STRATEGIC ASSESSMENT OF LAND USE OPTIONS FOR UGANDA

Phase I Completion Report

MAIN REPORT

Submitted to USAID/Uganda

The International Food Policy Research Institute
2033 K Street, N.W. Washington, D.C. 20006

April 2002

Report prepared by Simon Bolwig, Peter Hazell and Stanley Wood with input from Jordan Chamberlin, Peter Gruhn, Pamela Jagger, Mylene Kherallah, Ephraim Nkonya, John Pender, Dick Sserenkuuma, Kate Sebastian and Liang You.

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1. Background 1

1.2. Changes in Agriculture and Environment in Uganda 3

1.3. Sources of Information 6

1.4. Objectives of the Assessment 7

1.5. Introducing the Assessment 8

1.6. Databases and Scale Issues 10

1.7. Structure of the Report 11

2. IDENTIFYING THE BEST "PRIVATE" LAND USE OPTIONS AT DIFFERENT LOCATIONS 12

2.1. Introduction 12

2.2. Current Development Pathways and Land Use Changes in Uganda (Preliminary Analysis) 13

2.3. Best Private Land Use Options for Uganda: Characterization of Development Strategy Domains 20

2.4. Plans for Phase II 29

3. CHARACTERIZING THE NATURE AND VALUE OF ECOSYSTEM GOODS AND SERVICES AT DIFFERENT LOCATIONS 31

3.1. Introduction 31

3.2. Scale Issues in Ecosystem Analysis 33

3.3. Implementing the Ecosystem Goods and Services Approach 35

3.4. Biodiversity: Land Cover and Protected Areas 37

3.5. Physical Environment: Soil Quality and Relief 38

4. IDENTIFYING THE POTENTIAL ENVIRONMENTAL IMPACTS OF "PRIVATE" LAND USE OPTIONS AT DIFFERENT LOCATIONS 39

4.1. Introduction 39

4.2. Potential Environmental Conflicts by Land Use Option 39

5. IDENTIFYING INTERVENTIONS FOR MORE PRODUCTIVE AND ENVIRONMENTALLY SOUND LAND USE SYSTEMS 43

5.1. Introduction 43

5.2. Example I: Sustainable Agricultural Intensification in the Southwestern Highlands ……..... 44

5.3. Example II: Woodland Conservation Under Agricultural Expansion in Central Region……..... 46

5.4. Plans for Phase II..... 47

6. ASSESSING THE SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS OF THE BEST "SOCIAL" LAND USE OPTIONS..... 49

6.1. Introduction 49

6.2. Sector-wide Impacts of Land Use Options 50

6.3. Plans for Phase II..... 51

7. TARGETING USAID'S STRATEGIC INVESTMENTS..... 53

7.1. Criteria-Based Targeting of USAID Investments by Location and Sub-Sector 53

7.2. Economic Growth Potential..... 54

7.3. Environmental "Hot Spots" 54

7.4. Incidence of Poverty..... 54

7.5. Population Density 55

7.6. Markets and Infrastructure..... 55

7.7. Type of Commodity..... 58

7.8. Plans for Phase II..... 58

8. HOW CAN PROGRESS BE MONITORED..... 59

9. CONCLUSIONS..... 60

10. BIBLIOGRAPHY 61

ENDNOTES……...……..62

FIGURES 1-26 ARE ATTACHED AT THE END OF THE REPORT

APPENDICES

Appendix A Research Project on Improved Land Management in Uganda: Project Activities and Data Collected. *By Ephraim Nkonya*.

Appendix B Development Pathways and Land Management in Uganda: Causes and Implications. *By John Pender, Pamela Jagger, Ephraim Nkonya, and Dick Sserenkuuma.*

Appendix C Potential Economic Benefits of Increased Agricultural Productivity in Uganda. *By Stanley Wood and Liang You.*

Appendix D Market Feasibility of Land Use Options in Uganda. *By Mylene Kherallah and Peter Gruhn.*

Appendix E Literature database in Support of Assessing Strategic Land Use Options for Uganda. *By Simon Bolwig*

1. INTRODUCTION

1.1. BACKGROUND

USAID/Uganda has developed a six-year integrated strategic plan (ISP 2002-2007) for Uganda (USAID, 2001). A key ingredient in the ISP 2002-2007 is the merging of the economic growth and environment Strategic Objectives (SOs) in a new SO7, *Expanded Sustainable Economic Opportunities for Rural Sector Growth*.[1] The SO7 will "assist Uganda to reduce rural-based poverty and sustain economic growth by expanding economic opportunities and increasing employment, income, and the viability of enterprises" while halting environmental degradation and biodiversity loss (Ibid.:36-39). The key strategy to achieve this objective is the integration of economic growth, agriculture, and environment and natural resources interventions (Ibid.). The three core investment programs under the SO7 are: Productive Resource Investments for Managing the Environment / Western Region (PRIME/WEST); Agricultural Production Enhancement Program (APEP); and Uganda Trade Revitalization and Diversification of Exports (U-TRADE).

