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POLICIES FOR IMPROVED LAND MANAGEMENT IN UGANDA: SECOND NATIONAL WORKSHOP

edited by

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EPTD Workshop Summary Papers provide an overview of the discussions and findings of workshops and conferences that the division has helped organize and sponsor. It is generally expected that a proceedings volume of papers will be published at a later date

ABBREVIATIONS

IFPRI :	International Food Policy Research Institute
IITA :	International Institute for Tropical Agriculture
CBOs :	Community Based Organizations
NGOs :	Non-governmental Organizations
MAAIF:	Ministry of Agriculture, Animal Industry and Fisheries
MUFA :	Makerere University Faculty of Agriculture
MISR :	Makerere Institute of Social Research
NEMA:	National Environmental Management Authority
USAID:	United State Agency for International Development
SO :	Strategic Objective
LC1 :	Local Council 1
GIS :	Geographical Information System
UBOS :	Uganda Bureau of Statistics
NARO :	National Agricultural Research Organization
ZEF :	Center for Development Research, University of Bonn
APSEC:	Agricultural Policy Secretariat
UPE :	Universal Primary Education
AHI :	African Highlands Initiative
PMA :	Plan for Modernization of Agriculture
CIAT :	Tropical Agriculture Research Institute
SWC :	Soil and Water Conservation
SCRIP :	Strategic Criteria for Rural Investment in Productivity
SPR :	Subsistence Potential Ratio
KWCA:	Kawanda Composite A
PMA :	Plan for Modernization of Agriculture
UCDA :	Uganda Coffee Development Authority
SWH :	South-Western Highlands
ROU :	Rest Of Uganda
DRS :	Doho Rice Scheme
CGE :	Computable General Equilibrium
GAMS:	General Algebraic Modeling System
SAM :	Social Accounting Matrix
GDP :	Gross Domestic Product
DREAM:	Dynamic Research Evaluation for Management
ROW :	Rest Of the World
SOM :	Soil Organic Matter

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1. WELCOME AND INTRODUCTION

Welcome remarks by:
Professor E.N. Sabiiti,
Dean of Makerere University Faculty of Agriculture and
Chairman of the Project Advisory Committee

Hon. Dr. Kisamba Mugerwa, The Minister of Agriculture, Animal Industries and Fisheries, Honorable Ministers and Members of Parliament, The Director General, NARO, the visiting delegation from IFPRI and other International Institutions, other Participants, Ladies and Gentlemen:

It is my pleasure to welcome you all to the second national workshop on Policies for Improved Land Management in Uganda. We at Makerere University, and the faculty of agriculture in particular, are proud to co-sponsor this workshop, organized to discuss the findings of the 3 year project on Policies for Improved Land Management, which is about to be concluded. I wish to congratulate our partners (IFPRI, NARO, APSEC and ZEF) for this significant achievement.

Three years ago, we gathered here to plan policy research aimed at helping policy makers identify and assess policy, institutional and technology strategies for improving land management and reducing poverty without jeopardizing the natural resource base. To date, all the field activities that the project planned to undertake have been completed including the characterization survey, community survey, market surveys, and household and plot surveys. These activities have generated a lot of data, which must be analyzed and made available to all stakeholders, particularly the policy makers to help in formulating

policies that are supportive of agricultural modernization, which is the sure way of reducing poverty in this country.

Today, we are gathered here to receive some of the outputs of this research effort. I wish to congratulate the research team on a job well done, and to wish them good luck as they continue to process and analyze the rest of the data to produce usable results. In addition to the completed field activities, the project has made significant progress in capacity training by involving local collaborators in research design, implementation and analysis; and training Ugandan scholars at Ph.D. level at the Center for Development Research, University of Bonn (ZEF). Increased awareness of the project and its objectives has been achieved among policy makers through the project Advisory Committee, to which I am the chairman. This is a very significant achievement. The challenge is now upon all of us to use the findings of this carefully done research as a tool to contribute to national development by tackling the problems of land degradation, low agricultural productivity and poverty. Thank you very much.

I now take this opportunity to call upon the honorable Minister to open this workshop.

2. OPENING OF THE WORKSHOP

Opening Remarks By
Hon. Dr. Wilberforce Kisamba-Mugerwa,
Minister Of Agriculture, Animal Industry And Fisheries – Uganda

Distinguished chairman and members of the Advisory Committee for the research project on Policies for Improved Land Management in Uganda, the project lead scientist, Dr. John Pender from IFPRI HQ- Washington D.C., Development Partners and other international research and development organizations' representatives, and other Fellow Participants. Welcome to Uganda.

It is a great honor and pleasure to be invited to give opening remarks at this workshop, taking place in Kampala, Uganda. The government of Uganda is grateful for IFPRI's policy research activities in Uganda. Since IFPRI opened its offices in Uganda in 1999, many high-ranking officials have participated, and continue to do so, in IFPRI policy workshops and other activities. I understand that His Excellency, President Yoweri Kaguta Museveni is the chairman of International Advisory Committee of the 2020 Vision Initiative, the vehicle for raising awareness and stimulating a global dialogue about challenges and opportunities related to feeding the world, alleviating poverty, and protecting the environment. In September last year, Prime Minister Professor Apollo Nsibambi participated in the Bonn Conference on "Sustainable Food Security for all by 2020, from Dialogue to Action." I recently returned from Bonn for a follow-up workshop to the September 2001 workshop.

All this shows Uganda's commitment to IFPRI's policy research activities, which are very important for formulation of land policies in Uganda and other low-income countries. The need for policy oriented-research cannot be over-emphasized. As many of you are aware, the Government of Uganda is deeply committed to the Modernization of Agriculture in Uganda, as documented in the Plan for Modernization of Agriculture (PMA).

The PMA is a strategic framework for the implementation of programs and policies that the Government of Uganda intends to introduce in the process of modernizing agriculture in the country. As such there are several policy areas in which we need answers, but these can only be obtained through research. Looking through your workshop program and other materials sent to me, I am particularly happy to note that the research priority areas are very relevant to the research needs of the PMA and the policies we intend to adopt. The land degradation problem in Uganda is critical, including problems of soil fertility mining, soil erosion and others. Research is needed to understand the nature and extent of the problem, its causes, and to identify appropriate policy responses.

I should therefore say at this juncture that this research project on policies for improved land management has come at a very opportune time for Uganda. Uganda is grappling with the need to build capacity for policy-oriented research to guide policy makers to plan our long-term strategy for developing agriculture in Uganda. Strong local collaboration with NARO, APSEC and Makerere University has been a key element of this research. I am glad that local and international researchers have reaped such enormous benefit from this research project.

I also understand that the main objectives of the research project for policies for improved land management are to:

- Identify main factors affecting land management in Uganda
- Identify major current and potential development pathways, their causes and implications
- Identify and assess policy, institutional and technological strategies to promote more productive, sustainable, and poverty-reducing pathways of development and improved land management
- To strengthen the capacity of collaborators in Uganda to develop and implement such strategies; and
- To increase awareness of the underlying causes of land degradation problems in Uganda and promising strategies for addressing the problems

These are very important objectives, which I believe, if the project is able to achieve will help in meeting the PMA's requirements for information on how to increase smallholder farmers' productivity and to reduce poverty in a sustainable manner.

I can confirm MAAIF's commitment to this noble cause and challenge. We look forward to reading the reports and papers derived from your research activities in Uganda.

With these few remarks, MAY I DECLARE THIS WORKSHOP OPENED.

May you have a fruitful deliberation.

May God Bless You All and have a safe trip back home after the workshop.

3. POLICIES FOR IMPROVED LAND MANAGEMENT IN UGANDA: PROJECT OBJECTIVES, ACTIVITIES, AND ORGANIZATION

John Pender
International Food Policy Research Institute

BACKGROUND OF THE PROJECT

The project began in January 1999 with a planning workshop in Kampala sponsored by the International Food Policy Research Institute (IFPRI), the Makerere University Faculty of Agriculture (MUFA) and the National Agriculture Research Organization (NARO). The planning workshop included participants from the University of Bonn, Center for Development Research (ZEF); the Agricultural Policy Secretariat (APSEC); the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF); Makerere Institute for Social Research (MISR); the National Environmental Management Authority (NEMA); and various international research organizations. The project itself is a collaborative effect of IFPRI, Makerere University Faculty of Agriculture (MUFA), NARO, APSEC and ZEF, with financial support from the governments of Germany, Norway and the United States.

The focus of the project is most of Uganda, excluding insecure, lowland and dryland areas in the north. Seven of nine major farming systems in Uganda are represented within the framework of the project.

PROJECT GOAL, PURPOSE, AND OBJECTIVES

The long-term goal of the project is to contribute to improved land management in Uganda, in order to increase agricultural productivity, reduce poverty, and to ensure the

sustainable use of natural resources. The immediate purpose of the project is to help policy makers identify and assess policy, institutional, and technological strategies to improve land management in Uganda.

SPECIFIC OBJECTIVES

The project has several specific objectives:

- To identify the factors affecting land management and its linkages to agricultural productivity, poverty, and sustainability;
- To identify the major current and potential pathways of development in Uganda, as well as their causes and implications;
- To identify and assess strategies to promote more productive, sustainable, and poverty-reducing pathways of development and land management;
- To strengthen the capacity of collaborators in Uganda to develop and implement such strategies, based upon policy research; and
- To increase awareness of the underlying causes of land degradation problems in Uganda, along with promising strategies for solving the problems.

ACTIVITIES

To achieve the specific objectives listed above a series of research activities have been undertaken, including:

- Characterization of the land degradation problem and development of hypotheses using secondary information, field visits and interviews with officials and community representatives;
- Market surveys to identify market structure and responses to structural adjustment policies;
- Community surveys and resource mapping to identify pathways of development, their causes, and implications for land management
- Household surveys to assess impacts of policies and other factors on land management and implications;
- Farm level soil characterization and experimental work to better understand farmers' options and implications of alternative land management practices; and
- Household and market models to explore the potential impact of alternative policy, institutional and technological strategies.

PROGRESS

The project activities are now nearly complete:

- Characterization work has been completed and the results presented to the National Advisory Committee in January 2000;
- Market and community level surveys have been completed, initial results were reported in the first national workshop on policies for improved land management in Uganda in June 2001, and further analysis is being reported in this workshop;

- Household surveys, soils and experimental work and household bioeconomic models have been completed; and results are being reported in this workshop and a regional policy conference to take place next week in Addis Ababa Ethiopia;
- Work on market models is being completed and will be reported later this year.

WORKSHOP OBJECTIVES

1. To review and discuss the findings of the research project.
2. To increase policy makers' and other stakeholders' awareness of impacts of policies and other factors on rural livelihoods and land management in Uganda.
3. To discuss strategies to promote more productive and sustainable land management in Uganda in order to reduce poverty and food insecurity in Uganda.

4. SUMMARY OF MAIN THEMES AND KEY FINDINGS

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The workshop participants reviewed and discussed results of several studies of land degradation and land management in Uganda, the underlying factors determining land management and implications for agricultural productivity, food security, reduction in poverty and sustainable use of resources. Several key findings and themes emerged:

The problem of land degradation

The research confirms that land degradation is a major problem in Uganda, contributing to stagnant or declining agricultural productivity. Soil fertility depletion is an especially widespread problem, with evidence of declining soil fertility cited by farmers throughout Uganda (Pender et al.; Jagger; Nkonya, et al.; Brunner; and Sserunkuuma), and this is supported by findings from research on soil nutrient balances in several sites in eastern Uganda (Kaizzi, et al.; Nkonya and Kaizzi) as well as soil analysis conducted in several sites that were studied previously in the 1960's (Ssali). Research by Ssali shows that the problem in central and eastern Uganda may not primarily due to reduction in soil organic matter and macro nutrients such as nitrogen and phosphorus, but more related to soil acidification and depletion of bases. More research is needed to understand the dynamics and causes of change in soil fertility, as well as to conduct such historical comparisons in other parts of the country, to be able to identify adequate prescriptions for solving the problems in different soils and farming systems.

The causes of land degradation and productivity decline

The proximate causes of soil fertility depletion and productivity decline include declining use of fallow and increased commercialization of agriculture, without sufficient recycling and addition of soil nutrients or protection of the soil from erosion, leaching and other sources of nutrient loss. Underlying these proximate causes may be many factors, such as population pressure, poverty, lack of access to roads, infrastructure, and markets, limited farmer awareness of appropriate technologies, land fragmentation and tenure insecurity, and other factors. The research has shed light on many of these underlying causes, though more analysis is still needed before definitive conclusions can be drawn. We have not found conclusive evidence that population growth or high population density is the main reason for land degradation, as farmers adapt to population pressure by intensifying adoption of inputs such as manure and fertilizer and by other responses, such as seeking off-farm sources of livelihood. However, we observed that high population density is associated with lower yields and soil erosion. We also have evidence that better access to roads and markets has helped improve adoption of some improved technologies as well as improving some resource conditions, incomes from some activities and welfare outcomes. Still, tradeoffs between welfare and environmental objectives are apparent, since road development is associated with declining area of forest and wetlands (Pender, et al.). Such trade-offs should be carefully considered when considering road development in areas where the value of environmental services is particularly high (Wood, et al).

There is mixed evidence regarding whether poverty is an important contributing factor to land degradation. In investigating determinants of soil nutrient depletion in

eastern Uganda, Nkonya and Kaizzi found that poorer households had more negative nutrient balances, probably because they find it more difficult to afford to purchase fertilizer and lack access to other inputs such as manure from livestock. In modeling farmer household behavior in Mayuge district, Woelcke found that given the current state of technologies and markets, no households could be expected to achieve positive nutrient balances. However, he found that the rate of nutrient depletion is predicted to be greater for the commercially oriented farmers, who are wealthier than subsistence oriented farmers.

Lack of farmer awareness of appropriate technologies appears to be an important constraint to improved land management in many cases. We have found evidence showing that agricultural extension programs are associated with adoption of many improved land management practices (Nkonya, Pender, Sserunkuuma and Jagger; Sserunkuuma; Jagger and Pender). Extension programs are associated with increased incomes from bananas, livestock and nonfarm activities, and improvements in average incomes, though impacts on other crops are less clear (Nkonya, et al.). Extension programs are also associated with less food insecurity (Nagujja). Not all technical assistance programs have equal coverage or impacts, however (Jagger and Pender). Government programs were found to reach poorer and more remote areas to a greater extent than non-governmental organizations. To the extent that reliance on NGOs for provision of technical assistance related to agriculture and land management is important and increasing, efforts are needed to ensure that such organizations reach out to less well-served populations in poorer and more remote regions. Changes in incentives and institutions financing technical assistance may be needed to ensure that such improvements in service occur.

Solving problems of land degradation and low productivity

Two broad technological approaches to addressing soil fertility depletion and low productivity are to promote use of external inputs such as inorganic fertilizers, and to promote low-external inputs technologies that recycle and add nutrients using locally available materials, such as through application of manure, compost, mulch, growing leguminous cover crops and trees, etc. Evidence from eastern Uganda shows that fertilizer use can yield positive economic returns, especially on higher quality soils, but the profitability appears not to be high enough in general to promote widespread adoption or high levels of use of fertilizer on poorer soils (Kaizzi, et al.). Other low input approaches are therefore necessary to address soil fertility problems, and there is evidence that some of these can be effective in increasing yields and farmers' profits, as well as reducing soil degradation (Ibid.). It was pointed out by several workshop participants that use of fertilizer and organic approaches are not mutually exclusive, and that an integrated soil nutrient approach is needed. Some nutrients cannot be replenished very well using organic methods (e.g., phosphorus), and some organic practices, such as application of manure and compost, are very labor-intensive and therefore not practical for farmers farming more than a few acres of land or working on distant parcels. Less labor-intensive approaches, such as planting leguminous cover crops or legumes in crop rotation, appear to be more promising, at least for replenishing nitrogen in the soil. Use of animals for farm mechanization, which is quite limited, may also be a solution for the labor-intensive soil and water conservation technologies and for transporting organic materials to farms. Brunner, et al. also observed that crop residues could reduce soil erosion significantly. This underscores the need to

discourage farmers from harvesting crop residues since this practice leaves the soil bare and more prone to erosion.

The importance of improved infrastructure and information for farmers was a recurring theme throughout the workshop. Adoption of improved land management practices may be impossible without improved profitability of the technologies (Woelcke), and this requires improvements in both infrastructure and information. Improved information is important not only with respect to information about technologies, but also about prices and markets (Woelcke; Rashid; Kato and Nkonya). Better market price information, together with improvements in infrastructure, can help to ensure the efficiency and competitiveness of agricultural markets, which is needed to help farmers earn a higher return from their produce, thus helping to make improved land management profitable (Rashid). Improvements in roads and other infrastructure are also important for the efficient functioning of markets. While a great deal of investment in infrastructure is taking place, efforts are also needed to ensure that adequate maintenance of infrastructure is provided.

One study of the Doho rice irrigation scheme is finding that in the context of decentralization, problems of inadequate maintenance of the irrigation canals are arising due to failure of local collective action to ensure adequate financial contributions by beneficiaries (Sserunkuuma). Attention to improvements in the institutions for managing such collective resources is greatly needed if decentralization efforts are to be successful.

The impact of high population density on land degradation calls for the need to relieve land pressure by creating alternative non-land based activities and birth control campaigns to complement the agricultural intensification option that the farmers are

already pursuing in densely populated areas. Education may be one of the approaches of relieving land pressure since our research shows that education increases the probability of farmers getting engaged in off-farm activities.

OVERVIEW OF DISCUSSION

The discussion was centered on the implications of the study findings presented during the workshop, many of which warrant serious policy attention. Among these was the finding that while several welfare indicators and the adoption of inputs and some conservation practices has improved (albeit to a limited extent), crop yields, natural resource conditions and food security are perceived to have declined in many areas in the 1990s. The possibility that this was due to poor extension delivery was raised during the discussion. It was acknowledged that while the empirical evidence presented showed that agricultural extension programs were associated with adoption of many improved land management practices, and increased incomes from bananas, livestock and non-farm activities, the impact on other crops was less clear. Instead, commercialization of agriculture accompanied by low input use and growth of non-farm activities leading to reduced farm labor availability were suggested as alternative explanations for the declines in crop yields, natural resource and food security conditions. It was observed that agricultural commercialization and urban development increased in Uganda in the 1990s, leading to increased farmers' income earning opportunities both on and off the farm while at the same time contributing to soil nutrient depletion, as exported plant nutrients are not being adequately replenished. Use of inorganic fertilizer is very low, and organic practices

such as manuring, composting, mulching, and use of leguminous crops for biological nitrogen fixation are still relatively limited.

The finding of expanding maize production in all zones but continuing low fertilizer use was found to be surprising, given that several programs are known to have actively promoted improved maize seed and fertilizer as a package. It raised concern that if cereals and pulses are replacing perennial crops in the banana-coffee farming system, which are associated with better soil cover and soil conservation and less tillage, land degradation may be accelerated by spread of the cereals and pulses if not accompanied by a major increase in fertilizer use or soil conservation measures. There was general agreement of the need for more analysis to determine whether cereals and pulses are actually replacing perennial crops or if they are taking up new land within the banana-coffee system. An observation was made that smallholders may be receiving training on land management from technical assistance programs, but may not actually be adopting technologies because of the low profitability of some land management technologies. A call was made for a more vigorous campaign of better fertility management and soil conservation for annual crops in order to stem the potential increase in land degradation.

The issue of low profitability of inputs as a possible cause for their limited use was revisited, following from the finding that although fertilizer use yielded positive economic returns in eastern Uganda, its profitability does not seem to be high enough to promote widespread adoption or high levels of fertilizer use. The need for using low input approaches to address soil fertility problems was recognized, but several challenges still remain. For instance, it was recognized that some nutrients cannot be sufficiently replenished by organic methods and some organic practices, such as manuring and

composting are very labor-intensive and cannot be used on large scale or on distant parcels. Another observation was made that organic matter appears to be still adequate in many locations but is no longer the most important indicator of soil fertility. Evidence shows that the biggest problem is acidification and depletion of bases. If organic matter is not so much of a problem, then the returns from organic inputs may not justify the effort involved in using them. Indeed, evidence was presented showing that organic fertility sources did not significantly enhance yields for most crops. Thus more targeted approaches to addressing soil fertility problems are needed.

The importance of improved infrastructure and information about technologies, prices and markets was discussed at length. It was recognized that better market and price information, together with improvements in infrastructure, can help to ensure the efficiency and competitiveness of agricultural markets, which is needed to help farmers earn a higher return from their produce, thus helping to make improved land management profitable. Because most households in rural Uganda own radios, and because the radio was found to be the main source for market and price information of the rural household, it was observed that this offers a chance of using radios to disseminate extension messages and agricultural market information. To increase their effectiveness, it was recommended that local content and use of local language in the radio programs be seriously considered, and that the programs need to be broadcast at times that are convenient for farmers.

In the context of better understanding the causes of land degradation, suggestions were made for incorporating the impact of land conflicts which are on the increase in Uganda, gender issues, labor exchange and other issues into the analysis or in further studies that will build on this one. There was a general feeling among the participants that

since most presenters' findings were preliminary findings, it was not possible to draw conclusions with complete confidence at this workshop. It was suggested that another workshop be held in the future to present the final results. It was also noted that while the project was ending, it was clearly worthwhile to pick up on key research findings and recommendations and transform them into development programs to be funded by the government and development partners. The opportunities and prospects for doing so were discussed by the participants and among others, the following observations were made:

1. That there is already an on-going USAID project (SCRIP) which is building on some aspects of the closing land management project
2. IFPRI was discussing with the World Bank the possibility of implementing a study that will incorporate natural resource monitoring into the routine Uganda Bureau of Statistics Surveys (UBOS).

