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Resilient Conservation Farming Systems and Land Degradation in Bungokho Mutoto Ridge of Mt. Elgon Watershed, Eastern Uganda

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Abstract: With reference to sustaining the mountainous farming systems in eastern Uganda. This study presents some insights into the prime ecological and economic impacts of land degradation in Bunghoko Mutoto ridge of Mt. Elgon watershed, eastern Uganda. The declining forest resources, depleting soil fertility, small fragmented land holdings and intensive use of land to provide for subsistence needs of growing human and animal population, has raised serious concern over sustainability. The study ridge (124 ha) represents typical farming situation in the hilly landscapes of Uganda. Of the total cultivated area of 54 ha, about 80% is cultivated with food crops, 7% cash crops and 3% fruit crops. People depend mainly on agriculture for their livelihood. About 59, 21, 11, 7, 3 and 2% of the average income contribution to the household economy come from off-farm, livestock, fruits, vegetables, cash and cereal crops, respectively. Terracing farmland and planting fodder trees on terrace edge and on terrace risers are the resilient traditional farming practices in order to minimize soil erosion and to maintain crop production. Slash and burn activities are continuously being practiced. Few farmers have adopted soil conservation techniques like use of mulching, hedgerows, mixed cropping of cereals with legumes and minimum tillage and establishing fruits orchards and vegetables farming. It is possible to improve economic condition of people in the area through commercialization and diversification of resilient agricultural practices with minimum degradation of natural resources.

Key words: Agriculture, environment, farming systems, soil erosion, resilient conservation

INTRODUCTION

Uganda is facing serious problems of soil degradation due to over exploitation of limited soil resources and increasing population pressure (MAAIF, 2005). Management of soil resources for sustained agricultural productivity and for achieving food security, for present and future generations, is of utmost importance for this region. Agriculture is the largest sector of the Uganda's economy. About 80% of the population depends on it as the main source of income and livelihood. The agriculture resource base has been both shrinking and degrading with the increasing population pressure and marginal land with steep and very steep slopes increasingly being brought under cultivation. This has led to intense land degradation due to soil erosion in the hills and mountains (Siriri and Bekunda, 2001). Cultivation on sloping and terraced land is a common feature of the Uganda's hill agriculture. The resilient traditional farming system and cultivation on steep hill slopes have accelerated the rate of erosion and degradation. It causes severe on-and off-site environmental, economic and social impacts. To overcome these problems, research projects need to adopt a new research paradigm based on a participatory and interdisciplinary watershed approach (Fischler and Wortmann, 1999). The three key elements of this approach are: the focus on on-and off-site impacts, the provision of scientifically sound information for decision-makers and the involvement of the whole range of stakeholders from land users to policy-makers.

The challenge now is to introduce farming practices aimed at minimizing soil erosion and nutrient losses. Understanding the hydrological processes, the relationships among rainfall, runoff and sediment and nutrient transport and the socioeconomic conditions of the farmers in the area are important parts of the research. Therefore, to address these concerns National Agricultural Research System (NARS) in collaboration with International Water Management Institute (IWMI) has adopted a new research paradigm at the watershed-scale, based on an integrated, participatory

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and interdisciplinary approach for the sustainable management of land resources in the country (Nadhomi *et al*., 2006). This study is based on the study carried out in Mt. Elgon, Mbale district and aims at presenting the review of effects of the activities of Dubana Farmers' Group on conservation farming systems and assessment of the socio-economic environment and production system, the general impacts and level of their magnitude in the local condition.

MATERIALS AND METHODS

Study area: Dubana Farmers Group site is situated in Bungokho Mutoto Sub-county, Bumboyi parish, Namachere and Bugimeshi village, respectively in Mbale district. Physiographically, this site is located in the middle mountain region. Settlement in the area started about 300 years ago by mainly Gishu, ethnic group. Bungokho Mutoto ridge occupies an area of about 124 ha and is about 6 km away from small town of Mbale. It takes about 1 h to reach this site from Mbale town by road. This site with sloping land represents a typical hill-farming situation. Deforestation leads to soil erosion, low agricultural productivity and increased household costs such as land management practices that ultimately lead to poverty in the area. Conservation farming much of the mid-hills and in Bungokho Mutoto ridge in particular, is mostly of a subsistent nature. A majority of farm households in the area are small although there are few farmers who produce marketable surplus of fruits like orange and banana (Nabalegwa *et al*., 2007).