Developing sustainable and productive land use systems is essential for poverty eradication and sustained economic growth in rural Uganda where the vast majority of people depends on natural resources for their livelihood and is expected to do so in the foreseeable future. In recognition of this, USAID/Uganda asked the International Food Policy Research Institute (IFPRI) to prepare a strategic planning framework for rural land use development in Uganda, which successfully integrates the country's agricultural growth and rural livelihood needs with responsible environmental management (IFPRI, 2001a). The present paper reports from the first phase of this work and provides a preliminary assessment of strategic land use options for Uganda. The second phase (July 2001 - June 2002) will involve full implementation of the approach in partnership with the USAID/Uganda Mission and relevant national collaborators (IFPRI, 2001b). The "IFPRI approach" and associated analyses thus make up the "Strategic Criteria for Rural Investments in Productivity" (SCRIP) – one of SO7's two policy-related analytical frameworks (USAID, 2001: 40, 42).[2]

The assessment adopts “land use” as the key concept to combine biodiversity and natural resource conservation with agricultural development and economic growth in an integrated framework for strategic decision-making. Land use involves the human activities that are directly to land, making use of its natural resources or having an impact on it (Reenberg, 1998:47). Yet the present assessment also considers rural livelihood options that are not directly based on the use of natural resources (but are nevertheless often linked to agriculture), and it examines land use options such as biodiversity conservation that may not necessarily contribute to rural livelihoods. Our definition of land use thus includes these options and is not restricted to agriculture and forestry. The present framework differs from the ‘commodity’ approach by studying the spatial aspects of production and productivity; by including environmental factors such as soils, relief (slope), climate, and biodiversity; and by examining both managed and natural ecosystems, their interdependencies, and their provision of goods and services.

The strategic framework takes a dynamic systems approach to economic growth, agriculture, and environment by examining both socioeconomic and biophysical factors, their spatial and temporal patterns, and how they interrelate to produce location-specific outcomes. Building on theories of induced innovation (see e.g. Boserup, 1965; Pender, 1998), we consider market development and population growth as key forces shaping agricultural land use patterns. We place special emphasis on the influence of population density on actual and potential land use strategies through its effect on market access and the land/labor ratio. Our treatment of the natural environment in the framework will draw on concepts and methods developed for the analysis of ecological systems and their provision of goods and services (e.g. WRI, 2000; Izac and Sanchez, 2001). We will also attempt to deal with the problems arising from the scale-dependence of socioeconomic and ecological phenomena: the temporal and spatial scales at which we study land-use related factors directly affects our evaluation of the performance and sustainability of (current and potential) land use systems (Reenberg, 1998). This evaluation in turn influences policy and investment choices for raising the productivity and sustainability of land use systems.

1.2. CHANGES IN AGRICULTURE AND ENVIRONMENT IN UGANDA

The natural environment is a prominent feature in the present framework. Uganda exhibits great biodiversity and is home for charismatic species such as mountain gorillas, chimpanzees and the shoe-billed stork. Many of Uganda's natural ecosystems are globally important, and rare and endangered species are found within the borders of national parks, forest reserves and other protected areas. Others live in the many unprotected forests, wetlands and other natural habitats (Chemonics, 2001a).