Further analysis of the data may be done to validate the preliminary findings presented at the workshop to investigate the numerous issues and questions raised during the discussions; and identify gaps upon to be filled by further research.

5. DEVELOPMENT PATHWAYS AND LAND MANAGEMENT IN UGANDA: CAUSES AND IMPLICATIONS

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This study investigates the development pathways, changes in land use and land management practices occurring in Uganda since 1990, their causes and implications, based upon a community level survey conducted in 107 LC1's and villages. Development pathways are defined as common patterns of change in livelihood strategies. The concept is similar to the concepts of farming systems or livelihood strategies, but is more general than farming systems in that it incorporates non-farm activities, and unlike livelihood strategies is dynamic since it refers to changes in livelihood strategies over time.

The general picture of development in 1990 and 1999 is of increasing specialization and commercialization of economic activities based upon differences in local comparative advantages. This development pattern is associated with changes in land use, including expansion of cultivated area, settlements, and woodlots; and declining use of fallow, grazing land, forest, and wetlands. Ownership of cattle has increased but use of other livestock has declined. Use of purchased inputs has increased, though use is still low by international standards (especially of fertilizer).

Adoption of some soil and water conservation practices has increased, though rates of use are still generally low. Despite increased adoption of inputs and some conservation practices, crop yields and natural resource conditions are perceived to have degraded throughout most of Uganda. At the same time, many aspects of human welfare have

improved, stimulated by improved access to roads, transportation, health, education and other services; various government and non-government programs; and other factors. Nevertheless, food security appears to worsening in many areas. The rate of population growth is very high and may be one of the main underlying causes of degradation and food insecurity in Uganda.

There have been many changes in livelihood strategies in different parts of Uganda. Cereal crop production is increasing in importance, especially in bimodal low and medium rainfall areas (in the western and central parts of the country) and in the eastern highlands. Production of horticultural crops is also increasing in importance in some parts of these zones. Production of other storable annual crops such as pulses and oilseeds has increased, especially in the southwest highlands and the bimodal low rainfall areas. Banana production has increased in the bimodal high rainfall areas (in the Lake Victoria crescent), and to a lesser extent in the southwest highlands and bimodal low rainfall areas. Both banana and coffee production have declined in importance in the bimodal medium rainfall areas (in central and western Uganda), while coffee production is more stable in higher potential traditional coffee areas near Lake Victoria and in the eastern highlands. Cattle production has increased in several zones, especially the eastern highlands and the bimodal medium and high rainfall zones. Ownership of crossbred cattle has increased, especially in areas having better market access and higher population density in the bimodal high rainfall zone and the eastern highlands, indicating development of dairy production in these areas. Trading and other non-farm employment activities have become more important, particularly in the southwest highlands, the northern unimodal rainfall areas, and areas of high population density and good access to urban centers.

With respect to land management there has been increase in purchased input use and adoption of some soil and water conservation technologies. High market access areas are benefiting from privatization and market liberalization that make inputs easier to obtain. However, use of most purchased inputs, particularly fertilizer, is still low, and average yields are reported to be stagnant or declining in most places.

Declining soil fertility, soil erosion and other aspects of degradation are perceived to be worsening problems in the country, but these problems are particularly severe in the high potential bimodal rainfall areas and in the eastern highlands. The proportion of households adopting new conservation technologies is generally low, and suggests the need for programs and organizations to provide extension support that might act as a catalyst for the adoption of these technologies.

Improved access to roads, transportation, health, education, water and other services are contributing to perceived improvements in many welfare indicators. Nevertheless, poverty remains severe in much of rural Uganda, and food security is perceived to be worsening in many areas. The impacts of liberalization, privatization, decentralization and other aspects of the modernization strategy thus appear to be generally positive for welfare of people in rural Uganda, though significant problems still remain to be adequately addressed; particularly land degradation and increasing food insecurity.

We have investigated the development pathways and changes in land use and land management occurring in Uganda, their determinants and implications for agricultural productivity, natural resource conditions and human welfare using factor analysis and

econometric analysis. We have identified several key tentative findings (subject to verification through analysis of ongoing household and plot surveys in the region).

Six dominant development pathways emerged, including expansion of cereals production, expansion of banana-coffee production, non-farm development, expansion of horticulture, expansion of cotton, and stable coffee production. Of these pathways, expansion of banana and coffee was most strongly associated with adoption of soil and water conservation practices, improvements in resource conditions, agricultural productivity (at least of bananas) and human welfare. Promotion of this pathway may be a potential "win-win-win" developmental strategy, benefiting the environment while contributing to economic growth and poverty reduction. This pathway is not suited to all parts of Uganda, however, and has been developing most in the bimodal low and high rainfall zones. One factor associated with this development pathway is increasing access to rural markets, suggesting that continued development of rural markets would be an important component of achieving such a "win-win-win" development strategy.

Road development, and associated development of transportation and other services, appears to be a critical factor contributing to improvements in many natural resource conditions (except forest and woodland availability) and human welfare indicators. In areas where natural forests and woodland are still important, there may be tradeoffs between welfare and environmental objectives in pursuing road development. In other areas, road development can be a "win-win-win" strategy.

Irrigation appears to reduce pressure and to expand cultivated area at the expense of forest, wetland and fallow strips; contributes to fertilizer adoption; and is associated with improvement in several resource and welfare indicators. However, irrigation is also

associated with less improvement in some welfare indicators, though this may be because irrigated areas were better off initially in terms of these indicators. Further research is needed on these issues, but there appears to be potential to improve both resource and welfare conditions through appropriate investments in irrigation.

Government and non-governmental programs and organizations appear to have contributed to perceived improvements in many productivity, resource and welfare conditions; such as increased (or less decline in) yields of cassava and sweet potatoes, reduced soil erosion, increased quality of forests and grazing land, increased quality of housing and drinking water, improvement in child nutrition and reduction in infant mortality. However such programs are associated with some negative outcomes, such as declining yields of some crops, and declining availability of energy sources. It may be that by promoting some crops such programs cause farmers to devote less effort to the management of other crops, leading to some trade-offs in impacts on productivity. The environmental focus of many programs and organizations may be reducing the availability of energy sources (for example, by discouraging charcoal production or tree cutting), reflecting a tradeoff between environmental and welfare objectives.

It should be emphasized that these results are based upon rough and qualitative measures of impacts as well as fairly crude measures of the causal factors (such as the number of organizations of each type). Further research using household level data is needed to validate these findings and to enable greater confidence in the explanations of changes and impacts reported here.

6. A SPATIALLY BASED STRATEGIC PLANNING FRAMEWORK FOR SUSTAINABLE LAND USE IN UGANDA

Stanley Wood and Simon Bolwig
International Food Policy Research Institute

Governments and development funders have a constant need for information that helps to improve the quality of their investment decisions. And as investment decisions become more complex, so too do information needs. There is growing awareness in Africa, for example, that sustained economic growth can only be achieved by addressing the underlying causes of poverty, hunger, and disease, and to do so will involve better formulation and better harmonization of development strategies. Furthermore, in a region where livelihoods depend overwhelmingly on agriculture and other resource-based activities, it is fundamentally important that development approaches internalize the dynamic interdependencies between the welfare of rural populations, and the condition of land, water and biological resources. This paper describes a policy-focused evaluation framework being developed by the International Food Policy Research Institute (IFPRI) that builds around these core concerns. The framework adds explicit treatment of livelihood strategies, technological change, markets, and trade to assess the local and aggregate effects of livelihood choices and environmental policies on a range of welfare outcomes.

The origin of this research lies in a challenge that the Uganda Mission of USAID set itself in designing a new strategic objective (SO) targeted to increasing rural incomes. The "Expanded Sustainable Economic Opportunities for Rural Sector Growth" strategic objective will be implemented over the period 2002-2007 at a cost of some US$150 million. This new SO is a combination of previously separate strategies and country

programs for enhancing agricultural productivity, market and trade development, and improved environmental management. By design, the new SO has brought sharper focus on addressing the growth-environment nexus in all aspects of program design and implementation. However, it also required the development of a new conceptual framework that the Uganda Mission could use to justify and articulate its more integrated approach, and IFPRI was invited to assist in this task.

Through examining the purpose and relevance of the approach both within and beyond Uganda, a consensus was reached that the framework should be capable of generating policy- and investment-related information on the scope for improving rural livelihoods at a regional and national scale arising from:

- Enhanced agricultural productivity, product diversification, and better-informed, and more effective marketing channels;
- Improved management and utilization of forests, wetlands, and other "natural" ecosystems and natural resources; while
- Protecting the capacity of Uganda's natural resources and, the ecosystems they underpin, to meet current and future demands for environmental goods and services.

From the outset, however, it was recognized that the design and implementation of such a framework presents many conceptual and practical challenges. First, is the need to integrate both quantitative and qualitative information about socio-economic and biophysical factors. Second, is to strike an analytical balance between working at the level of information aggregation appropriate for policy dialogue, and working at levels of disaggregation that capture important aspects of variability in biophysical and

socioeconomic conditions. Third, and related to the second, is the need to match the complexity of each analytical element in the framework with the contribution it makes in shaping the analytical results.

One potential ally in meeting these challenges is geographical information systems (GIS) technology. Not only does the accessibility of GIS technology to development specialists continue to improve, but so too does its analytical potential as more types of data are generated in GIS compatible formats. Examples are the now common practice of geo-referencing plots and households when conducting trials and field surveys, as well as the increased availability and resolution of satellite-derived data on land cover. A GIS also provides data management capacities that support the integration and interpretation of data in diverse formats, and serves as a useful tool for communicating findings to policymakers. It does so by providing insights to patterns and processes that might be less apparent in tabular data. Given these opportunities, and acknowledging the fundamental relevance of location from an agricultural and environmental perspective, the framework has been designed from the outset to be spatially explicit.

There are six underpinning concepts in IFPRI's approach. First, existing policies, opportunities, constraints and preferences lead individual households and communities to adopt specific livelihoods and associated land use patterns. Second, there are broader social objectives to safeguard land uses that provide valued (often public) goods and environmental services, such as drinking water, flood regulation, pollinators, wild game, recreation and so on. Third, by overlaying individually- and socially-preferred land use visions, it is possible to identify areas in which the two visions differ, as well as to establish the nature of those differences.

Fourth, known options (inventories of technologies, land management options, institutional arrangements, etc) are examined to assess the extent to which individual and social preferences might both be satisfied at the local level, or to establish the nature and scale of potential tradeoffs involved. This step involves assessing the likely relative payoffs from alternate growth-enhancing land use options – benchmarked around the actual livelihood enterprises observed in Ugandan communities (drawing on national household surveys and complementary IFPRI survey work on natural resource management and development pathways). The analysis involves formal modeling of the likely economic benefits of alternative productivity improvement options, as well as a review of production, resource management and marketing constraints based on community, household and market survey data.

Fifth, the locally-preferred range of livelihood and associated land use options is assessed at the *aggregate level* to establish whether goals regarding income growth, poverty alleviation, export revenue, forest cover, wetland conversion, and so on are achievable and, if not suggesting alternative livelihood and land use configurations that might make those goals feasible. IFPRI is developing an agriculture-focused general equilibrium model to support this stage of the work. This model will assess aggregate impacts of productivity enhancements and improved marketing chains on representative household groups, including feedback on employment and wages. It can explore a wide range of domestic and appropriate international policy, trade and technology scenarios.

In the sixth stage, the most promising locations and opportunities for some form of support or intervention are matched against the priorities of development funders. These might be donors (such as USAID), government agencies, or NGO's. The goals and

priorities of each of these development funders can then be compared with the most promising of the intervention options identified by the above process. Potential funders can, thus, apply the information generated by the analytical framework to better target their own investments and planning studies, with more certainty that such interventions might also build towards established socioeconomic and environmental goals.

The application of the framework is still in its early stages; still, some interesting results are emerging from spatial analyses relating to especially the first three concepts or steps. They identify, for example: areas with a comparative advantage for different agricultural intensification or expansion strategies; areas with high levels of biodiversity or fragile soils; and based upon this information, areas of potential conflict or complementarity between agricultural development and environmental conservation. The analyses show that the areas where local communities most profitably can intensify agriculture are located in southwestern Uganda and in a west to east widening band around Lake Victoria. Agricultural expansion is likely to occur in a band starting from the shore of Lake Albert and heading eastward to encompass the Lake Kyoga basin, and in much of the far north and northwest.

The potential environmental impacts of these locally preferred scenarios were assessed using spatial information on soil conditions and biodiversity, including the geographical distribution of Protected Areas and threatened plant and animal species. In this regard, the areas with the highest conservation value were found in the central and extreme western and southwestern parts of the country, and in a few other locations such as Mt Elgon and along the River Nile in northern Uganda. These analyses suggest, for example, that there are large areas in northern region where agriculture may be expanded

without very significant biodiversity losses; yet we also found many economically useful plant species in that region's natural ecosystems that could supplement agricultural incomes if conserved. Conversely, high pressures from agriculture on Protected Areas are likely to be found in southwestern and extreme western Uganda, while the west-central (Luwero, Kiboga, Kibale and Masindi districts) and northeastern parts of the country exhibit potential conflicts between agricultural expansion and the conservation of unprotected ecosystems such as wetlands, forests, and woodlands. Agricultural intensification is in potential conflict with soil conservation objectives in especially the eastern region and in southwestern Uganda (unless intensification includes adoption of suitable soil conservation and fertility management practices). Conversely, it appears environmentally sound to intensify agricultural land use along the shores of Lake Victoria and in the extreme southeast of the country.

7. ALTERNATIVE GROWTH SCENARIOS FOR UGANDAN COFFEE TO 2020

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Coffee is the most important cash crop in Uganda. About 500,000 households distributed over two-thirds of the country depend on coffee production as an important income source, and many more people are employed in the coffee industry as hired farm labor and in businesses such as processing, input supply, trading, and transport. Coffee in Uganda is grown mainly by smallholders with an average coffee farm size of 0.58 hectares. Robusta coffee accounts for 85% of export volumes and 76% of revenues, and Arabica for the rest. Uganda produces 3.0% of the world's traded coffee and 9.1% of all Robustas. Ugandan Robusta is important in the world market because of its high volume and special quality. Especially European roasters demand it for its neutral flavor and the foam it creates on top of espressos. It therefore commands a significant premium over the world Robusta reference price. In the market year ending in 2001, Ugandan coffee exports generated US$104.8 million. Coffee's share of total export revenues has declined dramatically in recent years, from 66.8% on average in 1991-95 to 31.2% in 2000, because of the world coffee price slump and, to a lesser extent, the growth in nontraditional exports.

The Uganda coffee industry is facing challenges that are both domestic and international in origin, and which have put the industry under tremendous pressure during the last five years or so. The most serious challenge is the dramatic drop in world coffee prices that reached a 40-year low in 2001. The immediate cause of the price slump is a chronic oversupply due to a rapid expansion of world coffee production over the last ten

years, especially Robusta in Vietnam, combined with a low and stable growth in consumption of about 1% per year. The major underlying cause was the ending in 1989 of the International Coffee Agreements that had regulated coffee exports and world prices since 1962.

Changing strategies among the big roasters of Ugandan Robusta presents another challenge to coffee producers and exporters. New technologies and market strategies among these roasters affect the demand for and price premium of dry processed Ugandan Robusta. While this coffee is much demanded by some roasters as a component in certain blends, especially espressos and instant coffee, they are able to substitute it with other varieties and still get close to the desired flavor profiles. Some roasters have thus switched from Ugandan Robusta to the cheaper Vietnamese Robusta blended with mild Arabicas. To increase the quality of lower grade coffee, roasters are increasingly using steam cleaning. This technique could increase the demand for lower quality Ugandan coffee, but it also allows roasters to substitute Ugandan Robusta with cheaper types from e.g. Vietnam, thus reducing its demand. It is therefore imperative to maintain the availability of Ugandan Robusta at the present high levels, since the reliability of supply contributes to its price premium. This strategy is currently threatened by several factors, however, including: the coffee wilt disease which is infecting and killing more than 5% of all trees annually; ageing trees and slow replanting rates; low ability to prevent crop losses caused by pests and droughts; and low and volatile domestic coffee prices which discourage farm and marketing investments. Increased flexibility in roasters' blends also means that Uganda must maintain or increase the price competitiveness of Robusta by enhancing quality and lowering production, processing and marketing costs.

The third challenge, or opportunity, is the emerging markets for high quality and specialty coffees. Western consumers are increasingly willing to pay a higher price for coffee produced in responsible social and environmental ways, and in reputable localities or 'appellations'. Obtaining a price premium thus depends as much on the ability to "sell a story" as on the intrinsic qualities of the coffee. The recent spectacular growth in the specialty coffee market in North America and Western Europe (10-20% per year in retail sales terms) gives the Ugandan coffee industry the opportunity to increase its revenues from this niche market. Specialty coffee includes single-origin and highest-grade Arabicas, organically and shade grown coffee, and coffee sold through Fair Trade organizations, all of which command significant price premiums in the market. Traditional quality variables such as smell, taste, bean size, cleanness, etc. that are important in industrial coffee blends may be improved through better production methods, such as pruning of trees and adoption of improved 'Clonal' varieties, and by improved processing – especially wet processing. Given such opportunities for raising quality, it is unfortunate that the dry processing method makes quality control at the farm level difficult (the dry pulp covers the bean at delivery) thus constraining the transmission of quality-based price incentives to the producer. On the positive side, it is noteworthy that quality control is less important in the Robusta than in the Arabica market, and that the neutral taste of Ugandan Robusta is by far its most important intrinsic quality and one that is not easily degraded through poor practices.

Given the challenges outlined above, we find that the coffee industry in Uganda can pursue three types of development strategies:

1. Increase Production: a) increase production of Robusta through area expansion; b) increase production of high-quality Arabica.
2. Enhance Quality: a) coffee for traditional industrial blends: larger beans, better processing, storage, and grading, and wet processing of Robusta; b) develop specialty coffees for niche markets.
3. Increase Farm Productivity: reduce cost of production and increase yields to increase farm incomes and ensure export volumes at present high levels.

Using the Dynamic Research Evaluation for Management (DREAM) model of the International Food Policy Research Institute, below we evaluate these strategies as "alternative growth scenarios" to show their different potential impacts on Ugandan export prices, export revenues, and producer and consumer benefits. The base year is 2000 and the simulation period is 21 years. The model does not consider the costs or profitability of the different strategies.

Three scenarios are evaluated for the 'increase production' strategy. In Scenario 1, which is also our baseline scenario against which all others are evaluated, both Uganda and the rest of the world (ROW) keep the current production growth rate. In Scenario 2, Uganda gradually reduces its production growth rate from the current level to zero in 2020 while ROW keeps its current production growth. Scenario 3 simulates the Government of Uganda's strategic export plan from 2001, in which total coffee production increases from the current 3.5 million bags to 12 million bags in 2006, and then stays at that level. In the first scenario, the coffee price continues to decline over the 2000-2020 period because the growth rate for world production is higher than for consumption. Uganda's export revenue (in 2000 constant US$) is also falling throughout the period. In Scenario 2 the Robusta price in Uganda will continue to decline but at a slightly slower rate than in Scenario 1. Due to the small share (3%) of Ugandan coffee in world production, unilaterally reducing

production by Uganda cannot stop the coffee price from declining. In Scenario 3, the Ugandan Robusta coffee price falls sharply until 2006 and continues to fall thereafter. Export revenues peak in 2006 around $204 million per year because of increased coffee exports, but then gradually declines to around $124 million by 2020. This is just 15% more than the export value in 2000, despite the fact that coffee production is more than tripled. Therefore, even if the Government of Uganda reaches its production goal in 2006, the depressed international coffee prices are likely to erode the economic benefits of such a policy.

For the quality enhancement strategy we have three scenarios: 10%, 25% and 50% quality improvement, which means Uganda producing 10%, 25%, and 50% more high-quality coffee while reducing the same amount of low-quality coffee. The price of high-quality coffee is set to twice the price of low quality. The coffee price increases in the first four years because of farmers' adoption of quality improvement technologies, and then declines due to oversupply in the international coffee market. Quality improvement increases Ugandan coffee prices and reduces the price gap between Uganda and ROW, compared to the baseline scenario. By producing 25% more high-quality coffee, Uganda can obtain an export price which is higher than in 2000 throughout the whole simulation period. The 50% quality improvement shows a peak in the Robusta price of 32.85 cents/lb in 2003, and 31.39cents/lb in 2020, 17% and 20% higher than the baseline scenario prices. Compared to the baseline scenario, quality improvement would generate about $3 million, $8 million, and $16 million more in export revenue per year respectively for the three scenarios, while the total benefits to Ugandan producers and consumers, accumulated from 2000 to 2020, would be $70 million, $210 million and $530 million. Therefore, improving

coffee quality is a promising strategy no matter what will happen in the world coffee market.

As for the 'increase farm productivity' strategy, since most of Uganda's coffee production is for export, the productivity level in the rest of the world affects how much it gains from productivity improvements. In our simulation we therefore assume different levels of productivity improvements in both Uganda and ROW: 0%, 1%, 2% and 5% downward supply shifts due to new productivity-increasing technology. For example, Uganda would gain $1.09 million per year if it improves its Robusta productivity by 1% while ROW has no productivity gain. Conversely, if ROW has a 1% productivity improvement while Uganda has none, Uganda would lose $745,000 per year. If Uganda's productivity gain is 5% and ROW 0%, Uganda would gain $5.53 million per year, while it would lose $3.66 million per year in the opposite situation. Uganda and ROW both gain if both have the same percentage productivity increase, though Uganda gains less than if ROW had no increase, as a result of world price declines. For example, Uganda gains $334,000, $669,000, and $1,688,000 per year to Uganda for 1%, 2% and 5% productivity increases in both ROW and Uganda.