After the selection of site, the staff and students team composed of foresters, soil scientists, socio-economist and development scientists conducted a field visit for carrying out Rapid Rural Appraisal (RRA) of the area. Biophysical and socioeconomic information were gathered through discussion with the farmers and key informants like the village head and field survey.

Within Bungokho Mutoto Ridge (R1), four micro-watersheds were further identified and delineated on the topographical map of a scale of 1:5000. These were identified as Busamaga, Namachere, Bugimeshi and W5 with areas of about 72.6, 39.6, 11.5 and 1.6 ha, respectively (Nakileza and Nsubuga, 1999). The hydrological part of the Dubana Farmers Group area included discharge measurements at 5 locations and rainfall at 8 locations. There could be various off-site effects of soil erosion in the downstream area and some of the potential impacts as envisaged were on the crop yields, soil properties, stream water quality, flooding and sedimentation in the agricultural land and erosion due to stream bank cutting and so on.

Based on the potential impacts of soil erosion in the downstream areas, initial survey of farmers who could potentially be affected was conducted. They were asked about their experiences and observations on the effect of soil eroded from the upland areas. To complement the results of surveys and interviews, periodic monitoring and analysis of quality of flowing water, soil properties and fertility status, farm inputs and crop yields of upland rice was conducted.

RESULTS AND DISCUSSION

Biophysical attributes: The study was conducted in Bumboyi and Monni parish, Bungokho Mutoto Sub-county, Mbale District. The two parishes were selected for the study after discussion with the leaders of Dubana Farmers Group and based on the availability of integrated smallholder farming systems. The Bungokho Mutoto ridge of Mt. Elgon watershed is situated at 1^0N and $34^0$30'E, approximately 100 km northeast of Lake Victoria on the Kenya-Uganda border. The mountain area covers 2045 km^2 with 114 km^2 comprising Mt. Elgon National Park on the Ugandan side. The mean annual rainfall ranges from 1500 mm on the eastern and northern slopes to 2000 mm in the south and the west. On lower slopes, the mean maximum temperatures decrease from 25-28°C and mean minimum temperatures are 15-16°C. The topography ranges from moderate to very steep with 40-100% slopes. It represents typical farming situation in the hills. The region has got a subtropical climate. The average annual rainfall is about 2750 mm, 85% of which falls from May to September. The mean annual temperature is about 22°C with a maximum of 35°C in May and a minimum of 9°C in January (Nakileza and Nsubuga, 1999). Soils in the area are, in general, well to excessively drained, sandy loam to loam in texture and acidic in reaction. These are tentatively identified as Inceptisols, Alfisols and Entisols (USDA, 1975). Organic matter and NPK contents are generally moderate to high. The cropping system in the upland area consists of maize followed by groundnuts, vegetables, Soybean and potato crop (Wortmann and Elendu, 1999). In the lowland area, upland rice is grown as second rain season crop followed by fallow, Irish potatoes or maize as first rain season crop.

Socioeconomic attributes: Of the total cultivated area of 54 ha, about 80% is used for growing cereal crops, 7% for cash crops and 3% for fruit crops. The main source of irrigation is River Sipi. Two crops are mainly grown in a year. In case of lowland, only a single crop of upland rice is grown as second rain season crop and only a few farmers have recently started growing rice as first rain

Table 1: Agricultural land, productivity of different crops and input use

Parameters	Simple variables	Number		
Agricultural land	Total cultivated area ha.	53.55		
	Average farm size	0.66		
	Lowland	0.25		
	Upland	0.62		
Land utilization in %	Food crops	80		
	Cash crops	7		
	Fruits	3		
	Forest/pasture	10		
Area (ha) and productivity (kg)	Maize			
	area	28.12		
	Productivity	1176		
	Upland rice			
	area	9.38		
	Productivity	2257		
	Groundnuts			
	area	2.27		
	Productivity	867		
Input use	Inputs (kg)	Upland rice	Maize	Irish potatoes
	Seed	84	30	115
	Urea	1.67	-	7.0
	DAP	1.0	-	-
	FYM	541	1438	456

season crop after upland rice. Some farmers have also grown spring maize in lowland land before upland rice. The other crops grown in upland lands are maize, groundnuts, soybean and legumes. The overall cropping intensity is 147. Details on agricultural land, productivity of different crops and input use is presented in Table 1.

