands are specifically targeted to enhance higher output.

Intercropping, and maize-groundnuts rotations have positive effect on household total maize output. This is consistent with expectation and other findings (Page and Ndlovu, 1991; Shumba et al, 1991). Intercropping maize and cowpeas raises soil nitrogen with positive effect on maize yield.

The negligible positive impact of basal fertilizer application compared to top-dressing application could be explained by interaction between timing of fertilizer application and rainfall. Normally the smallholder farmers apply fertilizer on positive indication of rainfall. AN applied later in the growth of the crop is more likely to have greater impact than basal fertilizer applied at the pianting or establishment of the crop. The planting date and the pattern and amount of rainfall received subsequently are vital. This would explain the positive but negligible effects of delayed planting in the

9

estimated equation.

The positive impact of groundnuts, cotton and tobacco (interacting with winter ploughing) suggests that households producing cash crops are more efficient producers of maize. Several explanations are possible. One is that cash crop production provides cash resources that are invested in maize production as well as the other crops. Households diversifying into cash crops, particularly tobacco, do so on the confidence of being able to meet their food needs and having adequate resources for investing in tobacco.

The negative interactive effects of winter ploughing and groundnuts and AN are suggestive of the importance of groundnuts as a source of nitrogen. Winter ploughing lands in which groundnuts were planted could reduce the accumulative effects of nitrogen fixed by the groundnuts. This could be as a result of turning and exposing modulating agents in the soil.

The larger positive impact of groundnuts compared to AN, suggests that to some extent groundnuts can be used as a substitute for AN if the lands are not winter ploughed. The results indicate that farmers could reduce use of chemical fertilizers without a significant negative impact on output. Farmers would benefit from the reduction in cash required to purchase the fertilizers. Similarly the negligible impact of basal fertilizer suggests that farmers could reduce the rates applied without much impact on total maize output. This would have a beneficial effect on the environment as well as the farmers' cash outlay. The result indicates that the blanket fertilizer application rates by the extension service are not appropriate.

SUMMARY AND CONCLUSION

The objective of the study was to evaluate the relationship between adoption of soil and moisture conservation tillage practices and farm welfare, measured as output of the main food crop, maize. The study confirms that sustainable cropping systems and management practices are profitable and improve household food security and incomes at the farm level. The wide adoption of soil and moisture conservation practices by the Kandeya farmers is rational as the resultant increase in maize output is positive and therefore attractive for farmers to invest in the practices. They have greater chance to be widely adopted by farmers in other farming areas in the same agro-ecological zones.

The results of the study are location specific but suggest that there are incentives for other farmers in comparable agro-ecological zones to adopt sustainable soil and moisture conservation tillage practices. Maize producers adopting these soil and moisture conservation tillage practices in conjunction with rotation with groundnuts and intercropping with cowpeas can reduce use of chemical fertilizers without adversely affecting maize output. The results also suggest that production of cash crops has no negative impact on food output provided there is continued investment in soil and moisture conservation practices. In fact the high value cash crops provide the incentives and

resources for intensifying food crop production. Thus crop diversification tends to induce improved sustainable land management at the farm level. The smallholder households do not face difficult trade-offs between the requirements for investing in conservation and the need to meet livelihood requirements.

Results suggest that farming systems that are based on high value crops and high returns to the use of inputs, smallholder farmers will adoption soil conservation technology if there are immediate economic gains. Income generated from high value crops provides incentives for investment into productive inputs (such as fertilizer) and soil conserving practices. Similarly, soil-conserving technologies that are productivity enhancing are critical for the promotion of soil conservation in Communal Lands.

This study did not quantify the off-site benefits and costs of the soil and moisture conservation and tillage practices. The focus was on the impact at the farm level. There was no measurement of soil losses from the farmers fields, nor a control group for comparison purposes. However, these are not considered major set backs given that adoption of winter ploughing, contours, rotation were deemed universal by the extension service. One can then use the findings of Vogel (1992) to infer that adoption of the soil and moisture conservation tillage practices reduces soil loss. This would be positive for sustaining smallholder crop production, food security and income in the short-run and long-run. Sustainability of household food security and income in the smallholder is linked to sustainability of the cropping systems. The latter in turn depends on management practices that minimize soil loss caused by erosion.