The Government of Uganda's plan of increasing coffee production to 12 million bags in 2006 appears unrealistic and undesirable in light of the persistent oversupply of Robusta coffee in the world market. Our analysis shows that such a strategy would engage Uganda in a "race-to-the-bottom" price competition with other producer countries. This and other analyses suggest that Uganda would gain more (or lose less) by enhancing quality and farm productivity, while maintaining its competitive advantage (price premium) in the Robusta market through a stable supply of good quality Robusta.

Interventions should focus on improving the capacity and economic incentives of farmers to produce better quality coffee at a lower cost.

The quality improvement strategy is likely to pay high dividends from the growing high quality and specialty coffee markets in Europe and North America. Creating a demand for these coffees among visitors and urban elites in Uganda would be one way of gaining experience with this market, as would alliances with small and specialized roasters abroad. Value added may also be achieved by developing Uganda's processing capacity, especially for the production of instant coffee.

The farm productivity increase strategy may be achieved by increasing yields and reducing the cost of production, using improved technologies and practices. For Uganda as a whole, the greatest productivity gain can be (and is) made by replanting wilt-affected trees with resistant genotypes and replacing old plants with younger and more productive ones. Producing Robusta from improved clonal varieties can reduce the cost of production to around 75% of growing traditional varieties while also improving quality. In the short term, the multiplication and distribution of wilt resistant genotypes should have highest priority. Better data on the spatial distribution of coffee production and marketing within Uganda is needed to properly target such interventions. We cannot here suggest more specific types of interventions but it is clear that all strategies would necessitate a higher level of organization in the industry: horizontally among small producers, and vertically among producers, traders, roasters and consumers. Finally, Uganda has a high stake and important role to play in the international coordination efforts to stabilize and raise world coffee prices.

8. POTENTIALS AND CONSTRAINTS TO COFFEE DEVELOPMENT: AIDING THE COFFEE REPLANTING PROGRAM

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Coffee, which together with tea and cotton, constitute Uganda's traditional export crops, has been Uganda's largest generator of export revenue, earning over 400 million USD annually, at a time (between 1994 and 1999) when world prices were high. The coffee industry in Uganda provides employment both at production and processing levels. The industry is based almost entirely on smallholder producers who number more than 500,000. There are 400 primary processing factories, and 29 export grading facilities in Uganda. However, in the recent past, both external and internal factors have combined to dramatically reduce coffee's contribution to foreign exchange earnings and rural incomes. The dramatic decline in world coffee prices has been devastating while internally, the production of coffee has been on the decline.

Reasons for the coffee production decline are to a large extent associated with the fact that the majority of the coffee trees in Uganda are old and have exceeded their economic life. In addition, the recent occurrence of the coffee wilt disease (CWD) has exacerbated the situation. This alarming trend has made increasing production a major challenge for the Uganda government.

There are two types of coffee that are produced in Uganda, namely Robusta and Arabica. Robusta is native to Uganda and as such Uganda provides the perfect environmental mix including topography, soils, weather and other natural conditions. Production is primarily of Robusta, which accounts for 85% of the coffee earnings, while

Arabica generates the remaining 15%. The main characteristic of Uganda's Robusta coffee is the mildness, which is attributed to the fact that the coffee is grown at high altitudes. This characteristic makes it comparable to many types of Arabica.

The current policy in the coffee sub sector is to improve yields per unit area without necessarily increasing acreage under coffee production. The introduction and adoption of improved technologies is the key strategy by which this policy can be implemented. Clonal coffee has been identified and availed to farmers as a technology to either replace the old, low yielding trees or for establishing new plantations. However, there is a need for better understanding of the factors that affect its adoption to serve as a basis for promoting its adoption on a much larger scale.

The objective of this study was, therefore, to identify factors associated with adoption of clonal coffee and to examine their relationships in order to identify appropriate strategies that will increase adoption of clonal coffee.

There are six clones available to farmers. In order to ensure that the selected characteristics are maintained farmers have to establish these clones vegetatively and hence the name clonal coffee. The challenge now is to ensure that farmers replace the old, low yielding varieties with this clonal coffee and this is what motivates this study.

We use a Tobit econometric model to examine the socio-economic factors that influence, the decision to adopt and the extent of adoption of clonal coffee. Using village level and household level survey data, a number of community and household factors that were hypothesized to affect adoption were identified.

Our econometric results indicate a positive association between adoption of clonal coffee and market access, village and household wealth, access to credit, ownership of a

radio, membership in local organizations/programs, sex of the household head, and dependency ratio. Results also indicate a negative association between adoption and population density. These findings hold important policy implications for the coffee sub-sector, particularly in the context of the Plan for Modernization of Agriculture, poverty eradication and increasing coffee production.

The fact that high market access is positively associated with adoption of clonal is a result of great interest. This may be a reflection of the poor extension services in the remote area, as has been observed by other studies. Farmers in remote areas may also receive low coffee prices that may discourage them from planting clonal coffee. This suggests the need to increase extension services and improvement of the market infrastructure in the remote areas. Specifically, planting material needs to be availed in these remote areas. Further, investments in road construction and maintenance, which reduce the cost of accessing markets as well as investments in market development, are likely to yield high returns by promoting adoption of clonal coffee.

The positive association between wealth and adoption of clonal coffee suggests that coffee is a rich man's crop. Coffee is a long-term investment that yields returns after approximately three years. This may discourage poor farmers from replanting. A need to assist poor farmers with credit is therefore apparent. The positive association between coffee adoption and credit is further testimony to the fact that credit provision may enhance adoption of clonal coffee.

The positive association between radio ownership and clonal coffee adoption underlines the importance of the radio as an effective medium for transmitting extension messages. This avenue should be exploited further by putting more extension-related

programs on the radio. For greater efficiency, the timing of the programs should be such that a wider audience is captured. Programs run at the lunch hour or in the evenings are likely to capture wider audiences as many people in the rural areas tune in at these times. Programs also need to be presented in the local languages to ensure that farmers understand the messages. However, with an ever-increasing number of radio stations, it is important that programs be run on the more popular radio stations.

Membership in local organizations was found to be positively associated with adoption of clonal coffee. This result suggests that these organizations are effective social networks, which are being used to directly or indirectly promote coffee production and could be used to a greater extent. Organizations may be used to disseminate market information, assisting access to credit and marketing agricultural outputs and inputs. As the government plans to devolve such services, focus shouldn't be only on NGOs and external organizations in which farmers' involvement is sometimes limited. Government should also make use of existing community based social networks because they are bound to be quite effective since they are a product of local initiative.

9. THE RELATIONSHIP BETWEEN SOCIO-ECONOMIC CHARACTERISITICS OF MAIZE FARMERS AND HOUSEHOLD FOOD SECURITY IN EASTERN UGANDA

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Maize is the most important cereal crop in Uganda. The importance of maize in the country has been increasing due to its rising demand in the country and in the East African region. Maize is grown on an average area of 384, 000 ha (1970-96), which is 7% of total area planted with crops. Farmers' average maize yields remain much lower than potential yield. Average yields of farmers range between 0.8-1.5t/ha compared to potential yield of 3.5-4.3 t/ha for KWCA and Longe 1 varieties. The disparity between farmers' yields and those they could obtain has raised concerns about food security.

Many research studies have been done on adoption of maize production technologies. However, very few studies have attempted to identify the determinants of food security at the household level. A knowledge gap exists as to whether the socio-economic characteristics of farmers do in fact have any bearing on household food security. The aim of this study therefore was to determine the relationship between socio-economic characteristics of maize farmers and household food security. Data were obtained from household and plot level surveys that were implemented by the International Food Policy Research Institute (IFPRI) in December 2000 to June 2001. A total of 451 households were interviewed and their socio-economic demographic and production data were collected. This study is based upon a sub-sample of 170 households in eastern Uganda consisting of both adopters and non-adopters of improved maize varieties.

The majority of the farmers sampled for this study (65%) were adopters and 35% were non-adopters of improved maize varieties. The Subsistence Potential Ratio (SPR) was used as a proxy for food security. It is given as the per capita food available per day compared to an estimate of the Recommended Energy Requirement per day. Basing on a frequently used cut-off point a household was considered food insecure if the SPR was less than 0.8. The average SPR was found to be 0.54 for adopters, and 0.42 for non-adopters. However, this difference was not statistically significant. A higher percentage (12%) of the adopter households were found to be food secure (with SPR $\geq$ 0.8) compared to only 4% of non-adopter households. Adoption of improved maize varieties meant increased production hence an improvement in household food security. Adopters were found to have a higher income and consumption expenditure than non-adopters. This suggests that improved varieties should be promoted and awareness and timely availability enhanced.

Access to extension was positively associated with food security, implying that increasing extension efforts is likely to improve household food security. Advising farmers on the use of improved maize varieties should be increased in order to accelerate technology diffusion and increase maize production, hence enhancing household food security. Agricultural extension education should be complemented with nutrition education.

This study indicates that a significant relationship exists between household food security and some socio-economic characteristics of maize farmers in Eastern Uganda. Households with a higher number of crop types grown (an indicator for crop diversity) were likely to be more food secure than those with lower crop diversity. Thus efforts

should be made to encourage farmers to diversify by growing different crops so as to reduce risks in case of crop failure especially during drought.

Increasing household income would lead to a substantial reduction in food insecurity. Raising real income would be an effective strategy for increasing calorie intake of food insecure households. Policies are needed to promote increases in incomes of farm households in order to attain household food security. Government should put more emphasis on strategies for increasing farm incomes, especially for the rural poor as highlighted in Poverty Eradication Action Plan and the Plan for Modernization of Agriculture (PMA).

An increase in the distance between the household and all-weather road had a negative impact on food security. One explanation for this could be that these households cannot easily access inputs and improved technologies to increase production hence lower food availability. Government policies aimed at improvement of rural road network to ease accessibility to agricultural inputs should be promoted. It was, however, interesting to note that the further away the household was from the market the more food secure was the household. One possible explanation for this could be that a household was not able to sell its produce hence more food was available for household consumption.

Men are more likely than women to adopt improved maize varieties. Male-headed households were also found to be more food secure than female-headed households. There is no evidence from this study that women had less access to information or resources than men, but this could be a possible explanation. Other studies have also observed that households headed by men had a higher consumption level, which could be a function of their better access to technology and other resources. There is need to increase women's

access to information and inputs (for example new seed varieties, labor saving technologies and tools) for improved maize production so as to increase production and consumption. This implies that improving women's access to productive resources is key to increasing adoption of new technologies as well as improving household food security. Future breakthroughs will lie in the ability to involve women farmers in extension programs that educate them on new production technologies.

Adopter household heads were found to have a higher average number of years of schooling (an indicator of education level) than non-adopters. A higher education level also had a positive effect on household food security. This suggests that improved education for both men and women is a critical determinant of food security. These findings imply that the Government's investment in the Universal Primary Education (UPE) is helping to increase food security.

The amount of credit received by a household had a positive effect on household food security. Credit access is, therefore, increasingly important to achieving household food security. The Government in collaboration with stakeholders such as non-governmental organizations (NGOs) should address the credit problems faced by small-scale farmers, especially in the areas where food security is a severe problem. Farmer groups and credit schemes oriented to meeting food consumption needs could be used to extend credit to farmers.

Household food security is affected positively by increasing land area owned by a household. This implies that land tenure policies need to be geared towards offering land equity and accessibility. Policies should also be in place to assist farmers to increase productivity in order to improve food security for farmers holding small parcels.

10. LAND MANAGEMENT PROBLEMS AND POTENTIALS IN THE LAKESHORE INTENSIVE BANANA-COFFEE FARMING SYSTEM

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This study was motivated by the purported shift in production of cooking bananas (*matooke*) from the lakeshore intensive banana-coffee farming system to southwestern Uganda, due to several factors including increased pest and disease pressure and declining soil fertility. Because of its endowment of high population density, market access and medium to high agricultural potential, the lakeshore banana-coffee farming system has the highest economic potential among all rural areas in Uganda, with the intensive production of high value perennial crops such as coffee and *matooke* being one of the most profitable pathways of development (*common pattern of change in livelihood strategies*) for this region. Others include intensive production of livestock products, high value perishable annual crops such as vegetables and low value storable annuals such as maize and beans.

Different development pathways have different impacts on land management, productivity, and other resource and welfare outcomes. For example, if it is true as literature alleges that the decline in yield of *matooke* (a perennial crop) in the lakeshore region has resulted in its replacement by annual crops (such as maize) which leaves the soil exposed to erosive forces, then the apparent increase in soil erosion, estimated to be above the tolerable rate of five tons per hectare per year is not surprising. It is estimated that soil erosion and other avenues of soil nutrient loss have caused a loss of 80-100 kg of NPK per hectare per year in the lakeshore region and other parts of central Uganda.

Proceeding along the above-described maize-expansion pathway of development without investing in land improvement would result in a downward spiral of decreasing soil fertility and crop yields in the region, with serious implications for food security and poverty. On the other hand, adopting the intensive pathway (increasing investment in soil and water conservation and use of external inputs to replenish soil nutrients) could improve land conditions, current and future agricultural productivity and welfare outcomes. This has been found to be true by a survey of 107 LC1s (lowest administrative unit in Uganda) and villages in different development domains in Uganda, which shows that banana-coffee intensification is associated with more favorable resource outcomes than cereals expansion.

This paper adopts a narrow definition of intensification (use of external inputs such as improved seed and animal breeds; and the use of inorganic fertilizer or manure to maintain or enhance soil fertility) to address two key questions. The first question is about changes in development pathways involving the production of key crops and livestock in the lakeshore region and whether or not there is a tendency towards intensification as described by earlier studies. The second question is what influences (constrains or enables) farmers to intensify.

The data used to answer these questions is part of a bigger data set obtained through a survey of 451 households sampled from 107 LC1s in central, eastern, western and northern Uganda. Out of the total sample of households, 137 (30%) were from 8 of the 10 districts that make up the intensive lakeshore banana-coffee farming system (Mukono, Mpigi, South Luwero, Mubende, Rakai, Masaka, Iganga and Kamuli). Two districts (Kalangala and Wakiso) were left out because Wakiso was part of Mpigi district when the

surveys were conducted and Kalangala lies outside the study area. This paper thus focuses on the 137 households from the intensive lakeshore banana-coffee farming system to address the research questions.

The study results show that the production and sale of crops was the most common primary and secondary income source in 2000, mentioned by 67% (primary) and 34% (secondary) of households, and the proportion of households depending on crops as their primary source of income increased by over 16 percentage points between 1990 and 2000. During the same period, the production and sale of livestock and livestock products also grew in importance (though slightly) as a primary and secondary income source. The major livestock and crop enterprises that grew in importance during this period include cattle, pigs, poultry, banana, coffee, maize and beans. The proportion of households depending on trading in agricultural outputs and inputs as a primary and secondary income source also increased during the 10-year period, making it the second most common primary income source and third most common secondary income source. This could be a result of the liberalization of trade in agricultural inputs and outputs, which increased the number of traders dealing in agricultural products and stimulated production for the market (increased commercialization of agriculture).

Of the three food crops (maize, beans and bananas) that gained importance in the 1990s, maize is most important as a commercial crop because it has the highest proportion of total output sold (29%) and its contribution to household crop income (22%) is equal to that of coffee and is higher than both bananas and beans. This has serious implications for land management. As already mentioned, maize production exposes land to forces of erosion because it doesn't provide a good soil cover. In addition, it is associated with

export of nutrients from the farm via commercialization, which leads to nutrient mining if nutrients are not replaced by use of external inputs. Thus, the nutrient loss associated with maize production and export from the farm implies increased land degradation unless improved land management practices (such as use of external inputs) are adopted.

About 72% and 70% of the 137 households in the lakeshore region produced maize in the first and second cropping seasons respectively, in the year 2000. A lower, but substantial, proportion of households (44% in the first season and 40% in the second season) grew improved varieties of maize. This shows a high level of adoption for improved maize varieties. However, the proportion of households using inorganic fertilizer, manure and compost on maize is very low (ranging between 0 and 3%), and so is the average quantity of these inputs used. The implication is that many farmers are adopting high-yielding maize varieties that mine more nutrients from the soil (through increased harvests) without using external inputs to replenish the lost nutrients. This piecemeal adoption of improved seed-fertilizer technology packages will cause nutrient depletion, unless farmers are encouraged or supported to begin replenishing the lost nutrients. The case for beans is quite similar to that of maize.

Sixty eight percent of the surveyed households grew cooking bananas (matooke) in 2000, and about one fourth of these applied manure, and a lower proportion applied compost (nearly 7%). On average, 417 kg of manure and 51 kg of compost per household were applied to bananas in 2000. No household used inorganic fertilizers on bananas. 57% of the surveyed households grew robusta coffee in 2000, but only two of these households applied inorganic fertilizers and one household applied compost to coffee fields in 2000. A bigger percentage of households (10% in first season and 9% in second season) applied

manure to coffee fields, and on average, 152 kg of manure per household were applied to coffee fields in the year 2000. The percentage of households keeping improved breed cattle (crosses and pure breeds) increased from 9% in December 1990 to 12% in December 2000. The average percentage of improved breed cattle in the herds held by surveyed households also increased from 5% in 1990 to 10% in 2000, implying increased (albeit slight) intensification among cattle farmers. The proportion of households that kept improved breeds of pigs and chicken was very low both in 1990 and 2000, ranging between 0 and 3%.

Overall, the current level of intensification in crop and livestock production in the lakeshore region seems to be insufficient to bring about the improvement in soil fertility and agricultural productivity needed to reduce poverty and food insecurity in the region. Although a significant proportion of farmers are using improved varieties of maize and beans, this alone is not enough to sufficiently enhance yields. Instead, it increases the rate of soil nutrient mining and negatively affects current and future crop yields. It is imperative that the use of external inputs be increased to replenish lost nutrients. The use of inorganic fertilizers is almost non-existent but some households are using manure and compost on bananas and coffee. The use of improved breeds of livestock is also low. These results are consistent with the findings of an earlier survey of 107 LC1s and villages that the banana-coffee expansion pathway was most strongly associated with adoption of soil and water conservation practices, while the cereals expansion pathway was not associated with adoption of soil and water conservation practices.

Despite the fact that a growing number of rural households in the lakeshore region are embracing agricultural production as their primary income source, the existing

opportunities for increasing their incomes through greater intensification are not being exploited. Several factors were hypothesized as deterring farmers from pursuing the intensive pathway, including lack of supporting systems such as credit, extension, or agricultural training programs, lack of labor and capital (natural, physical, financial, human and social) or savings, land tenure insecurity, lack of access to markets, etc. However, the effect of a few of these variables such as land tenure, access to credit and savings has not been analyzed because of the problem of small number of observations on these variables.

The econometric results show that contact with extension agents, market access and livestock ownership (pigs and cattle) significantly enhances the application of manure on bananas, while farm size (total land endowment of the household) negatively affects it since larger farms can increase or maintain production using extensive methods which may not be possible for smaller farms. The positive effect of market access on manure use is probably because farmers with better access to markets receive better prices than those with poor market access, which induces them to use yield-enhancing inputs (such as manure) to increase yields and take advantage of the better prices. The fact that livestock ownership enhances manure use shows that farmers mostly rely on own supply of manure because of its low value to volume ratio makes it less tradable.

Population density (which contributes to farm size reduction) and cattle ownership significantly enhance manure use on coffee. Both the probability and intensity of use of improved maize varieties are enhanced by membership in organizations and distance to nearest markets as expected, although market access has a negative effect contrary to a priori expectation. It is hard to explain why market access would reduce adoption of improved maize seed. It may be associated with presence of better paying alternatives in

areas with better market access. The positive effect of organizations on adoption of improved maize varieties suggests that some organizations are promoting their use.

To conclude, the production of several crops and livestock has gained importance, the most notable ones being cattle, pigs, chicken, perennial (matooke and coffee), and annual crops (maize and beans). Associated with the production of annuals (especially maize), however, is increased nutrient mining through increased exposure of soil to erosive forces and nutrient exports from the farm through commercialization, unless external inputs (such as inorganic fertilizers, manure, compost, etc.) are used to replenish these nutrients. Unfortunately, the level of use of such inputs on annuals (maize and beans) is near zero, although some farmers are using manure and compost on perennials (matooke and coffee). Instead, a significant number of farm households are growing improved (higher-yielding) varieties of these annuals, which take out more nutrients from the soil than the low-yielding unimproved varieties, without replacing them. Moreover, a significant proportion of the annuals (maize in particular) is sold for cash, leaving no chance of recycling the nutrients lost through harvesting. The end result is bound to be faster land degradation.

The study shows that livestock ownership (particularly cattle), contact with extension agents, population density and market access significantly enhance the use of manure on perennials (bananas and coffee). Thus, improving farmers' access to markets through investments in rural road construction and maintenance as well as transportation is likely to result in improved land management in the lakeshore region. The positive influence of livestock ownership and access to extension on manure use suggests that extension services are correctly using the opportunity of increased livestock acquisition

(especially cattle) in the region to promote the use of manure on perennials. This effort needs to be expanded to include other types of livestock (such as chicken) and crops (such as maize) to ensure that synergies between all crops and all livestock (not just cattle manure and perennials) are fully exploited to improve land management in the region.