There are 54 households with the population of 354 and average family size of 6.65 in the area. Main ethnic groups are Gishu, Sabiny, Basoga, Banyoli and Iteso (Table 2). People depend mainly on agriculture for their livelihood. About one fourth of the total land is occupied by marginal and small farm households, which comprise half of the total households. About one-half of the land is under medium farm households and less than one fourth is under the large holding (Fischler and Wortmann, 1999). Given the limited opportunities for rural employment and low agricultural production, a few households have migrated to other adjoining villages. About 62.5% of the population, mostly Gishu and Sabiny go to other districts for wage labor.

Table 2: Demography and ethnicity

Parameters	Simple variables	Number
Demography	Total no of HH	54
	Population	356
	<15 years	148
	15-60 years	185
	>60 years	23
	Male	182
	Female	172
Ethnicity	Banyole	35
	Iteso	73
	Sabiny	81
	Gishu	165
	Religion HH no.	
	Christianity	38
	Islam	16

Soil erosion and sediment yields: Annual sediment losses from micro-watersheds were 0.240, 0.137, 0.088 and 0.077 ton h^{-1} in Bungokho Mutoto (W1), Namachere (W3), Bugimeshi (W4) and Busamaga (W2), respectively (Table 3). Annul sediment loss was generally higher (0.240 ton h^{-1}) for the watershed as a whole (Bungokho Mutoto) compared to those of individual micro-ridges. The sediment loss from micro-watersheds, Busamaga, Namachere and Bugimeshi are much less than that of Bungokho Mutoto but sediment loss of Namachere (0.137 ton h^{-1}) is almost double than of busamaga and Bugimeshi. The sediment loss from W5 with upland cultivation and slopes less than 5 % is almost negligible. The annual sediment losses from all the micro-watersheds in the year 2001 is much less than that in 2000 reflecting the variation on precipitation amounts and patterns. There is, however, a need to monitor the hydrological behavior in the watershed for some more years in order to derive conclusive results.

Socioeconomic trends: Agriculture is the predominant sector of the Bungokho Mutoto watershed economy. About 58.6, 20.8, 10.7, 7.3, 2.6 and 2.3% of the average income contribute to the household economy from off-farm, livestock, fruits, vegetables, cash crop and cereals respectively (Table 4).

Terracing the farmland and planting fodder trees on terrace edge and terrace risers are traditional farming practices of farmers to minimize soil erosion and to maintain crop production. Farmers have also adopted clearing terrace risers by slicing and adding it to soil at

Table 3: Yearly sediment loss (March-September 2001) (Source: MAAIF, 2005)

Village	Area (h)	Rainfall (mm)	Sediment (t h^{-1})	Sediment (t h^{-1})
Bungokho Mutoto	124.3	2761.00	29.752	0.240
Busamaga	72.6	2788.80	5.574	0.077
Namachere	39.6	2701.20	5.457	0.137
Bugimeshi	11.5	2856.00	1.014	0.088
W5	1.6	2794.50	Traces	Traces

Table 4: Food situation and income source

Parameters	Simple variables				Number		
Food situation	<4 months				3		
(HH no.)	4-6 months				18		
	6-9 months				19		
	9-12 months				10		
	Surplus				3		
	Average livestock herd				Av. milk production (liters)		
Livestock	Pig	Cow	Bull	Goat	Poultry	Milking cow	Milking goat
	2.5	3.5	2.0	5.2	9.7	47.4	84.0
Credit source (%)	Formal	70					
	Informal	30					
Cash income source (%)	Crop products	21					
	Livestock products	21					
	Off-farm	58					

least once a year during land preparation to maintain the soil fertility. Farmers apply, in general, about 10-15 tons of Farmyard Manures (FYM) in their farmland.

Relevant policies in watershed management: The Government has adopted different policies and programmes for watershed management in the country. These include mainly community and leasehold forestry programmes, afforestation in the degraded land area, terrace improvement and improvement in the farming systems. Individual approaches are needed to make intervention in the hill agricultural farming system. Among these, the Sloping Agricultural Land Technology (SALT) models were introduced in the area in an effort to promote conservation agricultural amidst changing ecological and social farming methods. The Dubana Farmers' Group carried out the training programmes and group discussions among farmers about these models. As a result, some farmers of the watershed have already established some hedgerows and hillside ditch in their farmland in order to reduce soil erosion. Other neighbor farmers also came to collect the information and tried to apply the technologies in their farmland.