The dramatic degradation of Uganda's unique flora and fauna over the past 30 years or so fully justifies a strategic planning framework for rural development centered on 'land use' rather than 'production'. Unregulated agricultural expansion, spurred by population growth and low agricultural productivity, has been a major cause of diminishing forests, savannas, and wetlands in some places. Table 1 shows the conversion of original vegetation into smallholder farmland between 1964 and 1992. The expansion of smallholder farming has been the dominant cause of land conversion in Uganda over the last 30 years or so. Altogether almost 90,000 square kilometers (twice the area of Denmark) of hitherto uncultivated land were included in these farming systems as fields or short fallows. Most new farmland was converted from wooded savanna, followed by forest/savanna mosaic and forest and woodland. The relatively small share of converted forest (top row) may be explained by the fact that this vegetation class originally occupied a small absolute area compared with other vegetation classes, i.e. most of Uganda's forests had already been cleared in the 1960s when Langdale-Brown et al. made their vegetation cover assessment. The remaining larger contiguous forests have been under protection as forest reserves or national parks.

The clearing of natural vegetation has meant a loss of natural habitats, which in combination with uncontrolled hunting during the 1970s and 1980s has taken a huge toll on Uganda's wildlife (Table 2). During these years mammal populations were decimated and rare and charismatic species such as the black rhino were hunted to extinction. Many species are still threatened and their numbers declining. A rare exception to this tragedy is the survival in the same period of half of the World's 600 mountain gorilla's on the tiny patch of forest in the heavily populated East Congo / Rwanda / Uganda mountains (Richard Lamprey, personal communication, 2001).

There is therefore a great need for strengthened environmental conservation in Uganda, which in our view can only be successful through an integrated approach to land use planning and development.

Table 1. Land Conversion into Smallholder Farmland Between 1964 and 1992

Original Vegetation Class	**Smallholder Farmland in 1992**	
	Area Converted (Km2)	*Proportion of Original Vegetation Class (%)*
Wooded Savanna	48,532	54.0
Forest/Savanna Mosaic	17,443	19.4
Forest, Woodland, Moist Thicket	5,632	6.3
Grassland Savanna	5,294	5.9
Vegetation on Sites With Impeded Drainage	4,667	5.2
Dry Thicket, Bushland, Steppe	994	1.1
Swamp	2,079	2.3
Other	5,242	5.8
All	89,883	100.0

Source: IFPRI, based on spatial analysis of digitized maps from Langdale-Brown (1964) and National Biomass Study (1996)

Table 2. Changes in the Population of Selected Mammals

Type of Mammal	1965	1995	Remaining Share (%)	Status
Rhino (Black & White)	700	0	0	Extinct
Oryx	2,000	0	0	Extinct
Bright's Gazelle	1,800	100	6	Precarious
Roan Antelope	700	8	1	Precarious
Zebra	10,000	3,200	32	Declining
Hippopotamus	26,000	4,500	17	Declining
Impala	12,000	2,000	17	Declining
Eland	4,500	500	11	Declining
Topi	15,000	600	4	Declining
Giraffe	2,500	200	8	Stable
Elephant	30,000	1,900	6	Stable
Mountain Gorilla	NA	325*	NA	Stable
Chimpanzee	NA	6000	NA	NA

*World total is 600. Source: Lamprey et al. (1999).

The intensification and expansion of crop and livestock production represent the most important influences on land use, land cover and biodiversity in Uganda. Agriculture is therefore the key sector in the assessment of strategic land use options. Agriculture is by far the most important sector in the national economy. It employs more than 80% of the labor force and accounts for around 40% of GDP and for 50% of total exports. These figures are higher than in countries such as Kenya and Ghana, with whom Uganda is often compared. It is, therefore, a major cause of concern that agricultural development in Uganda has been slow or even negative in some periods since 1970 (Table 3), causing widespread rural poverty and environmental degradation. Increases in crop production have occurred mainly as a result of area expansion, in particular in the 1980s and 1990s. Crop yields have been almost stagnant or declining. In value terms, land and labor productivity have grown slowly or even decreased in the same period. The slow growth in agricultural productivity since around 1980 is especially disturbing as it follows a decade of negative growth in

the 1970s. In the 1960s, growth rates were positive and relatively high for all productivity indicators.