Membership in organizations is associated with increased use of improved maize seed, suggesting that this technology is being promoted by some organizations in the Lakeshore region. However, the limited use of soil fertility replenishing inputs associated with maize production implies that these organizations are not promoting the use of these inputs as much as they are promoting improved seed or that farmers are only adopting the seed but not fertilizers. This is bound to deplete soil fertility in the long run and it is critical that such organizations put as much emphasis on soil fertility management as they do on improved seed to make sure that increased maize production in the lakeshore region does not come at a cost of increased land degradation.

The negative effect of farm size on manure use suggests that smaller farms are more likely to use manure than bigger ones. Thus, population pressure, which reduces farm size may not necessarily promote land degradation as the Malthusian pessimists have always argued, but may instead stimulate investments in land improvement. Consistent with this, population density significantly enhances the use of manure on coffee.

11. A REVIEW OF LAND USE CHANGE AND SOIL DEGRADATION IN THE SOUTHWESTERN HIGHLANDS OF UGANDA

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The objectives of this review paper are to examine land use and land degradation in the southwestern "Kigezi" highlands of Uganda (Kisoro and Kabale districts) based on recent research findings that challenge conventional views on these phenomena in the region, and to discuss what these and other findings imply for policies and investment programs. The paper is based on published and "gray" literature and will be followed up with fieldwork in the region.

Accounts from the early 20th century provide evidence for a high level of agricultural intensification and widespread use of soil and water conservation (SWC) practices in the Kigezi highlands, including mixed cropping and crop rotations using legumes, a good vegetation cover on plots, minimum tillage, avoidance of steep-sloping areas, trash lines along the contour, and use of forward-sloping terraces. These practices led to a dynamic mosaic of terraces in the hilly landscape. Colonial administrators and visitors to Kigezi in the 1930s and 40s appear to have agreed that there were mild degrees of soil erosion and soil fertility depletion in the area, which caused yields to fall. They believed the proximate causes to be a shortage of land for rotational fallowing, livestock grazing on hill slopes and growing livestock numbers, and the cultivation of steep hillsides without adequate terracing. Rapid population growth in the context of "overpopulation" was seen as the major underlying cause of degradation. Nevertheless, most observers at the

time also did not find that soil degradation in Kigezi was a “serious problem” or that a catastrophe was imminent to Kigezi agriculture from this cause.

There is no doubt that human activities have profoundly changed land cover in the Kigezi area during the last one or two centuries. Remotely sensed land cover data from the early 1990s show that small scale farmland covers 57% and 68% of the land area in Kabale and Kisoro districts respectively, while natural forests (excluding woodlots and plantations) cover only 2.0% of Kabale and 16.3% of Kisoro. People in the region have clearly expanded and intensified agricultural land use in response to increasing population densities and market opportunities, but it is much less certain how, where, and when intensification and expansion of land use have occurred, and what the consequences have been for soil quality and biodiversity. It is also important to note that changes in soil quality cannot be directly inferred from changes in land use and land cover; yet no study known to this author has measured long-term changes in soil quality in the area. Even less known are the social and economic effects of land use system changes.

Despite the widespread belief that soils and vegetation are degrading in the Kigezi highlands, only a few studies have actually attempted to measure the longer-term changes in land use and land cover in the area. Only two among those apply “objective” measurement methods: one aerial photography and ground truthing, the other a resurvey in 1996 of transects done in 1945. These studies reveal interesting changes in the pattern of land use in Kabale District since the 1950s. The total size of farmland (fallow and cultivated) increased significantly in one of the three surveyed areas, while in the other two the expansion of upland farmland had stopped already by the 1950s due to the lack of available land. The most apparent change in land use is the conversion of papyrus swamps

into fields and pastures, especially in areas where all upland areas had already been converted into farmland in the 1950s. Where grassland, bush land and woodlands were covering important areas in the 1950s, these land cover types were converted into small-scale farmland and planted woodlots. This suggests that farmers tend to expand production first into upland areas and thereafter into wetlands, possibly because of the significant work involved in draining swamps. Another clear trend in the surveyed areas was the increase in woodlots, which were planted mainly on the steepest hillsides. There was also a significant increase in fallow land around Kabale town, and in the average length of fallowing. The increase in fallow was more pronounced on the steepest slopes, where it tended to replace land hitherto grazed by local breeds of cattle. Interestingly, in spite of these changes, farmers in the area were convinced that fallowing in the area had decreased and not increased. The major land use and land cover changes in Kabale District between the 1950s and 1990s can thus be summarized as:

Bush land, woodland, and grassland on hillsides	→	Farmland and woodlots
Papyrus swamps in valley bottoms	→	Dairy pastures and cropland
Grazing land on steep slopes	→	Fallow and woodlots
Short (seasonal) fallows on hillsides	→	Longer fallows on hillsides

Amid these changes, the pre-colonial system of down-sloping terraces and drag-down hoeing, which sometimes entails “harvesting” the soil accumulated on the upper-side bunds, continues to this day. It causes a significant soil fertility gradient between the upper and lower part of the terrace, and a slow movement of particles and nutrients down the hill slope – that is, a relocation of soil resources within the landscape rather than their transport out of the area. High rainfall infiltration rates, well-structured soils, SWC techniques, and

fallowing on the steepest slopes all contribute to reduce soil erosion. Several studies in the area have thus found relatively low rates of physical soil erosion; yet recent research suggests that especially the upper parts of terraces suffer from very low soil nutrient status and very low yields.

The rhetoric on soil degradation in the Kigezi highlands almost invariably paints an image of imminent disaster, and has done so since the first colonial agricultural officers arrived in the 1940s, despite much scientific uncertainty on this issue. Indeed, many of the changes in land cover and land management since the 1950s described here cannot be said to promote or constitute instances of soil erosion or soil nutrient depletion. Some even suggest a positive change in land management. This is not to say that the conditions or productivity of natural resources has improved, or that low soil productivity is not a problem in the area. However, there is little if any hard evidence to support the widely held view that population growth during the last 50 years has caused farmers to degrade soils through the effects of diminishing fallow and inappropriate farm practices.

Instead, one could argue that farmers have changed their land management practices in response to increased land scarcity in several positive ways, and/or intensified the use of existing practices. There has been an increase in intercropping and in market-oriented tree cultivation on fragile lands. Population pressure has also induced the reclamation of papyrus swamps for year-round production of dairy and vegetables for the market, and sweet potatoes, which is important for food-security, thus increasing private economic benefits from wetlands (although at the cost of ecosystem services provided by wetlands). Livestock rearing has declined due to diminishing upland grazing land. This change is positive in environmental terms, but may have had negative effects on local

livelihoods. There was a pronounced increase in fallowing, but the reasons for it are debated. Some believe that more fallow is a consequence of soil degradation that renders some lands unsuitable for cultivation. Others see the phenomenon as a positive adaptation to increased population pressure, whereby farmers reallocate crop cultivation to less erosion prone lands while increasing yields on cultivated land through intercropping. It is also unclear whether "more fallow" is found also outside the Kabale town area, or whether it is a localized phenomenon related to, as some think, favorable off-farm employment opportunities in Kabale town combined with land abundance among a few wealthier farmers, a higher rate of government and absentee land ownership, or other factors. Such knowledge gaps show a need to study land use dynamics at a smaller scale and in a regional socio-economic context.

What are the implications of the above discussion for policies and investment programs aimed at promoting sustainable development in the southwestern highlands of Uganda? First, if soil degradation is less of a problem than first thought, and if farmers to a large extent are able to deal with that problem without expensive outside support, then it should be considered to allocate more of the scarce public funds to activities that more directly improve agricultural productivity and incomes. This in turn would provide farmers with both the means and incentives to invest in soil conservation. Second, when designing land management programs and policies, it is essential to understand that the amount of labor and capital farmers are willing to invest in their land depends on their access to alternative economic opportunities, particularly off-farm employment.

Thirdly, it is increasingly recognized that economic incentives are of key importance to the sustainable management of land resources. In the absence of tangible,

private benefits, regulation, persuasion, and training are unlikely to produce significant results. In the Kigezi highlands the prospects for improving incentives based on market production and agro processing seem promising as the area enjoys relatively good access to markets and (mainly male) labor resources. While most attempts to introduce nonfood cash crops such as coffee, tobacco, pyrethrum, and flax into the area have largely failed, Kigezi farmers have successfully produced and marketed food crops such as beans and maize in the region for at least a century. These traditions and skills should be made use of when promoting market-led agricultural development.

Fourthly, Kigezi farmers' seemingly good track-record of adapting to pressures on land resources supports the increasingly accepted idea that land management research and development programs are more likely to succeed if they integrate the knowledge, experience and innovative capacity of farmers into their activities. The improved technologies and practices developed during such an approach would also need to be sufficiently flexible to accommodate the great diversity of farmers' preferences, skills and access to land, labor and capital resources. There is also a remarkable spatial variability in land use and land degradation within the Kigezi highlands, which must be taken into account by programs and policies. Finally, the review suggests that we need better and "harder" evidence on land management/use and land degradation in the Kigezi highlands so as to design more effective programs and policies aimed at raising rural incomes while conserving natural resources.

12. UGANDAN CROP MARKET DEVELOPMENT: CHARACTERISTICS, CONSTRAINTS AND OPPORTUNITIES

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This study was conducted with a broad objective of understanding the constraints and opportunities for output marketing in Uganda. The study also aims at identifying policy interventions that may increase the output marketing efficiency in the country. Output marketing development in Uganda has been characterized by the market reforms that the government took in the last decade. Like many other African countries, Uganda abolished the centralized state agricultural marketing system, which was characterized by high costs and gross inefficiency. This policy reform created opportunities for the private sector to engage in agricultural marketing. However, the performance of the private sector in agricultural marketing has been poor since it is facing a number of institutional and policy constraints. These constraints and the emerging opportunities have not received adequate scholarly analysis. This study aims at contributing to filling this information gap.

Four crops were selected for this study: coffee, cotton, maize and cassava. Selection of crops is guided by the following five factors: 1) significance of smallholders' participation, 2) share of the crop in agricultural GDP, 3) prospects for international and regional trade, 4) recent studies on the crops, and 5) potential for value addition. While selection of coffee and cotton was straightforward based these criteria, selection of maize and cassava relied on expert opinions. Maize is the most important cereal crop in Uganda. Maize production in Uganda has been increasing due to its rising demand both in the country and the region. Cassava is the second most important staple food crop after banana

in Uganda. There is evidence of changing food tastes and preferences in urban areas where cassava is increasingly becoming a popular snack sold on street sides and busy market areas. It is also finding its way in restaurants and hotels that serve local dishes. This tuber crop also has a potential for being processed into a high value products like starch and chips.

A total of 352 output traders were sampled for interview. The output traders were divided into five types for each of the four commodities considered in this study. The five types were exporters, Kampala traders, main town traders, primary fixed traders and primary non-fixed traders. Exporters are expected to be well endowed with capital and operating larger businesses than all other types of traders. Kampala traders are expected to be large as they operate in the biggest city of Uganda. Main town traders are the third biggest traders operating in district headquarter municipalities or townships. Primary fixed traders operate in the rural areas with a fixed business location, where producers deliver their supplies or where customers go to buy commodities. It is also likely that the primary fixed traders travel to producers to buy supplies. Primary non-fixed traders are the itinerant traders operating in rural areas with no permanent business location. The data were analyzed using cross tabulation and comparing the mean or frequency across type of traders and/or commodity traded. An econometric model was used to determine the factors that determine a choice of commodity to trade.

Findings of this study show that five major problems remain impediments to efficient agricultural production and marketing in Uganda. The constraints are poor infrastructure, unreliable power supply, corruption, inadequate legal structure for business

operations, law enforcement and pockets of insecurity in the north and western regions due to rebel insurgencies, and cattle rustling in the northeastern region.

The study shows that credit availability remains a major constraint to the local Ugandan output traders. The local entrepreneurs who attempt to export coffee find it hard to penetrate the lucrative international market for lack of capital, information and experience in international trade. Price fluctuations in the world market also frustrate the new entrants who have low risk bearing ability. These problems have led to massive exit of local traders from the coffee export market. Currently, only ten exporters handle 80% of Ugandan coffee. Hence there is a potential risk for monopsonistic structure at the exporter level for coffee and cotton. Although competition among these exporters is perceived to be strong, it is not known if such marketing structure with so few exporters is efficient or not. It is also not clear why so many local companies went bankrupt. An in-depth study is needed to analyze the failure of the local potential exporters.

Findings of this study point to some areas that need to be examined closely to understand their role in performance of the export sector and efficient output marketing in general. These are credit availability, education, collective action through trade associations and cooperatives, gender of principal traders, contracting, and use of agents for market information collection and performing transactions. Level of education significantly influences the decision to trade in coffee, cotton, maize and cassava. Attainment of college/profession training increases the probability of being engaged in trading cotton or coffee. Hence there is need to support professional training programs since it appears to help exporters to run their businesses more competitively.

Trade associations seem to be important to exporters since more than 91% of exporters sampled belong to trader associations while less than a quarter of the main town and primary traders belonged to a trader association. This shows the potential of collective action among the exporters and a lack of it among main town traders, and hence their weakness for taking any collective action. This suggests the need to encourage local traders to form associations and cooperatives. The associations may help in pooling resources, obtaining credit and information and other benefits.

Female traders market a higher proportion of cassava, the crop with lowest value, than other commodities covered in this study. Coffee trading had the smallest proportion of female traders. Women are also likely to be more involved in cassava trading than one of the export crops. The need to have targeted support to women to get them involved in high-value crops trade is apparent.

There is lack of contracting in output marketing. Contracting is an important setup in the export market. The main reason for the lack of contracting seems to be the lack of enforceability of the contracts. Additional research could help to identify the problems and constraints that limit traders from entering into contracts with producers to secure products, and into contracts with processors and exporters to provide products.

Quality assurance appears to be the most common problem in output trading. In the case of coffee, one of the possible causes of the quality problem is the failure of traders to remunerate producers for high quality coffee. At the local coffee purchase market, farmers and traders negotiate price basing on weight of beans only. This may discourage farmers from producing high quality coffee since the premium for quality is not remunerated. Farmers may therefore have no incentive to invest in quality enhancing

inputs such as proper drying or storage facilities. This problem points to the need to effectively control and regulate coffee buyers in order to arrest the erosion of the Ugandan coffee quality in the world market. This is important for Uganda since addition of quality seems a way of partly compensating for the plummeting world coffee price.

Maize and cassava do not have an effective regulatory body that can ensure quality and standards of the products. Different varieties of commodities with different characteristics are often mixed together. Testing equipment for determining quality of maize and cassava are often unavailable at the local level. Prices for the most part do not appear to reward quality of maize and cassava. Other problems in maize and cassava marketing are lack of storage facilities, irregular supplies and low product volume. These problems lead farmers and output traders to fail to participate in the export market, which requires standardized product and regular supply. This suggests a need to have an institution to regulate and provide marketing services to the non-traditional export crop producers.

Half of the exporters, main town and primary fixed traders use intermediaries. Cotton traders reported the highest proportion of intermediary use. Intermediaries buy about half of the exporters', main town and primary fixed traders' purchases in the main market. Buying agents purchase 62% of cotton and 49% of coffee. These results signify the importance of intermediaries in commodity marketing in Uganda. The policy implication of these findings is that the government needs to recognize intermediaries and license their operations. Mechanisms should also be put in place to improve traders' access to market information search to improve their efficiency in providing brokerage services.

13. DYNAMICS OF MAIZE MARKET INTEGRATION IN POST-LIBERALIZED UGANDA

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The nature and extent of agricultural market integration influences decision making of agricultural households in many ways. Of particular significance are the decisions regarding technology adoption, farming practices, and overall management of natural resources. Farm households are not likely to adopt a production technology, even if it is otherwise considered the best, unless a well-functioning market for the product exists to make the technology viable. As a result, in the geographic regions that lack market integration, in addition to facing limited livelihood options, farmers are often observed to choose sub-optimal technology. In addition to substantiating these contentions, cross-country empirical studies—such as those investigating the determinants of poverty dynamics, optimal famine relief policies, and effective implementation of price stabilization policies provide evidence of the critical linkage between market integration and human well being in agrarian societies. In line with this general theme, this paper makes a modest attempt to provide empirical evidence on the dynamics of maize market integration in post-liberalized markets in Uganda.

While there is a general consensus that market integration refers to spatial flow of goods and information, a unique definition that captures all aspects of the concept with testable implications continues to remain elusive. As a result, empirical methodology for spatial market integration analysis varies widely depending on underlying economic and statistical assumptions. This paper uses a methodology, developed within Johansen's

multivariate cointegration framework, which, unlike bivariate analysis between a central market and a peripheral market, analyzes the extent of integration among a set of spatially separated markets. Empirically, the methodology is carried out in two broad steps. The first step involves identification of the district markets that share a common stochastic trend or, equivalently, belong to the same economic markets; and the second step assesses the relative importance of each of the markets in long run price formation. The underlying idea is that for a given set of market locations, not all locations belong to the same economic market, and among those that do belong to the same market, some will be more integrated than the others. Thus, these estimates can help policy makers in targeting geographic locations in order to set up information dissemination centers or to implement any other price stabilization interventions.

Data for this study are derived mainly from two sources: i) Famine Early Warning System Network (FEWS-Net), which collected and analyzed weekly price data from January 1993 to January 1999, and ii) *Foodnet* of the International Institute of Tropical Agriculture (IITA), which, at least in terms of data compilation, replaced FEWS-Net activities in late 1999. In addition to collecting weekly price data, *Foodnet* also disseminates price information in selected districts through radio broadcasting. The FEWS-Net started compiling weekly maize price data in eight Ugandan districts since the first week of January 1993. Subsequently, coverage was increased to 23 districts, but unfortunately the data for most of the districts are discontinuous with a large number of missing values. However, from the 1st week of 1993 to 40th week of 1994, the time series was continuous and long enough to be able to carry out the analysis in the following eight districts: Kampala, Jinja, Masaka, Gulu, Arua, Mbarara, Hoima, and Mbale. Furthermore,

in terms of the length of the time series, the first 92 weeks of FEWS data matches with the length of *Foodnet* data for the selected districts, which enable a valid comparative analysis between the two periods. Given the history of economic reforms in the country, analyzing data for these two sub-periods also helps us to understand how dynamics of market integration has changed since early years of market liberalization (hereafter referred to as liberalization).

Based on the empirical results, three broad conclusions are drawn. First, the study finds that compared to the early years of liberalization, the extent of integration in Ugandan maize markets has improved in recent years. Some district markets, such as Masaka and Mbarara, which did not integrate with the dominant central markets in the early 90's, became strongly integrated in recent years. In a broader sense, this result supports the fact that the impacts of market liberalization should be evaluated in a dynamic context, not during the immediate aftermath. Given that Masaka and Mbarara already had good road networks earlier, non-integration of these markets also suggests that access to infrastructure is not a sufficient condition for market integration, at least in the early years (1993-94) of liberalization when marketing networks are in their infancies and the institutions that ensure healthy market exchange are yet to be developed.

Second, although not surprising given the political realities, northern districts continue to lack integration with the central markets. Two of the northern districts considered in this study, Arua and Gulu, show disturbing trends. When compared with the price trend in Kampala, Arua shows a trend reversal during most part of 2000 and 2001. Furthermore, Gulu did not share a common price trend with central markets for both sub periods. In the context of market connectedness and poverty, this finding is very consistent

with studies on regional poverty in Uganda and elsewhere in Africa. It is in full conformity with Appleton's study on the dynamics of poverty in Uganda in the 90's, which demonstrated that while the overall poverty situation in Uganda improved in the 90's, the absolute poverty in the northern region increased in some cases. The continued non-integration of northern district markets can perhaps be attributed to continued insurgencies in the region. However, these results, particularly the trend reversal in Kampala-Arua prices, hold clear policy implications for regional trade. It seems to be common knowledge in Uganda that the traders in the northern districts continuously engage in trade with neighboring country traders. If such trading is viable, despite being illegal and consequently involving high transaction costs, it warrants serious consideration for devising policies for regional trade. If implemented effectively, such trade policy can enhance market integration as well as improve welfare of the producers who have to settle for lower prices due to low domestic market demand and high transaction costs to major domestic markets.

Finally, the major consumption markets, such as Kampala and Jinja, are the most influential factors in long run maize price formation in the country. Furthermore, this study observed that districts with larger production of maize seem to have larger influence on maize price. For example, analysis of the 2000-01 data suggest that Iganga and Lira, the largest and second largest maize growing districts in the country, ranks third and fourth respectively in terms of their importance in price formation. From a policy point of view, this set of results can be of significant importance in designing targeted market intervention, such as implementing ceiling and floor prices for market stabilization purposes. The unexpected decrease in maize prices in recent months in Uganda, which

received substantial media and political attention, reinforces the importance of initiating policy discussion in order to determine whether such price stabilization strategies are needed for the country.

From a policy standpoint, the bottom line questions are: what are the factors that contributed to improve market integration in Uganda in recent years? Is it worth investing in the market information system, such as *Foodnet*, for the role that it plays in improving market integration? Adequately answering these questions was beyond the scope of this study, but corroborating our results with some additional information can draw some cautious conclusions. Although not directly derived from our statistical model, this study finds a clear relationship between the information flow index for *Foodnet* and the significance of district markets in long run price formation. Specifically, high common trend coefficients, which implies relative importance of a district in maize price formation, are found to be positively correlated with the information flow index, measured in terms of length, frequency, language match, and other attributes of the *Foodnet* radio broadcasting. Also, a recent IFPRI household survey shows that the radio is the main source of market price information for rural households in Uganda. There can be a number of other factors (such as infrastructure, trade networks, political stability) that have contributed to the improvement in the spatial integration of Ugandan maize markets. Nevertheless, it appears that social returns of investment in *Foodnet* outweigh the costs.