Slash and burn activities are continuously being practiced in the on-site for many years and it is expected that it will still continue. In off-site area, these activities were done in the last year. Farmers specially those from Gishu ethnic group follow the slash and burn practice in non-irrigated marginal cultivated uplands in April and May. After these activities, farmers prepare the field for cultivation of maize, soybean and bean crops in the upland. About 7 households with 1.63 ha of land had followed the slash and burn activities.

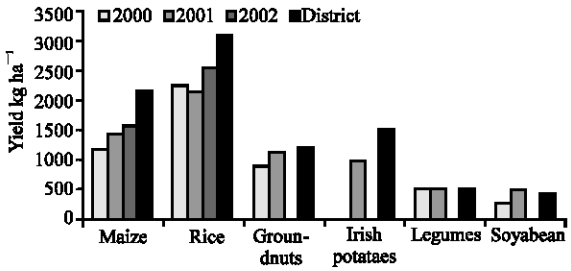

Fig. 1: Yield comparison of different crops with district average (Source: MAAIF, 2005)

Crop yield and income: Average yields of maize and rice were estimated to be 1560 and 2550 kg ha^{-1}, which have been increased by 32 and 13%, respectively as compared to in the year 2000. Their productions are still low as compared to the district average except legumes and Soybean crops but they have an increasing trend (Fig. 1).

There were some positive effects of intervention technologies like contour hedgerows on production and productivity that takes a few years' time for their well establishment that give some visible impacts. Positive impacts of adoption of technologies on productivity were seen based on positive results in the areas.

Soil conserving farming techniques: Appropriate soil conserving farming system technologies and other farmer's income generating land management technologies introduced within the watershed area for better and sustainable land and water management were as follows:

Sloping Agricultural Land Technology (SALT) farming system: In this system perennial leguminous plant species

and/or grass species, depending upon needs of farmers are grown as double line hedgerows along contours in association with annual or perennial crops in a spatial arrangement. This system once adopted can control soil erosion due to runoff water in the farmland to a greater extent and also, it helps to ensure sustainable production through the maintenance of soil fertility.

Hillside ditch farming system: In this, a furrow or shallow trench type hillside ditch is dug and maintained along the terrace on inner side just at the bottom of the terrace riser. This system helps in reducing soil erosion due to runoff water and also in maintaining soil moisture for a longer time, which will ultimately enhance sustainable farm production.

Inter-cropping (mixed) farming system: In this system, leguminous crops like soybean is inter-cropped with maize during the second cropping season and this provides good ground cover against soil erosion and also, helps in maintaining soil fertility.

Environmental degradation: Soil erosion, deforestation and overgrazing are the key factors of decreasing per capita income. Landholdings are depicted as a result of very rapid population growth and inappropriate cultivation techniques. It is observed that the most serious problem of environmental degradation has occurred in the marginal lands. Signs of soil erosion are evident particularly on slopes of more than 20-30 degrees. About 87% of total households reported that soil was being washed down from their sloping land and 83% have felt the deterioration of their soil condition due to soil erosion (Zake *et al*., 1999). Mostly, farmers use simple conservation measures such as terracing and planting bamboos, grasses (broom grass, small bamboo and napier grass) etc. to control soil erosion and degradation in sloping land.

The results of this study have indicated that there has a general enhancement of awareness among farm communities on soil erosion and land degradation and their negative impacts on crop production.