REFERENCES

Carcamo, J.A.,J. Alwang, and G. Norton. 1994. "On-site economic evaluation of soil conservation practices in Honduras." **Agricultural Economics** 11 (1994):257-269.

Eicher, C.K. 1995. "Zimbabwe's maize-based green revolution: Preconditions for Replications" **World Development** Vol. 23 No. 5:805-818

Elwell. H.A. 1987. "Sheet erosion from arable lands in Zimbabwe: prediction and control. In Challenges in African hydrology and water resources." **Proceedings of the Harare Symposium**, July 1984. IAHS Publication NO. 144:429-437.

Gunatilake, H.M. and P. Abeygunawardena. 1993. "An economic analysis of soil conservation in tobacco lands in the Hanguranketha Area of Sri Lanka." **Indian Journal of Agricultural Economics**. 48(1):106-112.

Lopez-Pereira, M.A., J.H. Sanders, T.G. Baker and P.V. Preckel. 1994. "Economics of erosion-control and seed-fertilizer technologies for hillside farming in Honduras." **Agricultural Economics** 11(1994):271-288.

Lutz, E.; S. Pagiola, and C. Reiche. (eds.) 1993. "Economic and Institutional Analyses of Soil Conservation Projects in Central America and the Caribbean." World Bank Environmental Paper no. 8. World Bank. Washington, D.C.

Mausolff, C. and S. Farber. 1995. "An economic analysis of ecological agricultural technologies among peasant farmers in Honduras." **Agricultural Economics** 12 (1995):237-248.

Mudimu, G. D. 1992. "Achieving and Maintaining National and Household Food Security: Zimbabwe's Experience and Issues for the 1990s". in C. Csaki, Th. J. Dams; D. Metzger; and J. van Zyl. (eds). **Agricultural Restructuring in Southern Africa.** International Association of Agricultural Economics. Windhoek.

Mudimu, G.D. and B.M. Maumbe. 1993. "Agricultural marketing and pricing policies in post-independence Zimbabwe: Distributional issues and the need for restructuring" Agricultural Economics **Analysis and Rural Development.** Vol. 3 No.1

Page, S.L. and Ndlovu, Z. (1991) "Towards improved food security for resource poor communal farmers." In MacRoberts, J.F. (ed.) **Proceedings of Crop Science Society of Zimbabwe: Twenty-first Anniversary Crop Production Congress.** 2-3 July, Harare
a. 50-54.

Rohrbach, D. 1982. **The Growth of Smallholder Maize Production in Zimbabwe: Causes and Implications for Food Security.** Unpublished PhD. Thesis. Department of Agricultural Economics, Michigan State University.

Rukuni, M. and Eicher, E.K. (eds.) 1994. **Zimbabwe's Agricultural Revolution.** University of Zimbabwe Publications Office. Harare

Shumba, E.M., H.H. Dhliwayo, B. Kupfuma and C. Gumbie. 1991. "Response of maize to NPK fertilizer under continous cropping in low rainfall area" In MacRoberts, J.F. (ed.) **Proceedings of Crop Science Society of Zimbabwe: Twenty-first Anniversary Crop Production Congress.** 2-3 July, Harare p59-62.

Stack, J.L. 1994. "The distributional consequences of the smallholder maize revolution " in Rukuni, M and C.K. Eicher (eds). **Zimbabwe Agricultural Revolution.** University of Zimbabwe Publications.   p. 258-269.

Vogel, H. 1992. Effects of conservation tillage on sheet erosion from sandy soils at two experimental sites in Zimbabwe. **Applied Geography** 12:229-242.

Whitlow, R. 1988. Potential versus actual erosion in Zimbabwe. **Applied Geography** 8(2):87-100.