14. INFORMATION ASYMMETRY AMONG OUTPUT TRADERS, PROCESSORS AND FARMERS IN UGANDA

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Access to reliable and timely information is essential for development, even for the resource poor farm households and village entrepreneurs in rural areas of developing countries. Farmers, traders and processors need to have equal access to information to eliminate exploitation of either party. This paper examines the different sources of price and market information, and their accessibility to traders, processors and farmers as well as their information needs. The data used was obtained from surveys of four sets of actors, namely: farm households, input and output traders and agricultural processors. The surveys were conducted between October 1999 and June 2001. It is observed in this paper that traders and processors have many, reliable and better sources of market and price information while farmers have less and poorer sources of market and price information. This information asymmetry affects farmers' ability to bargain for better prices and margins.

Access to the various types of communication infrastructure varies among traders, processors and farmers. The results showed output traders and processors seem to be adopting the usage of modern communication infrastructure including fax, Internet, email, and mobile phone. No farmer reported to own a mobile phone, telephone, fax, computer or using internet. The only information infrastructure farmers reported using is radios, which are owned by a majority of the farmers. However, since the Ugandan farmers are located in rural areas, where access to electricity is limited, they use dry cells, which are unaffordable

to some farmers owning radio. Therefore disseminating information through a radio may be limiting even to farmers owning a radio.

Governments should consider reducing taxes on the low cost radio and dry cells to make them more affordable to farmers. There is an increasing number of FM radio stations around the country. This has created an opportunity to use radio stations to disseminate information to the local population in their own local languages and at hours convenient to farmers.

The major source of day-to-day market information for traders and farmers is speaking with other traders and other farmers respectively. Information from other traders may be more reliable than from other farmers since traders are usually more educated, travel widely and are better informed about prices and markets than farmers. This implies that the quality of information farmers get from other farmers is likely to be poorer than that of traders and processors. Our results imply that direct conversation is the most common method of receiving market information by traders, processors and farmers.

Commercial networks through farmers and traders groups (associations) facilitate availability of information to their members. More farmers belong to associations than traders and processors, although most farmers' associations offer social services unrelated to market or production services. For example, many farmers' associations offer mutual support during death and funeral ceremonies to their members. Traders' associations commonly offer market information, among other services. This points to the need to facilitate farmers' associations to offer price and market information from institutions, government departments and other sources.

A number of government parastatals are legally mandated to collect and disseminate price and market information to traders and farmers. The Uganda Coffee Development Authority (UCDA), the Cotton Development Organization (CDO) and the Ministry of Trade and Industry are some examples. The survey results show that output traders and processors have more access to information from these institutions than farmers. Institutional information is more reliable, researched and detailed than information from other sources. These institutions are urban based, where most traders and processors operate. Even where institutional information becomes available to farmers, it is normally in reports, bulletins and pamphlets whose format, content and language is difficult to be understood by farmers.

Radio stations and newspapers report price and market information. Our results show that traders and processors have high access to radio and newspaper price information (80%) as compared to farmers (<20%). This is because the newspaper circulation is still limited to urban and peri-urban areas with a very limited penetration in rural area. Uganda, with a population of over 20 million people only circulates approximately 30,000 newspaper copies daily. Newspaper circulation and usage in rural areas is still very poor due to poor transport infrastructure, poverty and illiteracy. The use of the television and printed media common with government parastatals and institutions in disseminating information would only benefit traders and processors and not most farmers. This further limits farmers' access to market information.

The low use of information in the printed media, especially among farmers, calls for a new strategy of using village and community bulletin boards. These could be established at convenient points where bulletins on the weekly price information released

by the government or non-governmental institutions could be displayed. Farmers and traders should then be encouraged to visit these bulletin boards frequently to use the information in their sales and purchase decisions.

Internet, email, and telefax are little used by traders and processors and are not used by small farmers. Government and/or donor agencies may help to strengthen the district decentralization information capacity by equipping them with information systems that would enable prompt and fast access and use of market and price information in rural areas.

15. DETERMINANTS AND IMPLICATIONS OF DEVELOPMENT PATHWAYS AND LAND MANAGEMENT IN UGANDA

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The major objective of this study is to analyze the development patterns and land management practices in Uganda, their causes and implications, based upon household and plot level data collected from 451 randomly selected households in southern, central, eastern and parts of northern Uganda.

Agricultural commercialization and urban development are increasing in Uganda in the wake of structural adjustment and market liberalization policies. This is increasing farmers' income earning opportunities both on and off the farm, but is also contributing to soil nutrient depletion, as exported plant nutrients are not being adequately replenished. Use of inorganic fertilizer is very low, and organic practices such as manuring, composting, mulching, and use of leguminous crops for biological nitrogen fixation are still relatively limited.

We have investigated numerous factors influencing households' choice of livelihood strategies and use of land management practices, including agroclimatic conditions, access to markets and roads, population pressure, households' endowments of land, labor and various forms of capital, access to technical assistance and credit programs, land tenure, and others. This study demonstrates that different livelihood strategies and land management practices are pursued in different parts of Uganda, and that these are substantially affected by differences in agricultural potential, market access, population pressure, and other factors.

We find that technical assistance programs are having substantial impact on increasing adoption of improved land management practices, yields and income of some crops (e.g., bananas), livestock incomes, incomes from other farm and nonfarm activities, and in reducing soil erosion. This broad set of positive outcomes suggests that "win-win-win" strategies contributing to increased agricultural productivity, reduced poverty and sustainable use of natural resources are possible. Still, the coverage of these programs is very limited, and the vast majority of farmers have not been involved in extension or training programs, especially in remote areas such as much of the eastern highlands.

Adoption of fertilizer was found to be associated with much higher yields of maize and coffee, though the sample size was very small, limiting our ability to draw general conclusions about the impacts of fertilizer. Inorganic fertilizer was applied mainly to maize, especially in the eastern highlands. Many of the organic practices, such as application of manure, mulch, and incorporation of crop and household residues were found to have insignificant or mixed impacts on crop yields, in some cases being associated with lower yields. This may be because the impacts of such technologies depend importantly upon how they are applied. For example, inadequate storage and application of manure can limit its effectiveness. Also, soil organic matter appears no longer to be the most important indicator of soil fertility, and is still adequate in many locations. Thus more targeted approaches to addressing soil fertility problems are needed.

Our research found low oxen use and farm mechanization, especially in the high and low bimodal rainfall zones (in the Lake Victoria region and the southwest) and the southwestern highlands. Insurgency of rebels and cattle rustling may have affected use of oxen in the north, northeastern and eastern zones. However, it is surprising that even in

areas with a large number of cattle—like the bimodal low rainfall zone in the southwest—use of animal power is limited.

About 85% of households reported owning bicycles, which are important for transportation. However, bicycle payload is low and the estimated agricultural marketed surplus is only 20%. Ox-carts and other means of transport could help to stimulate agricultural marketing. Over three quarters of households reported owning radios. Radios may therefore be used to disseminate production technology and market information in rural areas.

We found that better market access contributes to some intensification of inputs, such as fertilizer, though this is still very limited. Market access was associated with higher yields and incomes from bananas, but lower yields of maize, perhaps as a result of land degradation. Efforts to intensify soil fertility management, especially in commercially oriented crop production in areas of good market access, are critically needed. Market access also is associated with some livestock activities, such as pig production, while other livestock activities are more important further from markets, such as extensive cattle ranching.

Population growth and small farm sizes are serious concerns, especially in the densely populated areas of the highlands and the Lake Victoria region. We find evidence that small farmers adopt more intensive methods, as predicted by Boserup, but we find yields of several crops to be lower on small farms. Thus, intensification does not appear to be overcoming the negative impacts of population pressure and small farm sizes on yields and incomes. Our evidence also indicates that erosion problems are greater on smaller farms, and that some of the intensive practices used by smaller farms appear to increase

erosion problems. Thus our findings do not support the optimistic "more people, less erosion" view; and indicate that efforts to control population growth and land fragmentation in Uganda are needed to help stem land degradation and declining productivity.

The importance of maize and bean production is increasing in almost all zones of Uganda. This increase may be a livelihood strategy that seeks to diversify household income and/or a response to changing food habits and emerging markets. The implication of the spread of cereals and pulses on soil fertility is not clear. However if cereals and pulses are replacing perennial crops, which are associated with better soil cover and soil conservation and less tillage, land degradation may be accelerated by spread of the cereals and pulses.

Investments in livestock offer opportunities for substantial economic returns and income diversification. However, the average livestock contribution to household income was only 5%. The high market access areas reported the highest adoption of improved dairy cows, while less densely populated areas reported higher number of cattle heads per household. We observe very limited availability of livestock extension and veterinary services. This points to the need to take deliberate efforts to improve technical assistance for the livestock sector.

Marginal rates of return appear to be highest for poultry and pigs (over 100%), though cattle are also relatively profitable. Livestock ownership contributes to intensification of crop production, as well as providing an important source of income. Complementarities between cattle and banana production appear to exist, though the exact

nature of the complementarity is not clear. There are problems of soil erosion related to livestock grazing, and these deserve greater attention.

Improvements in education are also helping to increase rural households' opportunities and incomes substantially in Uganda. Education is contributing to improved productivity of some crops and of livestock producers, but in general it appears to be promoting increased off-farm activities. As a result, more educated farmers are less prone to adopt intensive practices, and this appears to be contributing to the lack of intensification in Ugandan agriculture.

Other factors such as land tenure and access to credit were found to have mixed or limited impacts. There are mixed associations of land tenure rights and arrangements with land management practices and productivity. In general, we do not find support for the common presumption that freehold tenure is superior to other tenure forms in terms of promoting improved land productivity or sustainability. In many instances, productivity is higher and land degradation is lower on customary or mailo land. We also did not find support for the assumption that owner-operated plots are generally more productive than leased-in or borrowed plots. However, this may be due to greater soil mining on leased-in plots. Further study of such issues is warranted. However, the evidence in this study does not suggest a need for rapid conversion of mailo or customary land to freehold status, as envisioned by the 1998 Land Act.

This study observed that the poorest regions are the north and east, pointing to the need to target programs in these areas to address poverty problems. The impacts of market access and population density on poverty are ambiguous. The larger farm sizes and

livestock herds found in the low market access and low population density areas tend to lead to higher incomes in these areas.

Policy Implications

In general, the findings of this study show that there are many opportunities to increase farmers' incomes and help ensure food security while improving land management. Different comparative advantages exist in different parts of Uganda, and this should help to guide more targeted technical assistance and public investment strategies. There is no "one-size-fits-all" strategy that will work throughout Uganda, though successful development will require increased investment in technical assistance, continued investment in education and infrastructure, and a continued commitment to market liberalization, development of private markets for agricultural inputs, decentralization of governance, and assurance of peace and security.

Specifically, our observation that areas with high market access were associated with higher agricultural intensification but declining yields of several crops suggests that nutrient depletion in such areas is a major concern. Although improved market access may increase efficiency of agricultural marketing, low profitability of outputs may limit farmers' ability to apply adequate inputs to stop the nutrient depletion. Therefore large use of external inputs may not be a feasible option for addressing land degradation. One of the solutions often suggested for this problem is integrated soil fertility management, which includes use of a variety of sources of nutrients and cultural practices that conserve, add or increase availability of naturally occurring nutrients. However, we observe that use of organic fertility sources did not lead to significant increases in most crop yields. This calls

for increased research and extension efforts to generate and disseminate organic fertility management technologies that are acceptable to and profitable for smallholder farmers.

Special efforts are also needed to expand coverage of technical assistance programs to cover remote areas. Our study has shown that non-governmental organizations contribute significantly to provision of extension services, but that their coverage in remote areas is limited. This points to the need to encourage involvement of such programs in remote areas.

Our observation that high population density is associated with lower yields and soil erosion calls for the need to relieve the land pressure by creating alternative non-land based activities and birth control campaigns to complement the agricultural intensification option that the farmers are already pursuing in densely populated areas. Education may be one of the approaches of relieving land pressure, given that education increases the probability of farmers getting engaged in off-farm activities. However, education is associated with less adoption of labor-intensive land management practices. There is a need to include practical training in agriculture and land management in educational curricula to minimize negative impacts of education on land management.

The increasing importance of maize and beans in most farming systems, including the banana-coffee system, has not been accompanied by a major increase in fertilizer use or soil conservation measures. It is likely that the introduction of the cereals and pulses may increase land degradation in the banana-coffee system. This suggests the need to have a vigorous campaign of better fertility management and soil conservation for annual crops in order to stem the potential increased land degradation.

Livestock extension services need to be increased, to allow farmers to take advantage of the economic potential of livestock in rural areas. Opportunities for improved incomes from dairy cattle, pigs and poultry appear to be quite high, especially in higher market access areas. For this effort to be effective it needs to be accompanied by facilitation and improvement of livestock product marketing and processing. These efforts are likely to increase the value of animals and their products, which in turn would increase the present low contribution of the livestock sector to family income.

Use of animals for farm mechanization is also quite limited, perhaps because of lack of awareness of the benefits of using animals for transportation and farm operations. A need to encourage and sensitize farmers to use animal power for transportation and plowing is apparent. To support this effort, village artisans may be trained to make simple and cheap animal-drawn carts and plow sets that are affordable and easy to maintain.

The high proportion of radio ownership offers a chance of using them to disseminate extension messages and agricultural market information. To increase their effectiveness, local content and use of local language in the radio programs are critical. The programs also need to be broadcast at times that are convenient for farmers.

16. SOIL CONSERVATION PRACTICES AND NON-AGRICULTURAL ACTIVITES IN THE SOUTHWESTERN HIGHLANDS OF UGANDA

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This study is motivated by the problem of natural resource degradation that results from agricultural activities, over-harvesting of forest products and other human activities. Consequently, forest cover and biodiversity are decreasing due to pressure exerted by the increasing demand for forest products and agricultural expansion. As is the case for forest degradation, the rate of degradation of the land resource is also high. Agricultural production is the most important human activity that contributes to land degradation in Sub-Saharan Africa (SSA). It is for this reason that many studies have directed attention to the causes and remedies of land degradation resulting from agricultural production.

This study examines soil conservation practices and factors that determine their adoption in the southwestern highlands (SWH) of Uganda. It also analyzes non-farm activities and factors that condition participation in non-farm activities among household members. Non-farm activities are important determinants of soil conservation since they influence land use in many respects. Farmers in SSA have responded to declining per capita farm size and environmental stress by switching to non-farm activities. This implies non-farm activities may contribute to reduction of land degradation resulting from increasing population. Income from non-farm activities may also be used to purchase fertilizer and other external inputs used for improving soil fertility.

The SWH region is among the richest ecological regions of Uganda in terms of biodiversity and endemism, and is therefore a significant attraction to tourists. The SWH region includes highlands of the districts of Bundibugyo, Bushenyi, Kabale, Kabarole, Kasese, Kisoro, Ntungamo, and Rukungiri. The major ecological concerns in the region are threats to biodiversity and land degradation, especially with the current emphasis on commercialization of agriculture.

The data used in this research were obtained from a survey covering 451 randomly selected households from the central, eastern, northern and western regions of Uganda. From each sampled household, a plot survey was conducted to determine the farm management practices of each plot. This study focuses on the households that were sampled in the SWH region (45 households). Univariate and multivariate data analysis is done using simple descriptive statistics and econometric models to determine the key factors that influence adoption of soil conservation methods and participation of household members in non-farm activities.

Only about 44% of sampled household used at least one of the three types of soil fertility management technologies, i.e. agroforestry, soil and water conservation measures (SWC), and application of fertilizers. About 11% of the respondents in Uganda used inorganic fertilizer. This rate is considerably higher than that reported in earlier studies. It appears that use of inorganic fertilizer among farmers has increased due to the improved input markets and extension efforts by government programs and organizations. This is an encouraging sign, which shows that the input market reforms and extension efforts are having an impact. Since access to inorganic fertilizers remains low due to high prices and other marketing problems, the levels applied are still low. This points to the need of

encouraging farmers to use a combination of complementary soil conservation technologies.

Agroforestry is the most common fertility improvement technology used by the respondents. Hence agroforestry appears to be more feasible and compatible with the existing farming system than the other technologies considered. This suggests the need to increase efforts in promoting use of improved agroforestry practices that have been developed by researchers but have not yet reached farmers. The results also suggest the need to continue investment in agroforestry research to generate new technologies. However, there are very few well-established private traders or organizations that market agroforestry technologies such as seeds and planting materials of trees and shrubs. This may contribute to the low uptake of agroforestry technologies. There is a need to have concerted efforts to commercialize agroforestry research products since most government programs and NGOs have directed their efforts towards generation and dissemination of agroforestry technologies only.

A significantly higher proportion of farmers used bench terraces, grass strips, deep and minimum tillage and invested in drainage in the SWH region than in the rest of Uganda (ROU). These observations were expected due to the steep terrain in the SWH region that calls for soil conservation. However, there is reason to worry about the 68% of households that do not use any form of SWC practices in the SWH region where lands are fragile. There is therefore a need to increase extension efforts of improved land management technologies since the soils in the SWH are fragile, hence easily degraded. There is reason for concern even among farmers who reported to have adopted bench terraces and other conservation structures, since such structures are poorly maintained and

hence their effectiveness is low. In some cases, farmers have opened up the bench terraces to utilize the nutrients accumulated over time.

Land tenure, labor constraints, age and education of household head and non-farm activities appear to be important factors that influence adoption of agroforestry practices in the SWH region. The customary land tenure system, which is the most common in the SWH region, is associated with higher adoption of agroforestry practices than the freehold system. The reason for low adoption of agroforestry practices under freehold tenure may be tenure insecurity due to weak land law enforcement institutions. Therefore the government needs to strengthen the land tribunals at community and district level in order to ensure security and stability of land tenure systems.

Family size is found to reduce the probability to adopt SWC and agroforestry technologies in the SWH region. The reason for this observation is likely to be related to land scarcity, which is more severe with larger families. Land shortage for the large families may not permit adoption of SWC and agroforestry technologies that compete for land with crops. Promotion of participation in non-farm activities may take some rural labor force out of agriculture, permitting adoption of soil conservation methods that compete for land with crops.

In both the SWH region and ROU, farmers with more education have lower probability of adopting SWC and agroforestry technologies than less educated farmers. This was not expected as educated farmers may be better informed about the improved soil conservation technologies and the adverse effects of land degradation. The explanation for these results may be related to higher opportunity cost of labor for more educated farmers, which reduces the probability to adopt labor-intensive soil conservation methods. The

policy implications of these findings are that farmers may need to be given incentives for adopting labor-intensive technologies via tax breaks or non-monetary compensation such as personal recognition. Taxing people who harvest products from common resources like forests, wetlands, water, grazing lands, etc, may finance the loss of revenue due to the tax breaks given to adopters of labor-intensive soil conservation technologies. There is also a need to use moral suasion by educating farmers about the short-term and long-term effects of land degradation.

Older farmers are more likely to adopt agroforestry technologies than younger farmers in the SWH region, and elsewhere in Uganda. This may be related to differences in endowment of land between old and young farmers. Older farmers are likely to have larger farms than younger ones because older farmers acquired their land when population pressure was lower. This would allow older farmers to adopt agroforestry technologies that compete for land with crops. It also may be that the cost of labor for younger farmers is higher than older farmers since younger farmers are often better educated and have non-farm opportunities to pursue. This makes them less likely to adopt labor-intensive agroforestry technologies.

Agricultural and environmental related programs and organizations are predicted to increase the probability of using organic fertilizers in the SWH region and of adopting SWC technologies in Uganda as a whole. This was expected as such programs and organizations usually promote sustainable agricultural production practices. This points to the importance of institutional support in increasing the feasibility of adopting soil conservation methods. The institutions provide technical information, credit and other crucial support that is necessary for adopting new technologies. For instance, the number

of visits of extension agents and access to credit are found to increase the probability to adopt SWC methods in Uganda.

There are many programs and organizations in Uganda that are related to agriculture and the environment. However, in the SWH region, many programs and organizations are related to mutual support. This implies that there is a need to deliberately promote presence of agricultural and environmental-related programs and organizations in the SWH region, as these may be very effective in increasing adoption of soil conservation methods. However, the role of government in regulating activities of programs and organizations is quite crucial as some of their activities may be counter-productive. For instance some NGOs have been reported to discourage farmers from using inorganic fertilizer for fear of "destroying" the soil.

Non-farm activities are predicted to increase adoption of agroforestry in the SWH region. Non-farm activities are expected to increase income, spread production and price risks, and more importantly, they have the potential of reducing the pressure on land resulting from increase in population. All these factors may favor adoption of agroforestry practices that compete for land with crops or practices that involve considerable financial outlay. However, fewer than 10% of members of the sampled households in both the SWH region and ROU reported to have non-farm activities as their major primary or secondary activity. This implies there are few non-farm opportunities with comparative advantage over agriculture. There is a need to increase the competitiveness of non-farm activities in order to increase their profitability and acceptability among farmers. This is likely to relieve pressure on land, which is too high in the SWH region. Increased participation of

household members in non-farm activities could result in a win-win scenario where both environmental degradation and poverty are reduced.

The factors that significantly influence participation of household members in non-farm activities in Uganda are family size and presence of agricultural related programs and organizations. An increase in family size is predicted to increase participation of household members in non-farm activities. The results suggest that in rural Uganda, agriculture has a comparative advantage over non-farm activities. This is probably caused by the lack of market for non-farm products and/or the poor quality of the products that are made using minimum or no skills.