- Dubana Farmers Group has organized training on land management technology (hillside ditch, contour hedgerows, strip cropping, etc.), which was participated by 9 farmers.
- Farmers expressed their views that deposition of sand, gravel and stones in cultivated land due to flooding during heavy rainfall seemed to be low as compared to in previous years. Therefore, they did not have to clear such things and repair the terraces by themselves and that the net profit margin of the products was high in this situation. Besides these positive impacts, farmers complained about the associations's negligence to maintain the irrigation channel in on-site and off-site areas. Also, there was limited employment opportunity to local people and fruits saplings and black gram seeds were not provided to the farmers.
- One farmer had practiced slash and burn in an area of 0.33 ha between Namachere and Bugimeshi villages. Three farmers with farm areas of 0.23 continued slash and burn for upland rice after maize in second cropping season of 2002. This was done in April-May where maize crop was cultivated in the previous year.
- The farmers' group distributed about 0.5 kg the foundation seed of maize to each households of 80 farmers of both on and off-site watershed areas.
- The farmers' group also distributed fruit saplings of mango, guava and litchi to 14 leading farmers in the site.
- Fodder tree saplings like *calliandra* and *Leucaena leucocephala* (Ipil Ipil) were distributed to 7 farmers who now realize the importance of fodder trees for milk animals like cattle and exotic goats in increasing milk production as compared to previous year.
- Dubana farmers group encouraged use of compost together with chemical fertilizers in the farmers' cultivated field for sustainable agricultural development in the area.
- Farmers usually planted two crops (Upland rice-Maize) in the irrigated land previously. The cropping pattern in the irrigated land has changed gradually from the last year. Subsequently, 4 lead farmers have included Irish potato crop during first rain season of 2001. In the upland areas farmers have started the practice of second season bean mixed with maize.

Although there is no immediate effects, the above interventions could lead to several impacts in the long run: Intervention technologies like contour hedgerows and hillside ditch in the farming system were introduced in planting season of 2001. According to experts, hedgerows take at least 3-4 years to become well established so that their impacts on hydrological behavior and positive effects on run off and soil erosion may be observed.

One farmer established hillside ditches of about 150 m long and 5 farmers established hedgerows with a

Table 5: Farmers opinion of the performance of Dubana farmers group activities

Dubana farmers group activities	Opinion*	Give reasons for your choice
Stream water quality	2	Dam construction, reduce run off soil loss
Less soil erosion	2	Due to terrace construction
Control of sediment loss	2	Due to terrace construction
Soil fertility status	2	Reduce run off top soil
Environment conservation	4	It takes long time to evaluate
Basic food crop yield	2	Depends on monsoon rainfall, reduced nutrient loss
Cropping pattern change	2	Irish potato crop and bean vegetables
Milk products	2	Grass available
Fruit trees	2	Mango and guava are still in the field
Fodder trees	2	
Grass for livestock	2	Calliandra and sesbania sesban grass practices
Technology development SALT farming system Hill side ditch	3	Reduce water and top run off soil, moisture
Intercropping farming Hedgerows (Alley cropping)	3	Vegetative barrier for sediments and runoff water and maintain soil moisture and fodder
Technical advice	2	For hillside ditch but no advice on hedgerows
Income activity through vegetables, fruits and grass	2	Second season bean relay with maize crop
Total member of beneficiary	2	8-10 HH benefits from control of sedimentation and soil loss
Total no. of local employed	2	Two local peoples employed in the Dubana Farmers Group

NB: *Opinion: 1 = Unsuccessful, 2 = Moderately successful, 3 = Successful and 4 = Highly successful

total length of 2010 m. Although the area is too small to observe impacts on run off and soil erosion at the watershed level, the results obtained from the on-farm experiment showed that there was about 20 % decrease in soil loss due to this technology. This is positive impact that helps to maintain soil fertility in the long run. During the discussion, farmers expressed the positive impacts of hillside ditch and hedgerow in controlling the water, sedimentation and by minimizing soil erosion loss from their fields (Table 5).

The farmers group's activities were steps towards food security for farmers in the study areas. The average yield of different crops has increased as compared to previous year. Some farmers expressed that the nutrient contents in the run off water from their fields was somewhat low so the yield of upland rice increased. The cropping intensity was increased due to cultivation of new crops such as Irish potatoes and vegetables in the water assisted and rainfed lands, respectively. It may contribute to reduce poverty, increase livelihoods and provide food security for farmers. Farmers also practiced inter-cropping in the lowland e.g., upland rice with soybean on the bond. They have introduced ginger as a new crop in 2001 in both on and off-site areas. Five farmers cultivated lentil crop in upland in both on and off-site areas.

CONCLUSION AND RECOMMENDATION

This study has revealed that agriculture is the main activity of the farm household and although it has proved resilient to the drastically changing natural processes, it is not enough for rural livelihood. The agricultural production in the watershed area has not increased satisfactorily because of sloping terrace land, erosion problem, fragmented holding, biophysical constraints and poor infrastructure. Farmers have put a great effort to improve their living condition. But they are confronting with natural calamities (drought, heavy rain and hailstone). Efforts should be made to integrate the different farming components for the promotion of agriculture by introducing suitable crop varieties and improving farming systems like legumes, Soybean, off-season vegetables, milk production, goat raising and fruit farming with less degradation of natural resources. Commercialization of agriculture generates farm income and increase employment opportunities in the area since the watershed is situated close to the highway.