Table 3. Indicators of Agricultural Development in Uganda 1961-98

	Annual average growth (%)			
	1961-70	1971-80	1981-90	1991-98
Population	NA	3.2	2.4	2.9
Harvested area	2.9	- 3.7	2.2	2.0
Average crop yields (weight / area)	3.2	- 3.1	1.0	- 0.8
Land productivity (value / area)	3.8	- 3.1	1.4	1.4
Labor productivity (value / agric. worker)	1.9	- 4.4	1.0	- 0.3

1.3. SOURCES OF INFORMATION

The assessment of land use options for Uganda makes extensive use of ongoing IFPRI research in Uganda, notably the research project "Policies for Improved Land Management in Uganda" (see Appendix A), undertaken by IFPRI in collaboration with the Center for Development Research of the University of Bonn (ZEF), Makerere University Faculty of Agriculture (MUFA), the National Agricultural Research Organisation (NARO), and the Agricultural Policy Secretariat (APSEC). Valuable information was also obtained through a number of Ugandan Institutions, notably the National Biomass Study (NBS) of the Forestry Department, Uganda Bureau of Statistics (UBOS), Makerere University Institute of Environment and Natural Resources (MUIENR), and Uganda Wildlife Authority (UWA). The present assessment benefited from data and reports submitted to USAID/Uganda by Chemonics International (Chemonics 2001a/b/c). We also make use of a wide range of published and unpublished data and literature (see Appendix E).

The team held several meetings with the Director and staff of the USAID/Uganda Mission in Uganda, and interacted closely with the BIOFOR teams and the other consultants contracted by USAID for the preparation of the SO7. We believe that this kind of interaction between researchers and development practioners greatly enhances the quality and relevance of both research and development efforts.

1.4. OBJECTIVES OF THE ASSESSMENT

The objective of the assessment was to prepare a strategic planning framework for rural land use development in Uganda that successfully integrates the country's agricultural growth and rural livelihood needs with responsible environmental management. The planning framework should:

a) provide quantitative assessments at the region and sector levels of the likely growth, food security, poverty and environmental impacts of alternative land use strategies, and identify important tradeoffs between these goals where they exist;

b) show how land uses are likely to change over time in response to changes in population pressure, market conditions, policies, technologies, public investments, and local institutional and social arrangements;

c) provide a practical way of reconciling for policy and investment purposes, regional and national land use aggregates with the enormous diversity of conditions that exist at the local (micro-watershed or community) levels;

d) provide guidance on how to reconcile the sometimes conflicting interests and decision rights of the individuals and communities who manage natural resources with the concerns of national policy makers and the international development and environment community; and

e) provide a set of practical indicators that can be used to monitor the growth, poverty, food security and environmental impacts of future land use strategies and that are (i) insightful for understanding the causes of the observed changes (including the part that is due to USAID's own interventions) and (ii) provide an efficient learning mechanism for improving future policy and investment strategies.

We are building such a framework by combining analytical methods at several levels. Objectives b), c) and d) are best met by utilizing agroecological maps and representative community and micro-watershed level studies to identify land use options that are agroecologically feasible and economically and socially attractive to local people, and then using community typologies and GIS mapping tools to assess their potential across larger areas. Objectives a) and b) require appropriate market and

sector level models that integrate regionally-based characterizations of land use and agricultural production systems with market demand and input supply systems at the national level. Objective e) requires identification of practical indicators that can be monitored by remote sensing and through survey and census data, and which can be linked to the modeling analysis in order to attribute causes to the observed changes.

We undertake the study in two phases. The first phase (from which this paper reports) ended in June 2001 and involved developing and articulating the approach, building up a relevant data base, developing some preliminary results and establishing collaborative arrangements with national partners.[3] Phase two runs from July 2001 to June 2002 and involves full implementation of the approach in partnership with the USAID/Uganda Mission and national and International collaborators (IFPRI, 2001b).

1.5. INTRODUCING THE ASSESSMENT

The assessment of strategic land use options in Uganda involves answering the following seven clusters of questions in sequence.

1. What are the best livelihood and land use options at different locations from the "private" perspective of individual farmers and local communities?
2. What is the nature and value of ecosystem goods and services – including soil quality, biodiversity, and habitats for endangered species – at different locations?
3. Where and in what ways do individually-preferred livelihood/land use options conflict with environmental goals, i.e., with socially-desired land uses that conserve or enhance ecosystem services? Where are the "hot spot" areas with high potential for conflict between "private" and environmental goals? Which areas present "win-win" opportunities for combining local livelihood and environmental interests?
4. Which interventions – compensation, regulation, new technologies, or mixes hereof – can most effectively mitigate potential conflicts of interest over land use in different situations, i.e. increase rural incomes while conserving or rehabilitating biodiversity and natural resources?
5. What are the likely local and aggregate socioeconomic and environmental impacts of different land use options? As for socioeconomic impacts, what are the economic benefits from alternative growth-enhancing land use options within the

adopting regions? And what are the aggregate impacts on household incomes, food prices, employment, wage rates, poverty, and trade? As for environmental impacts, what are the potential effects of "nature-based" and conventional agricultural land use options on ecosystem services in different locations?