The presence of programs and organizations promoting agriculture and the environment reduces the probability to engage in non-farm activities. This is expected as such programs and organizations are likely to increase the competitiveness of agricultural products over non-farm products. This points to the need to create and support programs and organizations that train farmers to produce higher quality non-farm products and services and facilitate them to engage in non-farm activities. Such efforts would increase the competitiveness of non-farm products and hence attract more farmers to engage in non-farm activities. Such programs and organizations may be related to training farmers in agricultural processing, bookkeeping and accounting for their small businesses, and supporting vocational training institutions in rural areas. They could attract young high school dropouts to train in masonry, carpentry, farm tools and machinery repairs, and other skills. The non-farm products produced by skilled and semi-skilled producers would become more competitive and hence result in higher participation even among smaller families who are predicted to participate less in non-farm activities due to labor constraints.

The general conclusion of this study is that measures that need to be taken to increase adoption of soil conservation technologies call for a multi-sectoral approach since land degradation is a complex phenomenon. Both markets for inputs and outputs need to be improved to lower the transaction costs and hence the input prices. This would allow farmers to earn remunerative returns to their labor invested in soil conservation and other technologies. This means transportation and information infrastructure need further improvement. Efforts to increase farmers' vocational education would increase the competitiveness of non-farm products, which in turn would increase their participation in non-farm activities, reducing the population pressure on land. However, non-farm activities require rural electrification and other sources of energy.

Further research is needed to understand the impact, costs and benefits of soil conservation technologies in the SWH region. It is also important to develop bio-economic models to help understand the adoptability and sustainability of the different soil conservation technologies in the SWH and other regions of Uganda.

17. COMMON PROPERTY AND COLLECTIVE ACTION IN NATURAL RESOURCE MANAGEMENT: THE CASE OF DOHO RICE SCHEME IN TORORO DISTRICT, EASTERN UGANDA

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During the past two decades, many developing countries (Uganda inclusive) have undergone policy reforms, including the decentralization of state powers from the central to local governments and the devolution of management of natural resources, such as irrigation water, from government agencies to user groups because of mismanagement by the former. Such policy changes are predicated on the notion that local users who live and work in an area have a comparative advantage over government agents in monitoring resource use and, because their livelihoods depend on the resource, they are assumed to have the greatest incentives to maintain the resource, and thus to organize and take the necessary management tasks. However, when state agencies fail to effectively perform management tasks, it cannot be assumed that farmers will necessarily be able to take over the role of managing the system, more so when the devotion policy calls for considerably more time and cash contributions from the farmers.

It is against this background that this study was undertaken to examine the extent and determinants of farmers' willingness to voluntarily contribute towards the management of the irrigation system at Doho Rice Scheme (DRS) in Tororo District, eastern Uganda, where government is in the process of transferring responsibility and control over the irrigation scheme to a farmers' association (Doho Rice Scheme Farmers' Association). The study aims at providing a better understanding of the conditions needed for successful collective action in managing DRS, which is critical for identifying what

needs to be done beyond the devolution of management from government to the farmers' association to increase farmers' participation in the collective maintenance of the irrigation system.

The objectives of the study are to characterize the current system of management (structure, function, rules and performance) of DRS and identify areas that need improvement to promote farmers' cooperation; to establish whether there is variation in the degree of cooperation across blocks and strips (administrative units) and determine the underlying block and strip level factors (administration, location, size, etc.) associated with cooperation or defection; to identify individual farmers' attributes (socio-economic, cultural, etc.) correlated with cooperation or defection and quantify the relative importance of each of these factors in influencing cooperation or defection among farmers.

The study involves a survey of 400 households that produced rice at DRS in 2001, 6 block chairmen and 25 strip leaders. The households were selected through stratified random sampling methods, using the blocks as the stratification variable. All chairmen of the 6 blocks participated in the survey, but many strip leaders were hard to find and as a result, only 25 out of more than 100 strip leaders participated in the study. Originally, the survey was planned to involve 606 households that grew rice at DRS in 2001 and 44 households that exited DRS by 2001, to collect information on why they exited and whether this was related to governance of DRS; and to understand how governance has evolved over the years and how this might have affected the condition and performance of the irrigation system. Unfortunately, it was not possible to find farmers who exited DRS, and because the interviews took much longer than expected, only 400 households that grew rice in DRS in 2001 were interviewed.

Household-level data was gathered on amount of time and money spent on collective activities; location of the household's parcel along the irrigation canal (a proxy for potential benefits from de-silting); household endowments of physical assets (farm size, land quality, livestock, savings, etc); human capital (education, agricultural training, farming experience, etc) and social capital (membership in organizations, family and ethnic relations, etc); access to off-farm income, credit, and extension services; inputs used in rice production (labor, draught power, seed, chemicals, fertilizers) and their prices; output, prices and area planted to rice and other crops; and types of soil and water conservation practices used. Because location factors were perceived to be very important in explaining cooperative or non-cooperative behavior, information on the location of strips along the main irrigation channel was geo-referenced for all participating households, using GPS equipment. It was not possible to geo-reference individual plots because some plots were flooded with water at the time of the interview and thus inaccessible.

Data entry is in progress and will be followed by analysis soon. The analysis will involve descriptive statistics to determine factors that favor the emergence of collective action at the block level; as well as econometric analysis to explain why some farmers cooperate and others don't in the collective maintenance of the irrigation system at DRS.

Despite the fact that data analysis is yet to begin, a few observations can be made based on the data gathered and entered to date. First and foremost, the existing bylaws against non-cooperative behavior are weak and poorly enforced. For example, if one fails to pay the irrigation fee of Ushs. 5000 per acre per cropping season of rice, the bylaw states that this person's land is rented out by the administration to someone else for one

season after which it reverts back to the defaulter. Besides this being a weak law, enforcement is also poor as there are reports of defaulters who have not been punished.

The fact that there is no system of controlling irrigation water reaching individual plots means that, once water is released to a block, there is no way of denying water from those who don't pay. This causes a breakdown in the incentive structure for cooperation. The condition of the irrigation system has deteriorated due to several years of mismanagement and as a result, some individual plots do receive irrigation water for all or part of the year, which also discourages voluntary contribution of the irrigation fee. Over the years, farmers have lost confidence in the DRS administration because of lack of accountability on how the collected irrigation fee is used and this may explain why some farmers are reluctant to pay this fee.

It must be emphasized that these are not conclusive results based on analysis but rather observations based on yet to be analyzed data on factors affecting collective action in DRS. Data analysis is needed to validate these observations and to draw conclusions on the determinants of successful collective action at DRS. This is the next activity for this study.

18. MOTIVATING SMALLHOLDER INVESTMENTS IN SUSTAINABLE LAND MANAGEMENT: EMERGING ROLES FOR NGOS AND CBOS IN UGANDA

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Under the Plan for Modernization of Agriculture (PMA) the government of Uganda is decentralizing many government services that have traditionally been responsible for promoting sustainable land management. One of the main goals of the PMA is that all activities related to agricultural production, agricultural processing, trading and supply of inputs, and the import/export of agricultural produce will eventually be carried out by the private sector. Because the private sector is underdeveloped in many sectors and regions, non-governmental organizations (NGOs), and community-based organizations (CBOs) are being called upon to take the lead in providing these and other services in the short to medium-term. For example, the National Agricultural Advisory Service (NAADS), one of the five central initiatives of the PMA will rely on NGOs to provide demand-driven fee-for-service extension services to smallholders within three to five years.

The objectives of this research are to characterize government programs, NGOs and CBOs in communities, and understand the determinants of their presence; to characterize and understand the determinants of household level involvement in organizations; and to consider the role that the presence of a program or organization in a community – and household level involvement in an organization – plays in the adoption of land management technologies. The analysis is based upon data from a survey of 107 communities conducted in 1999/2000, and a household level survey of 451 households conducted in 2000/2001. The random sample of communities surveyed was stratified by

agricultural potential, market access and population density. Approximately 4 households were randomly selected from within each community surveyed.

Our analysis of programs and organizations functioning at the community level between 1990 and 1999 indicates that government programs were better distributed throughout Uganda than NGOs or CBOs, and that in general government programs focused on poorer communities. Approximately half of the 107 communities in our sample had government programs, NGOs or CBOs that focused on what we refer to as the proximate causes of land degradation (i.e. provided agriculture or environment related information and services), and in general these communities were in the high potential bimodal rainfall areas (near Lake Victoria). We hypothesize that households will be more likely to adopt land management technologies where there is a program or organization focused on the proximate causes of land degradation present in their community. There are few communities in the highland areas that have a program or organization with a main focus on agriculture or the environment despite the fact that land degradation is a serious problem in these regions. Higher average numbers of agriculture and environment programs and organizations are also found in communities with good market access and relatively high population densities.

We also considered the distribution of other types of programs and organizations (i.e. those focused on alleviating population pressure; providing, improving or maintaining basic infrastructure and services (i.e. health, education, water etc.); providing credit; reducing poverty; and providing basic community services) among the communities in our sample. We hypothesize that these types of programs and organizations may indirectly affect the adoption of land management technologies. For example, if a household

receives credit from an NGO that allows it to address some immediate need, the household may be able to adopt a longer-term perspective on investments such as tree planting that lead to improved land management. We found high average numbers of programs and organizations dealing with infrastructure in the southwest highlands. In addition, programs and organizations dealing with poverty and community services were well represented in the southwest highlands. In contrast, the eastern highlands had very few communities with programs and organizations addressing poverty, and none with programs or organizations that provided community services.

The distribution of government programs, NGOs and CBOs throughout the country, as well as the current focus of NGOs and CBOs has implications for how smooth and equitable the devolution of service provision will be. The question of whether or not the government should be providing incentives for NGOs and CBOs to locate or evolve in regions of the country that are currently lacking an adequate NGO and CBO presence should be considered.

Data on household level involvement in programs and organizations revealed somewhat different trends, possibly due to differences in how community and household respondents interpreted "involvement" in programs or organizations. For example, communities often report involvement in government infrastructure projects (e.g., providing labor services in road construction), while households may interpret this as "employment" but not "involvement". In general, respondents reported very little household level involvement in government programs and only moderate levels of involvement in NGOs. For example, in the unimodal and bimodal high rainfall areas approximately 20% of households reported involvement in NGOs. At least 75% of all

households reported involvement in CBOs with the exception of the eastern highlands where less then 5% of households were involved in CBOs. Approximately 30% of households were involved in organizations focused on agriculture and the environment. We found that households reported very high levels of involvement in credit and community service oriented NGOs and CBOs, particularly in the southwest highlands.

Econometric analysis of the determinants of household level involvement in NGOs and CBOs indicated that female headed households and households with higher numbers of female members were more likely to be involved in organizations. We also found that social capital was an important indicator of household level involvement in organizations – if the household head was a member of a dominant ethnic group, or if the spouse of the household head was born in the village – involvement in an organization was more likely. Additionally, smaller land holdings were associated with involvement in agriculture or environment related organizations.

In the context of household involvement in community service oriented organizations, we can consider this involvement a proxy for strong social capital. It is likely that much of the technology transfer that is taking place may be occurring through these institutionalized social networks. However, we note that the community may not be in all cases the appropriate unit of observation to understand social networks that promote the exchange of information. It may be that information on technologies is being exchanged across communities according to family networks, inter-community networks or groups, or other units of social organization. More research is needed to understand the sociological aspects of technology diffusion as it relates to the adoption of land management technologies.

In general communities *perceived* that programs and organizations focused on agriculture and the environment were having a positive impact on land management, crop production, and livestock production. To validate these perceptions we used a two-stage probit model to explore whether or not the presence of an organization in a community and/or household level involvement in an organization was related to the adoption of various land management technologies in 2000. Our results indicate that presence of an agriculture or environment focused program or organization in the community had a positive effect on the adoption of only one of the five technologies we considered. Also, we found that household involvement in agriculture or environment focused organizations had a negative effect for one of the technologies we considered. These findings are of limited encouragement regarding the effect of agriculture or environment focused programs and organizations being present in a community, and/or household level involvement in such a program.

A possible explanation for our weak results regarding the effect of agriculture/environment focused programs and organizations on the adoption of land management technologies is that smallholders may be receiving training on land management, but may not actually be adopting the promoted technologies. This may be due to the limited profitability of investing in some land management technologies. If it is determined that agriculture and environment related NGOs and CBOs are having little impact on the actual adoption of land management technologies, there may be a need to evaluate the role and effectiveness of these organizations, as well as the relative profitability of the technologies they promote.

More promising are our findings on the effect of household involvement in credit, poverty alleviation, and in some cases community service oriented organizations on the adoption of land management technologies in 2000. The impact of household involvement in credit related organizations in particular appears to offer promising opportunities for improving land management. Our findings clearly indicate that community-based credit organizations should be promoted as a means for improving the adoption of land management technologies. However, we emphasize that linkages between programs and organizations focused on credit, poverty alleviation and other activities that are not directly related to land management, and the adoption of land management technologies is indirect and likely related to the alleviation of immediate stresses that households face, and/or the building of social networks that facilitate the transfer of information on technology adoption.

19. SOIL ORGANIC MATTER AND ITS RELATIONSHIP TO SOIL FERTILITY CHANGES IN UGANDA

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Soil resources studies in Uganda have indicated that most of the soils are old and highly weathered with little mineral reserves, hence soil organic matter (SOM) is very important as a source of nutrients and to maintain good soil physical properties. As a result SOM is used as the best indicator of soil productivity.

In the 1960's, 1700 field trials were conducted at 62 centers covering the entire country. The results indicated that SOM level was more closely related to soil texture, particularly the clay and silt content, than other parameters like rainfall or farming systems. It was found that where silt plus clay was greater than 26%, the SOM ranged from 3% to 7%, while where silt plus clay was less than 26%, the SOM range was 1% to 3%. It was also found that SOM was closely related to major parameters of soil fertility, namely, indices of crop nutrient reserves, soil pH, and cation exchange capacity (CEC). There was little response to fertilizer application if SOM was greater than 3.5%. This recommendation is still in use.

Subsequent studies indicated that SOM decreases during the cropping phase, that SOM was higher following a good fallow period, and that application of inputs (organic and inorganic) during cropping phase help maintain SOM at higher levels compared to no application. Green manures had little effect on SOM levels. A number of recent samples of points/plots around the country have indicated that soil fertility is declining; however, there has not been a systematic survey to indicate what has happened with time.

As part of the Policies for Improved Land Management Project in Uganda, it was decided to revisit sites that were used in the 1960's studies to evaluate what has happened. Although sites were not geo-referenced in the 1960's, it was possible to identify most of them based on field records found at Kawanda Agricultural Research Institute (KARI). Seven centers with 139 fields representing light (where clay plus silt was less than 26%) and heavier (where clay plus silt was greater than 26%) soils were selected.

Fields were located by interviewing extension officers, chiefs and farmers. Identified sites were geo-referenced and soil samples taken and analyzed. Analysis was carried out at KARI where the 1960's analyses were done and where the same analytical methods are still being used. According to the farmers interviewed most of the fields have not been rested since the 1960's and it was observed that fields found under fallow were in a poor state and appeared to be abandoned rather than a deliberate fallow.

Laboratory analysis indicated that SOM distribution still depended on texture and that the magnitude of SOM had not significantly changed. However in many cases soil pH, extractable phosphorus (P), calcium (Ca), and potassium (K) were below critical levels despite the little change in SOM. In some cases P, Ca and K levels in the topsoil were 20% to 70% of the levels found in the 1960's.

The implications of these findings are that under continuous cultivation, nutrients in the topsoil are decreasing and soils are becoming more acidic. Under prolonged continuous cultivation conditions total SOM level may not be enough to indicate soil fertility status, hence there is a need to identify a better indicator.

To arrest the land degradation process, appropriate soil and water conservation methods need to be used to reduce nutrient losses through erosion. External inputs will also

be required to reverse nutrient depletion and acidification trends. Where nutrients are leached rotating-shallow rooted crops with deep-rooted crops/grasses or agroforestry species should be encouraged to increase recycling of leached nutrients and reverse acidification trends.

Policy challenges/implications

For continuously cultivated soils inputs are necessary to reduce degradation and nutrient imbalances due to losses through erosion and nutrient exports. Although the fertilizer market in Uganda is liberalized and there is no tax on fertilizers, the fertilizer market is not developed. Some of the major reasons for the underdeveloped fertilizer markets are lack of credit for input traders and farmers, inadequate research and extension services and information dissemination mechanisms. This suggests a need to facilitate availability of credit for both input traders and farmers. It is also critical to increase efforts that would ensure that production technology and market information is available and accessible to both farmers and agricultural traders. This calls for efforts to improve the extension delivery mechanism in order to increase the farmer-extension contact and quality of extension messages. Policy makers also need to be sensitized to understand the long-term effects of land degradation such that they will design pragmatic policies to address the declining soil fertility. Training of fertilizer traders is poor or non-existent. Hence fertilizer traders are not able to advise farmers on the proper fertilizer that suits their crops and addresses their soil fertility problem. There are different fertilizer products for different crops/situations/times. The fertilizer traders should be able to stock the appropriate product and assist customers (farmers) to purchase the most suitable product. However, for this to happen, fertilizer traders need to be trained on basic crop agronomy and soil fertility

problems in the area they conduct business. For other inputs (e.g. pesticides and herbicides) that have trademarks the manufacturers train their agrochemical traders. There is no such arrangement for fertilizer.

There should be efforts to find markets and to stabilize farm-gate producer prices. Where producer prices are low or fluctuate, farming may not be profitable enough to encourage farmers to invest in proper land management (soil and water conservation, use of inputs to replace nutrient losses or improve soil conditions, e.g. increasing soil pH through liming, long term strategies to increase SOM, etc.).

20. DETERMINANTS OF NUTRIENT BALANCES IN MAIZE PLOTS IN EASTERN UGANDA

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Many studies have observed that soil erosion and soil nutrient mining are the leading causes of land degradation in Uganda. Declining crop yield has manifested the impact of land degradation. Consequently per capita food production in Uganda has been falling in the past 16 years, despite the expanding crop acreage.

Soil fertility mining in Uganda is among the highest in Sub-Saharan Africa (SSA), with an estimated average annual rate of nutrient depletion of 70 kg. of nitrogen, phosphorus and potassium (NPK). This is because less than 10% of farmers apply inorganic fertilizer, at an average rate of 1 kg NPK/ha. This is among the lowest fertilizer rates in SSA; where the average fertilizer application is 13 kg. NPK/ha. The effect of the consequent soil fertility mining is a downward spiral of soil fertility, which makes the current low-external input crop production unsustainable. This study investigates the nutrient balances of 58 households in eastern Uganda. The study identifies and analyses the socio-economic determinants of nutrient balances of maize plots.

The 58 households were selected from four villages, namely; Nemba/ Kasheshe, Agonyo II, Odwarat and Kongta in Sironko, Soroti, Kumi and Kapchorwa districts respectively. The sites are located along a transect which captures variability in soil productivity, land use intensity and agricultural potential. The altitude ranges from 1060 meters above sea level (m.a.s.l.) for Odwarat to 1890m for Kongta. The rainfall is of a

bimodal pattern with an annual mean total above 2000 mm. at Kongta, 1850 mm. at Kasheshe/ Nemba, 1350 mm. for Agonyo II and 1310 mm. Odwarat sites. Rainfall is much more reliable at Kongta and Nemba/Kasheshe. The farmers' fields were characterized using soil chemical and physical characteristics obtained from soil samples collected from the 0-20 cm depth. The pH, organic matter, extractable P, extractable K and Calcium plus texture were obtained using the routine soil sample lab analytical method.

The nutrient inflows and outflows were determined for each plot and the nutrient balance at household level was calculated. The nutrient inflows were mineral fertilizers, organic inputs from outside the farm, animal feeds and concentrates, external grazing, purchased food, atmospheric deposition, biologically fixed nitrogen, and sedimentation. The outflows were crop and animal products sold or given away; crop and animal residues/waste sold or given away; leaching of nutrients below root zone gaseous losses from soil, and soil erosion. The atmospheric deposition, fixed nitrogen and sedimentation were calculated. The other nutrient flow and socio-economic data were obtained from household and plot surveys conducted in 2000/2001.

The results show that only 5% of households had positive total NPK balances, with N and K being the most deficient nutrients. N had the lowest percent of households having positive balances. P had the highest percentage of farmers with positive balances and the smallest mean negative balance. If inorganic fertilizers were used to replace the negative balances, the total value of mined nutrients would be 18% of household income, which is estimated to be US$793/household per year. This underscores the heavy reliance of subsistence cereal farmers on soil fertility mining to provide for their subsistence in eastern Uganda.

Human and financial capital, technical assistance and distance from plot to markets and to residence are important determinants of nutrient balances. Household income increased significantly the nutrient balances of nitrogen (N), phosphorus (P), potassium (K) and total NPK. An indicator of wealth (roofing material) also increased the balance for N and P. This implies that wealthier farmers are likely to buy mineral fertilizer to replenish the outflows. Contrary to expectations, however, access to credit had a negative impact on nutrient balance of nitrogen and phosphorus. Given the fungibility of money, borrowed money is not necessarily used to purchase fertilizer or other inputs. The results suggest that the borrowed money is used for activities that lead to more nutrient mining (e.g., purchase of improved seeds, financing of commercialization of agricultural production).

As expected, distance from plot to residence has a negative impact on nutrient balances. This is due to the cost involved in transporting animal manure and other household refuse to distant plots. Plots around the homestead benefit from household refuse thrown regularly after cleaning home or animal confinement structures. This observation is supported by the positive effect of tropical livestock units (TLU), which increases significantly the balances for N, P, K and NPK. The results suggest that farmers with more livestock are likely to apply animal manure to their plots and hence improve the nutrient balances.