It is possible to improve economic condition of people in the watershed area through commercialization and diversification of agricultural practices without degradation of natural resources. Due to poor economic condition of the households and poor resource base of the operation site, the immediate plan for improvements as envisaged by the farmers are as follows and in this regard, it is necessary to adopt the need-based approach to development.

- Being mostly a rainfed area, lands are left fallow for 3-6 months. These areas should be utilized by cultivating legumes and vegetables to increase the income of the farmers. Insects, pests and diseases are the major problems of the staple crops. In this regard, it is necessary to adopt need-based approach by introducing on-farm research and development in collaboration with extension.

- Farmers should be encouraged to adopt the soil conservation techniques like mulching, growing hedgerows, mixed cropping of cereals with legumes and minimum tillage.
- Maize is the major crop in the area. Thus, emphasis should be given to promote the rain-fed crops like maize, Soybean and legumes and farmers should be provided with suitable varieties of these crops.
- Intensive training for control of soil erosion, livestock raising and off-season vegetable cultivation should be given to farmers so that they can take advantage of being close to the national highway.
- Farmers of this area should be encouraged to establish fruits orchard and vegetable farming.
- Market-oriented high value crops like Soybean, legumes, fruits and off-farm vegetables should be grown.
- Training on livestock production and management should be provided to the farmers.
- Cropping intensity has to be increased to provide increased on-farm employment opportunities to improve the existing farmers' economic condition.

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REFERENCES

Aniku, J., D. Kataama, P. Nkedi-Kizza and S. Ssesanga, 1999. PDCO and soil fertility management: Uganda results and experience. FAO, United Nations, Rome, 2001, pp: 65.

Bagoora, F.D.K., 1988. Soil Erosion Mass-wasting Risk. In: The Highlands areas of Uganda. Mountain Res. Dev., 8: 173-182.

Ellis-Jones, J. and A. Tengberg, 2000. The impact of indigenous soil and water conservation practices on soil productivity: Examples from Kenya, Tanzania and Uganda. Land Degradation and Dev., 11: 19-36.

MAAIF (Ministry of Agriculture, Animal Industries and Fisheries), 2005. Plan for Modernization of Agriculture. Progress report on Government Strategy and Operational Framework for Poverty Eradicating Action Plan in Uganda, Kampala.

Nabalegwa, M., M. Buyinza and B. Lusiba, 2007. Changes in soil chemical and physical properties due to land use conversion in Nakasongola district, Uganda. Indonesian J. Geog., 38: 154-165.

Nadhomi, D.L., J.S. Tenywa and F.D.K. Bagoora, 2006. Interactive effect of slope magnitude and land-use on runoff and soil loss on a Luvisol in the Lake Victoria basin of Uganda. Makerere Univ. Res. J., 1: 49-62.

Nakileza, B. and E. Nsubuga, 1999. Rethinking Natural Resource Degradation in Semi-Arid Sub-Saharan Africa: A review of soil and water conservation research and practice in Uganda, with particular emphasis on the semi-arid areas. Kampala, Uganda: ODI.

NEMA (National Environment Management Authority), 2005. The State of the Environment1 Report Uganda, 2002.

Siriri, D. and M.A. Bekunda, 2001. Soil fertility management in Uganda: The potential of Agroforestry. AFRENA, Kabale, Uganda.

UBOS, 2002. Uganda Bureau of Statistics. Provisional Population Census Results. Ministry of Finance, Planning and Economic Development. Entebbe, Uganda.

USDA, 1975. Soil taxonomy, Handbook No. 436. Soil Conservation Service, USDA, Washington.

Wortmann, C.S. and C.A. Eledu, 1999. Uganda's Agro-ecological Zones: A guide for planners and policy makers, Kampala, Uganda (CIAT).

Zake, J.S., C. Nkwijn and M.K. Magunda, 1999. Integrated Soil Management for Sustainable Agriculture and Food Security in Southern and East Africa. FAO, Rome.