6. Where should USAID choose to focus its own land use development efforts?
7. How can progress be measured?

The framework for assessing strategic livelihood and land use options in the context of USAID/Uganda's SO7 is illustrated in Figure 1. The box numbers correspond to the sequence of questions (or steps) outlined above. The center of the diagram (box 1-5) shows the major analyses involved in the assessment of sustainable land use options at the national and sub-national (regional) levels. Analyses 1-3 identify the scope of the problem, and in box 4 and 5 we identify and analyze possible response options. In box 6 on the right we develop a criteria-based method of targeting investments according to location and sub-sector, which builds on the output of the previous analyses. The criteria are chosen and weighted according to the strategic goals of the investor (here, USAID). In box 7 we identify key indicators for monitoring and evaluating the environmental and socioeconomic impacts of the land use investments. All these analyses rely on, and contribute to, the georeferenced database developed in the upper right-hand box of the diagram.

[Figure 1. Analytical Framework for USAID/Uganda's SO7]

The analyses outlined here should be regarded as necessary but not sufficient tools for the design of land-use focused investment programs: they answer in a broad way the questions: where to invest in which options; what policy instruments are suitable for which situations; and what are the likely effects of such interventions on economic welfare and the environment. But the analyses are less concerned with the organizational and technical issues involved in designing and implementing actual rural development programs. Such issues must be addressed during the identification and design phase of concrete investment programs through more fine-grained and different types of analyses.

1.6. DATABASES AND SCALE ISSUES

In phase I we have commenced the collection, assessment, and systematization of secondary information to supplement the primary data collected by IFPRI and its partners. This includes data on land use, agriculture, environment, poverty, markets, and the like. Yet like the BIOFOR teams (Chemonics, 2001a/b), we found serious caveats in the availability and quality of this type of data for Uganda. A number of digitized maps were produced during phase I, which have been included in the report and its other appendices and in the presentational material shown and submitted to the USAID/Uganda Mission. Other maps will be produced in phase II as needed. The maps are produced using IFPRI's spatial (GIS) database for Uganda, which we are continuously expanding. Appendix E contains a bibliography generated from our Reference Manager database on Uganda, which likewise is under continuous development. In phase II we will continue the work of developing the database for land use planning and program design in collaboration with Ugandan and International partners.

Since much of the analysis is undertaken spatially, it is necessary to be clear about the units and scales of analysis and the resolution of the data.[4] We have data for different variables at different scales. For example, population data is available at the parish level, and poverty data is at the district level. Some aspects of biophysical data, such as climate, are available on a grid covering the entire country at around a 60km grid cell size. While the soil grid data is at a resolution of around 10km, the spatial complexity of soils is much higher, and much of the source data predates the more recent losses of soil quality. Topographic data are currently available to this study at a 1km resolution, and while this is useful for developing broad typologies of landscapes, it is too coarse to be useful in assessing, say, soil erosion potential from farmers' fields. Thus, while these databases will continue to be refined during phase II, much reliance will continue to placed on the collection and analysis of location-based information such as IFPRI's household, community and trader surveys that can be correlated to more spatially extensive explanatory variables.

The development and integration of such a diversity of information on biophysical, market, and socioeconomic data by IFPRI also demands that attention be given to identifying one or more organizations or institutions within Uganda where

this information can be stored, managed and utilized during and beyond the phase II activities.

1.7. STRUCTURE OF THE REPORT

The report is structured according to the question clusters of Section 1.5. Following the division of the assessment into two phases, some questions are answered more fully than others in this phase one. In each section of the report we indicate how we plan to expand the analyses in phase II. Selected analyses are expanded upon in technical reports that are included as appendices.

2. IDENTIFYING THE BEST "PRIVATE" LAND USE OPTIONS AT DIFFERENT LOCATIONS

2.1. INTRODUCTION

This section concerns the land use options that are most profitable from the perspective of individual farmers and local communities given local socioeconomic and biophysical conditions. We term these options individually-desired or "private" land use options, since we deal with economic incentives based only on the balance of benefits accruing to, and costs incurred by, such land users themselves. They are the land uses chosen by rural communities, who are likely to use land resources from short or medium-term economic objectives of income maximization and livelihood security, and for whom ecosystem services such as biodiversity conservation, carbon sequestration, and (long-term) soil conservation tend to have low priority. This is due to poverty (that puts a premium on short-term income benefits), low capability for collective action (that favors private over social benefits), lack of the political influence to prevent outsiders' extraction of local resources, and an inherent unwillingness to invest in land uses for environmental purposes if most of the benefits are not captured locally.