Extension services first show a negative impact on nutrient balances at low levels of contact with farmers. However, as number of contact hours increase, the impact of extension contact hours on nutrient balances becomes positive. This is perhaps due to farmers' behavior of stepwise adoption of technologies. At fewer extension contact hours, farmers are likely to adopt improved maize varieties without fertilizer. This increases the

nutrient depletion. At a higher level of contact hours, farmers are likely to adopt use of both improved seed and inorganic fertilizer. This leads to the observed U-shaped curve depicting the relationship between extension contact hours and N and NPK balances.

Education of household head and spouse shows a negative relationship with nutrient balances. This appears to be consistent with another study that has shown that education increases farmers' opportunities to be engaged in other non-farm activities. Such options may reduce farmers' incentive to invest in crop production. The age of household head also shows a negative relationship with nutrient. This may be explained by the resistance of older farmers to adopt new technologies like use of inorganic fertilizers.

The policy implication of these findings is that farmers may not be applying fertilizer because they cannot afford to buy the input. Restoring the negative nutrient balances would cost US$140/hh/year, which is beyond the reach of most farmers. This suggests the need for increasing availability of credit to farmers. However, credit offered in cash may not be effective because of its fungibility, unless fertilizer use is clearly seen by farmers to be profitable. A need to reduce the price of fertilizer is also implied by our results. Strategies of reducing fertilizer prices include improvement of marketing infrastructure through building and maintaining roads in order to reduce the transportation costs, facilitating input traders by training and offering them credit, waiving some of the taxes levied on input trading businesses, etc. There is also a need to increase the trade relationship between the Ugandan and Kenyan input traders to benefit from the economies of scale of the larger Kenyan fertilizer market. The ongoing custom union negotiation among the three member countries of the newly revived East African Community is the right direction towards realizing this. Farmer associations may also help reduce the

transaction costs of inputs and outputs. Deliberate efforts are needed to revive farmer cooperative unions and associations.

Emphasis of extension services should also be directed to both new crop varieties and the fertility problem. Less contact extension hours are likely to lead farmers to adopt high-yielding varieties without fertilizer. This is likely to exacerbate the nutrient mining problem.

21. THE POTENTIAL BENEFIT OF VELVET BEAN (*MUCUNA PRURIENS*) AND N FERTILISERS IN MAIZE PRODUCTION ON CONTRASTING SOILS IN UGANDA

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Per capita agricultural production and crop yields in Uganda, like other Sub Saharan African (SSA) countries, is declining. The main contributing biophysical factors are nutrient/soil fertility depletion, low soil fertility (particularly N and P deficiencies), cultivation of marginal land and continuous cropping. In addition, loss of nutrients as components of crop harvests through runoff and soil erosion is on the increase for most of the farming systems. All of these have contributed to the negative nutrient balances reported for SSA countries and for the farming systems of eastern and central Uganda. One of the limiting factors that leads farmers to use low or no external inputs is lack of financial capital. Smallholder farmers use low-input production technologies without appropriate soil and water management practices. Equally there are constraints limiting the use of on-farm inputs such as organic materials. In the case of green manure or in-situ biomass production farmers have to sacrifice land and have to invest labor, both of which lead to competition with other farm activities that require the same inputs.

Little is known about the economics of green manure when used in combination with other sources of nutrients. The objective of the study was to assess the most suitable strategy for soil fertility maintenance for resource poor farmers in Eastern Uganda cultivating soils of different fertility status. The N replenishment strategies investigated in this study include (1) the exploitation of biological nitrogen fixation (BNF) through the use of Velvet

bean (*Mucuna pruriens*) in relay rotation (2) use of *mucuna* as an improved fallow and (3) inorganic fertilizers.

On-farm research was conducted with 58 randomly selected farmers at four sites in Eastern Uganda namely; Nemba/Kasheshe, Agonyo II, Odwarat and Kongta in Sironko, Soroti, Kumi and Kapchorwa districts respectively. The sites are located along a transect which captures variability in soil productivity, land use intensity and agricultural potential. The farmers' fields were characterised through analysis of a composite soil sample collected from the 0-20 cm depth for pH, organic matter, extractable P, exchangeable K and Ca and texture using routine methods. The four sites were divided into two groups using soil productivity and rainfall reliability. Kongta and Kasheshe/Nemba were considered together as representing highly productive areas while Odwarat and Agonyo II were considered as representing less productive areas.

Mucuna biomass production was not significantly different ($p<5\%$) at Odwarat, Agonyo II, Kasheshe and Nemba sites, but was significantly less at the higher altitude of Kongta. *Mucuna* accumulated 192, 169, 204 and 77 kg N/ha at Agonyo II, Odwarat, Nemba/Kasheshe and Kongta respectively. It is estimated that 42% of the N was derived from the atmosphere.

Farmers' fields at each site were grouped into low and high productivity using the maize grain yield from the farmer practice (control plot). Significant ($P=0.001$) difference in maize yield between the two farmer groups was attributed to differences in soil properties at Kongta and Kasheshe/Nemba. For Odwarat, the significant ($P=0.001$) difference was attributed to the number of seasons the field has been under cultivation. There was a significant response ($p > 5\%$) by maize to the application of inorganic

fertilizers and a preceding *mucuna* fallow or relay. However, increasing the inorganic N level from 40 to 80 kg N/ha did not further increase maize yield significantly. The "partial budget" indicated that higher economic benefits were obtained from the alternative N replenishment strategies on highly productive soils.

Conclusions and policy recommendations

Mucuna has potential to accumulate a large amount of biomass and N from the atmosphere, which is of great importance in agriculture of the smallholder farmers in Uganda. *Mucuna* and inorganic N fertilizers have the potential of increasing maize yield in soils of contrasting productivity. The magnitude of yield response and the economic benefits depends on the level of soil fertility. Economic returns are better with low levels of inorganic N fertilizers and *mucun*a relay. Higher economic benefits are obtained with the different strategies on the more productive soils. However, on less productive soils, economic benefits are lower when the fertility levels have gone down. In such areas, farmers derive more benefit by not investing in any N replenishment strategy. Though this may be a strategy for survival, the sustainability of the system is lacking so that long-term survival remains threatened.

The results of this study have shown that in the current situation of limited resources, it is better to invest the resources for soil fertility replenishment in areas with productive soils because of more economic benefits. However, soil fertility replenishment in less productive areas could help to ensure food security.

22. MODELLING APPROACH TO IDENTIFY SUSTAINABLE LAND MANAGEMENT TECHNIQUES ON EROSION-AFFECTED SLOPES

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The prevention of soil erosion is one of the most essential requirements for sustainable agriculture in developing countries. In Uganda, soil erosion is widely recognized as one of major causes of land degradation. Topography is one of the most important contributing factors to soil erosion. Different parts of the landscape experience different intensity of erosion processes. Such spatial variation of erosion processes may directly or indirectly be related to soil property changes, which again influence subsequent erosion processes. Therefore it is important to consider the impact of reciprocal relationships between soils and topographic positions along the slope.

Given the variability of soils within a landscape, it is necessary to adjust land management methods to these particular conditions on the hillslope. However, quantitative investigations dealing with reciprocal relationships between soil-landscape position and land management options are limited. This research quantifies the influence of different land management on a hillslope by applying a deterministic soil erosion model. The research combines the catenary concept by considering spatial variability of soils along the slope with farmers' awareness of their soils in order to develop site-specific land management strategies.

The study area is Magada village, which is located in the Lake Victoria Basin (4°59`N, 33°51`E, 1160m above sea level). Rainfed cultivation is the basis for agricultural production of diverse food crops. Although average slope gradient is approximately 3-5%,

the gently rolling landscape is affected by moderate to severe erosion due to intensive cultivation. The soils of the research site are classified as Oxisols (USDA Soil Taxonomy) or Ferralsols (FAO-classification). Soils generally have a sandy clay loam to sandy clay texture. Hydromorphic soils can be found in valleys. Most of the soils contain plinthites in their subsoil.

The soil erosion model "Water Erosion Prediction Project" (WEPP) was applied to evaluate the effect of land management methods on soil erosion. The physically based model WEPP simulates the influence of climate, slope, soil, and land management on soil loss and runoff along the hillslope. The climatic data for the stochastic Climate Generator (CLIGEN) were obtained from the meteorological station in Jinja over a period of 10 years. Topographical data for the slope profile were obtained from a differential Global Positioning System based on a 20m x 20m grid. Soil samples were taken to analyse soil texture, rock fragments, organic matter content and cation exchange capacity for each soil horizon of seven profiles surveyed along a slope transect. Input data for land management were collected from a household survey. Crop parameters, which characterize the crop response to different management and physical conditions, were calculated using transfer functions. Maize, variety Longe 1, was assumed to be the dominant food crop on the hillslope. Two cultivation periods a year were simulated to fit the bimodal rainfall pattern of the site. The standard tillage at the research site was minimum tillage using a handhoe.

The model was validated by comparing simulated soil loss versus measured soil loss values obtained from previous erosion studies under similar environmental conditions. A radionuclide technique (Cs-137 and Pb-210) was used to assess the performance of WEPP to simulate soil erosion at the research site. Four different land management

methods including minimum tillage by handhoe, residue management, contouring and high tech tillage by chisel plough were used to assess soil loss simulated by WEPP.

Results indicate a catenary sequence of soils exists along the hillslope and a participatory hillslope mapping proved that farmers distinguish such natural units of soil property change by their experience. One discrepancy is that farmers did not recognized erosion features at the shoulder position, which are mainly caused by soil creep and tillage erosion. This indicates that farmers are more perceptive towards water erosion than other erosion processes. In general farmers' perceptions can be combined with scientific approaches in order to rapidly delineate appropriate hillslope units.

WEPP simulation showed average soil loss rates of 2 t/ha for the hillslope under a minimum tillage condition. This value was in the range of soil loss recorded by erosion plot studies for Uganda. Erosion plot studies, however, cover only a small part of the hillslope and may not be able to take spatially variable erosion and deposition into account. The modelling approach represents a first step to overcome these spatial limitations and considers soil loss and sedimentation as spatially distributed along the hillslope.

To simulate the influence of different soil types on erosion, the hillslope was divided into seven soil-landscape units: summit, upper shoulder, lower shoulder, upper backslope, lower backslope, footslope and valley. The delineation was based on individual hillslope conditions including topography and soil types. Soil loss varies highly between these landscape units. The upper shoulder position shows lower soil loss (of 2-3 t/ha) than the summit position. The limited extent of the upslope contributing area at this position may be the reason for the reduced soil loss. Relatively high soil loss rates of up to 9 t/ha occur at the lower backslope position. This hillslope unit is characterized by a relative high

slope gradient of 4-6% where active erosion processes occur. The presence of impermeable plinthite-rich B-horizon at shallow depth may further increase surface runoff at this slope position. On the other hand active deposition occurs at those valley positions where slope gradient decreases and hydraulic conductivity increases due to coarse soil texture.

These significant changes in soil loss rates along the hillslope confirm that each hillslope unit respond differently to soil erosion and sedimentation processes. When soil loss rates are averaged over the entire hillslope without appropriate consideration of soil variations, the estimated erosion rate will result in incorrect conclusions. Specific soil-landscapes with significant changes in slope or soil properties should be integrated in modelling approaches to reflect areas with high soil erosion risk along the slope.

To illustrate the impact of different management practices on soil loss four land management scenarios were modelled: minimum tillage, residue management, contouring and high tech tillage. Minimum tillage by handhoe was characterized by low disturbance of soil as practiced by local farmers, whereas high tech tillage by chisel plough represents high soil disturbance. Residue management was applied when crop residue, primarily stems and leaves, were left in the field or added to the field to function as additional soil cover and biomass source. Contouring involved ploughing parallel to contour lines of the slope, which decreases downslope erosion compared with ploughing up and down the slope.

Annual soil loss rates averaged over the entire hillslope are 2 t/ha for minimum tillage, 0.3 t/ha for residue management, 1.9 t/ha for contouring and 47 t/ha for high tech tillage. This indicates that soil conservation methods, such as residue management and contouring, reduce soil loss rates compared to minimum tillage and high tech tillage. Even

though the difference in average soil loss is less than 2t/ha between minimum tillage and tillage with residue management, it becomes larger –up to 4 t/ha – when comparing soil loss for individual soil-landscape units. For steeper slopes at the backslope position soil loss was simulated to be approximately 6 t/ha under minimum tillage, but less than 2 t/ha for residue management conditions.

To illustrate the impact of soil-landscape positions on soil loss under alternative management methods, fractional changes were calculated by comparing soil loss rates under standard tillage conditions on the hillslope (minimum tillage) and soil loss rates when applying conservation tillage (residue management and contouring). In general, residues can reduce the rate of soil loss along the hillslope by up to 70%, whereas high tech tillage increases the rate of soil loss by 200 to 1500%. Soil erosion along the hillslope differs significantly with topography and land management. Residue management for example may reduce the rate of soil loss by almost 70% when applied on a steeper footslope position, but may reduce the rate of soil loss by only 40% when implemented at shoulder positions. This confirms that the rate of soil loss is dependent on the individual soil-landscape units and specific management method.

Land management practices should be adjusted to the requirements and conditions of the specific soil-landscape unit as soil and slope gradients vary along the profile. For example it is more effective to implement soil conservation methods such as residue management on steeper slope sections where a soil loss rate of 6 t/ha for standard tillage conditions can be reduced by up to 70% to less than 2 t/ha, than on flat summit position where simulated soil loss rates changes by less than 20% (1 t/ha) between standard and residue management systems. Residue management might be the most appropriate method

to reduce soil loss on shoulder and steeper slope positions along the hillslope. Despite the technical advantage, a socio-economic analysis should be done to analyse costs and benefits of residue management. A new land use optimisation procedure to reduce the erosion and also to increase farmers' income is currently under investigation.

This research draws three policy implications for sustainable land management in developing countries. Firstly, future agriculture projects may require more detailed research on soils' spatial variability on a hillslope scale. As spatial variability has a significant influence on simulated soil loss, various soil-landscape units should be considered in any decision support system. Such a decision-support system may be used to determine which part of the hillslope is most affected by soil erosion problems and at which hillslope unit improved land management methods should be implemented to reduce soil erosion and maintain soil fertility.

Secondly, farmers are highly aware of soil erosion problems on their fields and conscious of natural changes of soils on a hillslope. As shown by the participatory mapping approach, the zonal distribution of soil types and soil erosion/sedimentation features mapped by farmers correspond to the catenary sequence of soils identified by a soil survey, which indicates that farmers' perception of soil matches those of scientists. The participatory community resource mapping, in which farmers help researchers to draw community resource maps, may be used as an effective tool to identify natural resource constraints. Integrating the farmers' local knowledge into scientific soil investigations might be the most cost effective way to identify the spatial variability of soils.

Finally, researchers and local extension workers should strengthen farmers' awareness of the spatial variability of soils over the landscape, and encourage them to understand that the processes along the slope are interrelated. The integration of technical knowledge of extension workers and/or researchers on one side and local knowledge of farmers on the other side may be a fundamental base for adequate, dynamic and sustainable land management. Furthermore, incorporating farmers' knowledge will encourage farmers' participation in newly developed land use options.

23. TECHNOLOGIES FOR IMPROVED LIVELIHOOD IN SOUTHWESTERN UGANDA

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Based on combinations of population density, agroecological conditions and access to markets, agricultural intensification appears to be the most promising development pathway for Kisoro, Kabale, Kanungu, Rukungiri, Ntungamo, Bushenyi and Kasese districts in Southwestern (SW) Uganda. However, sustainable resource management must be integrated into production systems in order for beneficial changes to take place. Furthermore, farmers need concrete examples and incentives to increase their productivity through intensification of the land use system. This requires viewing food, cash and export crops holistically, from production, value-addition, processing to marketing. Prior to intensification in SW Uganda, information is critical on the following questions: What are the commodities suitable for intensification in the southwest? Where are they most suitable in the southwest? How can they be identified?

Consequently, the objective of this study is to develop and test a methodology to identify potential win-win (income/food – environmental goods) technologies and to apply it to the SW Uganda, which has been identified as a priority area by the United States Agency for International Development (USAID) strategic objective 7 (SO7). The framework that was developed to evaluate win-win technologies encompassed the following: One is the criterion pertaining to technology's effects on key objectives of farmers and society and another involves assessment of current and potential status of the

technology in the SW region and prospects for scaling up the adoption of the technology. Further assessments were based on whether the technology addressed environmental concerns, livelihood impact, equity, and needed institutional support. The aim was to establish the actual or potential effect of various technologies on improved livelihoods of people living in SW Uganda while conserving or enhancing the environment.

To generate an inventory of agricultural technologies suitable for SW Uganda, the team used:

- Available literature and reports;
- Discussions with specialists on various commodities;
- Own knowledge and experience from work in SW Uganda;
- Farmers and extension workers views, and discussions with local leaders and departmental heads.

The intensity of agricultural extension activities varies across the various zones. While Kabale and Kisoro districts have large numbers of non-governmental organizations (NGOs) supporting extension, in other districts such support hardly exists. Currently, the main concerns of farmers and leaders are limited income opportunities, decrease in soil fertility and high rates of runoff and erosion. The latter also leads to serious flooding at the valley bottoms. Much of the fertile topsoil has been lost and replenishment of soil nutrients leaving the field through the harvested products is only taking place through limited organic inputs in some fields of the farms. Very few farmers use fertilizer in SW Uganda, but this is characteristic of the whole of Uganda.

Various mitigation measures are implemented by farmers' own initiative or stimulated by formal extension services and NGOs. The measures taken to conserve soil and water are usually limited to 'pilot areas' and often fragmented efforts based on actions by individual farmers. Given the high fragmentation of land, the length, and the slope of the land, these individual efforts only have limited success. However, a positive example of a local government-driven watershed management was observed in Kabale District. Results from the survey indicate that a few examples of successful adoption of improved technologies were found in the 7 districts studied. Much of the farming practice is based on technologies that have been available for over 30 years. The few successful adoptions relate to:

- Contract farming, e.g. cotton or tea, where the contracting enterprise determines and often provides (on credit) all the inputs and where inputs are given out free, e.g. seedlings of clonal coffee;
- Farmers clearly see the superior attributes after intensive extension efforts;
- Response to disasters, i.e. where local governments have initiated soil conservation initiatives after land slides; or replacing bush beans which are severely affected by root rot with climbing beans tolerant to that disease.

The major factors that influence uptake of technologies are low and fluctuating prices which render investment in agriculture unprofitable, limited market access, low quality of crops such as tea or passion fruits due to poor plant protection or other production technologies, lack of processing and value addition, limited input availability, poverty, and limited access to extension services. Another factor hampering adoption of

some production technologies is the fact that many interventions in natural resources management require community action and agreements, which need time and local support to be accepted.

Based on these factors, economic returns to inputs under smallholder farmer conditions should form the basis for appropriate recommendations. Furthermore, intensification of agricultural production in SW Uganda could be based on comparative advantages of the region. The key elements of the comparative advantage are:

- Farmers' and leaders' willingness to intensify given the high population density and the vulnerable environment;
- Reasonable market access in most areas;
- Cool climate as a niche;
- Relatively plentiful labor;
- Cash enterprises are already integrated into parts of the farming systems.

Some important policy implications related to this work could include the need to support marketing, processing and value addition for some commodities identified for intensification; strengthen decentralization of agricultural research and development centers; provide support for improved infrastructure; increase availability of credit to allow farmers improve on quality and quantities of agricultural products; and improve the quality and timeliness of extension messages and availability of technologies from research centers that are situated mainly near Kampala.

24. LAND MANAGEMENT AND TECHNOLOGY ADOPTION IN UGANDA: AN INTEGRATED BIO-ECONOMIC MODELING APPROACH

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Although Uganda's economy has been growing at an annual average of 6% over the past few years, the productivity in the agricultural sector has either stagnated or declined. Land degradation is generally assumed to be a major factor contributing to declining agricultural productivity, poverty and food insecurity. Recent studies in eastern and central Uganda have revealed high negative nutrient balances for most of the cropping systems.

The proximate causes of land degradation – e.g. very low use of inorganic and organic fertilizers, declining fallow periods, deforestation, crop production on steep slopes with limited investments in terraces or other conservation measures – are relatively well known, but the core of the land degradation problem is of economic nature. Poverty and imperfect market conditions induce many farm households to adopt livelihood strategies that contribute to nutrient depletion. Additional labor and land constraints are limiting households' ability to invest in land improvements. It is therefore an important and difficult task to design public policies that make these technologies affordable and adoptable, especially for the poor farmers.

The objective of this study is to examine the key economic factors that affect land management decisions in the context of soil fertility management and resource constraints. Specifically, the study:

1. Identifies the most binding factors affecting land use practices and adoption of new technologies (e.g. labor shortages, capital constraints, imperfect capital markets, distorted input and output prices, transaction and information costs).
2. Explores the feasibility of land management practices leading to non-negative nutrient balances from the farm households' point of view.
3. Explores the incentives of policy and institutional interventions mentioned as priority areas in the Plan for Modernization of Agriculture (PMA) (e.g. development of local credit markets, promotion of improved technologies, labor exchange institutions) for the decision making of farm households.

The data used in this study were collected from two villages in Iganga, which were representing a program induced development pathway with high market access, high agricultural potential and high population density.[1] Approximately 7% of the households were collaborating in agricultural technology trials conducted by CIAT (International Center for Tropical Agriculture) and Africa 2000 Network (A2N). Principal component analysis and a subsequent cluster analysis were used to identify the following four representative household types: subsistence farm households (30%), semi-subsistence farm households (52%), commercial farm households (10%) and trial farm households (7%). Out of each group, households closest to the cluster centroid were selected for the second round of the household survey, in which the following data were collected: biophysical data at plot level, detailed input-output coefficients, data on income and expenditure, and data on factor acquisition and disposition.

[1] The International Food Policy Research Institute (IFPRI) and the Center for Development Research (ZEF) identified the predominant development domains in Uganda. Three factors were used for the stratification: agricultural potential, market access, and population density. Each development domain has a unique combination of these factors that give it a comparative advantage, or lack of it, that influence the communities to follow a development pathway (common pattern of change in livelihood strategy) taking advantage of its comparative advantage.

A bio-economic model was used to study the optimal level of technology adoption and the impact on incomes and natural resource conditions under a changing socio-economic environment. Bio-economic models combine socio-economic factors influencing farmers' objectives and constraints with biophysical factors affecting production possibilities and the impacts of land management practices. These models may identify the optimal level of technology adoption and the impact on incomes and natural resource conditions under a changing socio-economic environment. Implemented as multi-agent systems outcomes from agent-agent and agent-environment interactions could be captured as well, e.g. diffusion of innovations together with the evolution of farm incomes and natural resource conditions over time.

The bio-economic modeling approach chosen for this study consists of three major components: mathematical programming models at farm household level to reflect the decision-making processes under different constraints, artificial neural networks (ANN) as a yield estimator, and nutrient balances as a sustainability indicator. The farm household decision-making problem is captured through mixed-integer linear programming consisting of 507 variables and 201 constraints. The results of the yield estimator and computations of nutrient balances are incorporated into the comparative-static programming model.

Using simulation techniques, we tested whether or not farmers could profitably produce using practices that result in non-negative nutrient balances. In the first simulations we tested whether under current constraints the adoption of ecologically sustainable farming practices is financially and technically feasible. For each representative household we ran several scenarios taking into account the given resource

endowments, financial and technical coefficients, and searched for land management practices that lead to non-negative nutrient balances. Our findings showed that only the commercial farm household could realize non-negative nutrient balances when the binding capital constraint was relaxed through provision of credit. For the other farm household types the priority of satisfying the food requirements of its members prevents achieving non-negative nutrient balances. The second scenario that we simulated included the changing socio-economic environment implied by the priority action areas of the PMA. Specifically the changes introduced were introduction of credit and more favorable prices for farm outputs and inputs.

We then tested from a normative point of view whether certain technological innovations in combination with changing conditions of the socio-economic environment would have the potential to improve the negative nutrient balances substantially. Under current market conditions, none of the household types could profitably apply any of the promoted fertilizers, besides rock-phosphate. Input prices would have to decrease or output prices increase substantially and credit would have to be provided to the farm households in order to adopt these innovations profitably. An exception is the trial farm household who could profitably adopt NP-fertilizer without the provision of credit, but only on a very small piece of land (0.02 ha). In general, output prices would have to increase by 50 % and input costs of fertilizers to decrease by 70-80 % to induce a profitable adoption of NP and NPK. Relaxing the seasonal labor shortages in addition could in some cases lead to a significant increase of NPK adoption. Labor exchange within the village – as a form of labor acquisition – would allow the semi-subsistence farm household, for example, to profitably expand the adoption of NPK-fertilizer from 0.27 ha to 1.29 ha and increase farm

total gross margin per year from the baseline scenario of 1.49 Million Uganda Shilling (USh). The application of NPK fertilizer would also lead to a substantial improvement of nutrient balances. In the baseline scenario, the semi-subsistence household, for example, has a balance of -52 kg/ha of N, -12 kg/ha of P and –62 kg/ha of K. In the scenario with improved output price coupled with a decrease of input prices, available credit and labor exchange it has a balance of +16 kg/ha of N, +76 kg/ha of P and -1 kg/ha of K.

The findings of this research reveal that substantial improvements of the market environment in eastern Uganda are needed to give farmers sufficient incentives to adopt more sustainable land management practices. However, the market environment in Iganga, as in many parts of Uganda, is characterized by high transaction and transportation costs. This leads to low output prices coupled with high input prices. One essential step to increasing output prices and reducing input prices is to reduce transaction costs through building an efficient transport infrastructure and improving market information collection and dissemination.

The low volume of fertilizer imported in Uganda also appears to increase the transaction cost of fertilizer trading in the country. This suggests the need for input traders to form partnerships with traders in Kenya in order to take advantage of the economies of scale from the Kenyan larger fertilizer import volume. This requires the political will to adopt a customs union through the East African economic bloc, which will facilitate the trade relationship between the Kenyan and Ugandan traders.

25. MODELING POLICY IMPACTS USING AN AGRICULTURE-FOCUSED CGE MODEL

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International Food Policy Research Institute

As part of the USAID-supported project "Strategic Land Use Options," IFPRI is developing an agriculture-focused Computable General Equilibrium (CGE) model of Uganda.[2] The model will be used to analyze the consequences of agricultural technological change and infrastructure development. The purpose of this presentation is to provide a brief overview of this activity and its methodology, and to discuss potential future activities in this area.

In outline, I will provide a general description of CGE models, an overview of IFPRI's Standard CGE Model and its data requirements, and then finally describe the CGE model of Uganda and its database (both of which are currently being developed).

Formal models of the CGE type are often used in policy analysis given the need for quantitative information and the complexity of the links between policies and outcomes.[3] Since the first CGE models for developing countries were constructed in the mid 1970s, this class of models has become widely applied to policy analysis. They can be used to analyze a wide range of "shocks" (in policies and other exogenous conditions) including changes in taxes and subsidies (domestic or trade-related), technology, and world market conditions. The economy wide perspective that they provide is indispensable in analyses of: (i) changes affecting one sector if the feedback effects are large, making partial

[2] The key researchers in this activity are Paul Dorosh and Hans Lofgren
[3] Under the alternative "before-after" approach (which does not use a formal model), it is impossible to separate the effects of a specific policy change from those of other shocks and policy changes that also occurred during the period covered. The use of an economywide econometric model with sufficient household and policy detail is almost invariably precluded by lack of data.

equilibrium analysis misleading (for example, technological changes in a sector that represents a large share of the economy may lead to changes in prices throughout the economy, including the exchange rate, which will have an impact on the production decisions in the sector where the initial technological change occurred); and (ii) policy changes that simultaneously affect different sectors in the economy (for example an across-the-board change in import tariffs). Another advantage of CGE models is that they provide information about both the macro and micro effects of the changes that are analyzed.

CGE models are a class of models that are solvable numerically (on a computer) and economy wide (giving a full account of the production, consumption and trade in the modeled economy). The solutions of the model characterize an equilibrium in the sense that (i) optimizing agents (households and firms) have found their "best" solutions (making production choices that maximize profits subject to the available technology; and consumption choices that maximize utility subject to budget constraints); (ii) quantities supplied and demanded are equal in all commodity and factor (labor, land, and capital) markets; and (iii) the macroeconomic accounts balance. The set of conditions that characterize equilibrium are not as constraining as they may sound. Substantial economic research confirms that it is reasonable (albeit a simplification) to assume that micro agents, including farmers in developing countries, behave optimally. The second condition, that supply and demand quantities are equal, should hold by definition in any model that fully tracks the different destinations of the quantities that are supplied to the market. Finally, the "macro" accounts of the model refer to the government budget, the current account of the balance of payments (the account of the rest of the world), and the savings-investment account. For each of these accounts, the model imposes that current receipts and

expenditures are equal. This equality is true by definition.[4] Within this general definition of CGE models, there is plenty of scope for differences across models, among other things in terms of how markets function and the mechanisms through which the macro accounts reach their equilibria.

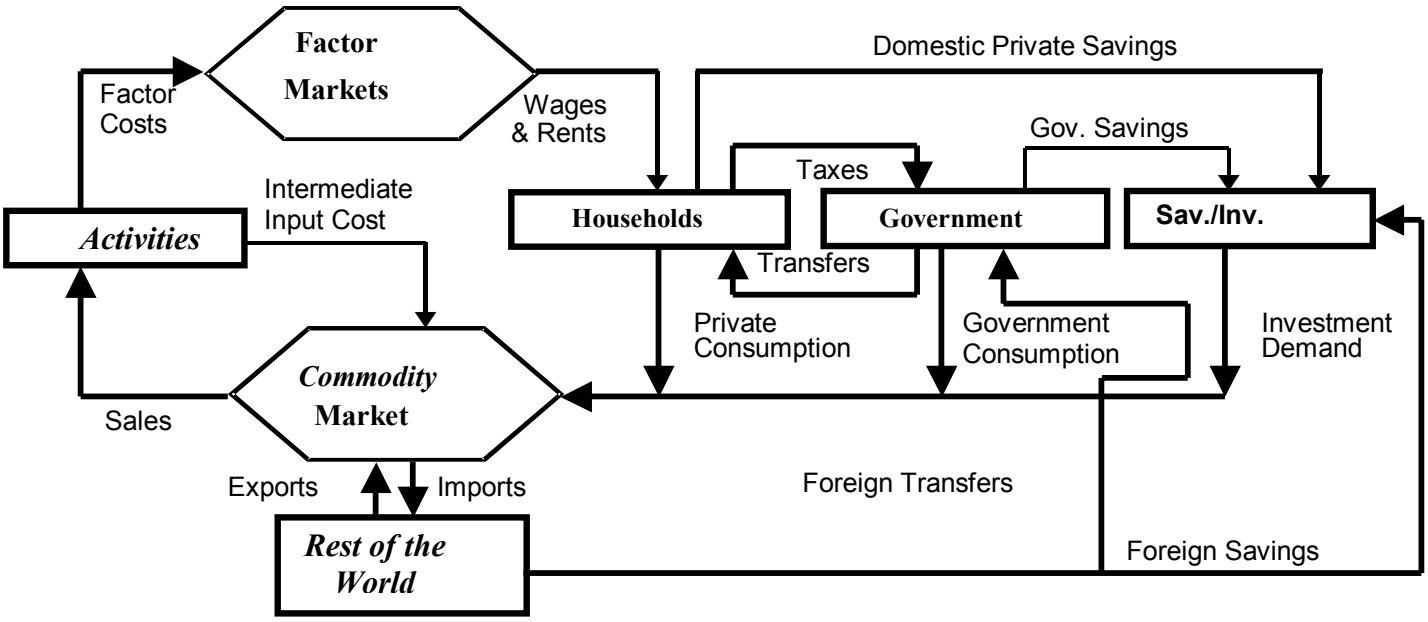
IFPRI has developed a "standard" CGE model written in the GAMS (General Algebraic Modeling System) software with the aim of facilitating the use of CGE models in policy analysis. Like most CGE models, it is written as a set of simultaneous equations without an objective function.

The key characteristics of the standard model include: (i) the separation between model code and database (making it easy to apply the model in new settings);[5] (ii) a flexible disaggregation of households, production activities, and commodities (determined by the degree of detail found in the database); (iii) transactions costs in domestic and foreign trade (both of which may require the use of transportation services and other trade-related inputs); (iv) household home consumption (i.e., household consumption of outputs from production activities that are under the control of the household, valued at producer prices which do not include marketing-related transactions costs); and (v) pre-programmed alternative rules for clearing factor markets and macro accounts. It is also worth noting that the standard model, even though it was initially designed for applications at the country level, in fact represents a modeling approach that, with minimal changes, is applicable at more disaggregated levels (for example single villages or farm households).

[4] Note that, for the government and the rest of the world, savings are included among the expenditures (otherwise equality would not hold).
[5] By April 2002, the Standard Model (often including some extensions) had been applied to at least 35 developing countries.

The following figure provides a simplified picture of the links between the major building blocks of the model.[6] Activities, households, factors, and commodities – the blocks on the left side of the figure – are almost invariably disaggregated. The "household" represents the totality of all domestic non-government institutions, including not only households but also enterprises and non-government organizations. The arrows represent payment flows. With the exception of taxes, transfers and savings, the model also includes "real" flows (a factor service or a commodity) that go in the opposite direction. The producers (or activities) earn their income from sales in domestic and foreign markets, and allocate their income to intermediate inputs and factors. In any activity that has both domestic and foreign sales, the allocation of outputs between the domestic market and exports responds to changes in the relative prices that producers receive when selling domestically and abroad. Domestic commodity demands (for investment, private consumption, government consumption and intermediate input use) are met by supplies from domestic producers and the rest of the world (imports). For any commodity, the ratio between the demands for imports and domestic output responds to changes in the relative prices of imports and domestic output that is sold at home. In world markets, import demand is met by an elastic supply of imports at fixed prices. In the domestic markets for products of domestic origin, flexible prices assure that the quantities demanded and supplied are equal.

[6] The picture is simplified in that it does not include transactions costs and has an incomplete coverage of transfers and taxes.



For the factors of production, alternative mechanisms for market clearing have been pre-programmed, covering situations with fixed (possibly full) employment, unemployment, and different degrees of mobility or segmentation within the market for any given factor. The factor costs of the producers are passed on as receipts to households and enterprises in shares that reflect ownership. The households receive factor incomes and transfers from the government (which are CPI-indexed). These incomes are spent on savings, direct taxes and consumption (which is split across different commodities according to consumers' demand functions).

On the macro side, the government receives direct taxes from the households and transfers from the rest of the world. It then spends this income on consumption, transfers to households, and savings. The rest of the world (more specifically the current account of the balance of payments) receives foreign currency for the imports of the model country, and

then spends these earnings on exports from the model country, transfers to the model country's government, and on "foreign savings" (i.e. the current account deficit). The savings-investment account collects savings from all sources (households, the government, and the rest of the world) and uses these to finance domestic investment.

The model code includes alternative specifications for the mechanisms that bring about balance for these three macro accounts. For example, it is commonly assumed that the account-clearing variables are government savings, the exchange rate, and the savings rates of selected households or enterprises.

The standard model is used for comparative static analysis, implying that the impact of the shock (or the combination of shocks) that is being simulated is found by comparing the model solutions with and without the shock(s). Each model solution provides a relatively full set of economic indicators (including GDP data, sectoral production and trade volumes, and household welfare and poverty indicators). It is straightforward to extend the model for dynamic analysis.

The database of the standard model consists of a Social Accounting Matrix (SAM), elasticities (for production, consumption, and trade), and optional factor quantity data. A SAM is a comprehensive, economy wide data framework that is captured in a square matrix. The major account categories in the standard model's SAM are the same as in the figure above showing the model structure. The difference between the SAM and the model is that the SAM is a data framework that records payments, whereas the model "explains" the payments. The model follows the SAM disaggregation and is "calibrated" to it in the sense that the model parameters for the base solution are defined in a manner that assures

that the base solution (if expressed in value terms) replicates the values in the original SAM.

When the standard model is applied in a new setting it is typically necessary to go through three steps: develop a new data base, make changes in the model structure, and conduct simulations.[7] For Uganda, the core element in the database, the SAM, is built for 1999/2000. It will be disaggregated into 6-7 rural regions and one urban region, with each region represented by one household. It will include some 20 production activities and related commodities. For agriculture, the activities will be further disaggregated by region. The main data sources are project household and community surveys; data on GDP, the government budget, foreign trade, and the balance-of-payments; and the 1992 Input-Output Table. Methods for SAM construction and balancing, developed at IFPRI, will be used to generate a consistent SAM drawing on these data sources.

At this stage, the model will be used to analyze the effects of changes in agricultural technology and improvements in transportation infrastructure. In order to properly address these issues, some changes are needed in the model structure, most importantly to permit the introduction of new agricultural technology options (including high-yielding varieties for selected crops) and to capture the fact that agricultural marketing costs differ across regions. For each simulation, the effects that will be analyzed are both at the micro level (including changes in household welfare and poverty, land use, production and foreign trade) and the macro level (including changes in GDP, the government budget, and the exchange rate).

[7] The model structure will be informed by earlier applications of CGE models to Uganda, including Bashasha (1998).

The model and its database is a tool for the analysis of a wide range of policy issues. It is important that the selection of issues be driven by the knowledge gaps that are identified by Ugandan policymakers and researchers. It is also important that Ugandans take on a significant role in the research activities. To this end, the second research stage should emphasize capacity-strengthening activities (both formal courses and collaborative research) aimed at transferring an understanding of the standard model and permitting Ugandans to further develop the tool that is generated during the first research stage. Examples of important research areas that can be addressed using the model and feasible extensions include agricultural modernization, poverty reduction, and government tax and spending policies.

APPENDIX A: WORKSHOP AGENDA

Policies for Improved Land Management in Uganda

International Food Policy Research Institute (IFPRI)
Makerere University Faculty of Agriculture (MUFA)
National Agricultural Research Organization (NARO)
Agricultural Policy Secretariat (APSEC)
Center for Development Research (ZEF)

April 17-18, 2002
Hotel Africana, Kampala Uganda

OBJECTIVES

1. To review and discuss the findings of the research project.

2. To increase policy makers' and other stakeholders' awareness of impacts of policies and other factors on rural livelihoods and land management in Uganda.

3. To discuss strategies to promote more productive and sustainable land management in Uganda in order to reduce poverty and food insecurity in Uganda.

Participants of the Second National Workshop on Policies for Improved Land Management in Uganda, April 17-19, 2002

AGENDA

Wednesday, April 17

Session 1: Opening
Chairperson: Hon. Chebet Maikut
Rapporteurs: Pamela Jagger and Betty Abang

09:00	Welcome and introduction	Dean E.N. Sabiiti, MUFA
09:15	Opening of workshop	Honorable Kisamba-Mugerwa, MAAIF
09:30	Research and workshop objectives	John Pender, IFPRI
09:45	Questions/clarifications	

Session 2: Development Domains, Pathways and Strategies in Uganda
Chairperson: Rhoda Tumusiime
Rapporteurs: Pamela Jagger and Betty Abang

09:50	Conceptual framework and summary of findings from community survey	John Pender, IFPRI
10:10	Questions/clarifications	
10:15	Spatial framework for evaluation of livelihood and land use options	Stan Wood, IFPRI
10:35	Questions/clarifications	
10:45	Coffee/photograph	
11:15	General discussion	

Session 3: Case Studies of Selected Development Pathways
Chairperson: Isaac Minde

Rapporteurs: Pamela Jagger and Betty Abang

11:30	Uganda coffee to 2020: Spatially explicit scenarios for coffee productivity, trade, and livelihood strategies	Liang You/Simon Bolwig, IFPRI
11:50	Questions/clarifications	
12:00	Potentials and constraints to coffee development	Ronnie Babigumira, IFPRI
12:20	Questions/clarifications	
12:30	Lunch	
13:30	Potentials and constraints to cotton development	Rhona Walusimbi, IFPRI
13:50	Questions/clarifications	
14:00	Land management problems and potentials in the lakeshore banana-coffee system	Dick Sserunkuuma, MUFA
14:20	Questions/clarifications	

14:30	Dynamics of livelihoods and land management in the southwest highlands	Simon Bolwig, IFPRI
14:50	Questions/clarifications	
15:00	General discussion	
15:30	Coffee	

Session 4: Market Development and Land Management
Chairperson: Hon. Grace Akello
Rapporteurs: Pamela Jagger and Stella Nagujja

16:00	Development of input markets and land management	Ephraim Nkonya, IFPRI
16:20	Questions/clarifications	
16:30	Integration of agricultural output markets and implications for land management	Shahidur Rashid, IFPRI
16 :50	Questions/clarifications	
17 :00	Farmer – trader information asymmetry and implications for land management	Edward Kato, IFPRI
17 :20	Questions/clarifications	
17 :30	General discussion	
18 :00	Close	
18 :30	Reception	

Thursday, April 18

Session 5: Impacts of Policies and Other Factors Influencing Land Management
Chairperson: Charles Gashumba
Rapporteurs: Stella Nagujja and Ronnie Babigumira

09 :00	Determinants and implications of land use and management practices in Uganda	John Pender
09 :20	Questions/clarifications	
09 :30	Soil conservation practices in the Southwest Highlands	Ephraim Nkonya
09 :50	Questions/clarifications	
10 :00	Collective action in land management – Doho Rice Scheme	Dick Sserunkuuma, MUFA
10:20	Questions/clarifications	
10 :30	Coffee	
11 :00	Programs and organizations influencing land management	Pam Jagger, IFPRI
11 :20	Questions/clarifications	
11 :30	General discussion	

Session 6: Changes in Soil Conditions/Impacts of Alternative Technologies
Chairperson: Prof. Julius Zake
Rapporteurs: Pamela Jagger and Ronnie Babigumira

12:00	Changes in soil organic matter and other soil conditions in Uganda	Henry Ssali, NARO
12:20	Questions/clarifications	
12:30	Lunch	
13:30	Soil nutrient balances and their relationship to farming systems in Uganda	Ephraim Nkonya
13:50	Questions/clarifications	
14:00	Impacts, costs and returns of selected land management technologies in eastern Uganda	C.K. Kaizzi, ZEF
14:20	Questions/clarifications	
14:30	Modeling impacts of land management practices on erosion at the landscape scale	Almut Brunner, ZEF
14:50	Questions/clarifications	
15:00	Technologies for improved livelihoods and land management in the southwest highlands	Wilson Bamwerinde, Forestry Research Institute
15:20	Questions/clarifications	
15:30	General discussion	
16:00	Coffee	

Session 7: Modeling Impacts of Policy and Technology Options
Chairperson:Dr. Henry Ssali
Rapporteurs:Pamela Jagger and Betty Abang

16:30	Modeling technology diffusion and land management in Uganda	Johannes Woelcke, ZEF
16:50	Questions/clarifications	
17:00	Modeling policy impacts using an agriculture-focused computable general equilibrium model	Hans Lofgren, IFPRI
17:20	Questions/clarifications	
17:30	General discussion	
18:00	Close	Dean E.N. Sabiiti

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