This being said, rural communities obviously differ with respect to the sustainability of their development pathways. Preliminary results from IFPRI's community survey on land management in Uganda suggest that some communities are better able to integrate private and environmental objectives in their land use strategies, because they use the land in ways that give them important benefits from local environmental services (including soil quality). Generic forms of such 'win-win' land use strategies are agro-forestry, ecoagriculture, ecotourism, and managed tropical forests (e.g. improved with fruit trees). Much can be learned from situations where these strategies have been successfully adopted. In Section 5 we provide two examples of how conservation strategies might be applied in environmental "hot spot" areas of Uganda where threats of soil degradation or biodiversity loss are particularly high. In phase II we will expand this analysis using IFPRI survey data to help identify "best practice" land uses, i.e. pathways that the better-off communities use. These may not solve all local environmental problems, but should provide better than

average outcomes, and perhaps very significantly better outcomes in worse-off communities.

In the remainder of this section we identify private land use options through the characterization of development pathways (common patterns of change in livelihood strategies) and their spatial extents (development strategy domains). Development pathway characterization is based on considerations of the comparative advantage of an area (locality) with respect to a particular economic activity, including activities that do not depend directly on local land resources (e.g. rural industry and urban employment). A "private" land use option in this context is a change in land-based livelihood strategies desired by local farmers and communities. These analyses are based on the IFPRI community survey data and are reported in more detail in Sserunkuuma et al. (2001) and Pender et al. (2001).

The first step in the identification of private land use options is carried out in Section 2.2 where we make a preliminary characterization of *current* patterns of change in livelihood strategies and land use in different regions of Uganda. We then identify *potential* "private" development pathways and land uses for different regions in Uganda, based on the current pathways and on the comparative advantage of these regions for particular livelihood strategies (determined by local-specific socioeconomic and biophysical characteristics, e.g. population density, agroecology, and market accessibility). This is done in section 2.3. These potential pathways and land uses are likewise tentative results that will be validated in phase II.

2.2. CURRENT DEVELOPMENT PATHWAYS AND LAND USE CHANGES IN UGANDA (PRELIMINARY ANALYSIS)

Design of the Community Survey

We base the analysis of current development pathways and land use in Uganda on the results of a survey of 107 communities, conducted by IFPRI as part of the "Policies for Improved Land Management" research project (Appendix B). The community survey focuses on the plateau and highlands regions of Uganda (above 1000 m.a.s.l.), excluding the lower, drier and/or more insecure parts of the country in the west, northwest, far north, and northeast (Figure 2).[5] The communities were selected using a stratified random sample of communities from the different development domains shown in Figure 4 (Section 2.3). One hundred LC1's were

selected in this way. An additional seven communities were purposively selected in southwest Uganda, where the African Highlands Initiative is conducting research, and in Iganga district, where the International Center for Tropical Agriculture (CIAT) is conducting research. The survey includes local peoples perceptions of the change since 1990 in natural resource conditions, livelihood strategies, and land use, among many other issues.

[Figure 2. Geographical Coverage of IFPRI's Community Survey (Sample Parishes)]

The analysis of the community survey data follows a typology of development pathways made by classifying the economic activities of rural people according to (Table 4):

? type of occupation – crop production, livestock production, forestry, non-farm employment;

? orientation of the activity – market or subsistence, linked or not to agriculture in case of rural industry;

? type of crops produced – annual or perennial;

? marketability of the product – whether perishable or storable, and high or low value relative to the cost of transportation to the market.

Table 4. Classification of the Economic Activities of Rural People in Uganda

Type of Occupation	Orientation	Crop Period	Marketability	Examples of Products / Activities
Crop	Subsistence	Perennial	NA	*Matooke*
		Annual	NA	Sorghum Millet Cassava Sweet potato
	Cash	Perennial	Storable	Coffee
			Perishable	*Matooke* Fruits Sugarcane
		Annual	Storable	Cotton Maize Beans
			Perishable	Vegetables
Livestock	Subsistence	NA	NA	Oxen Cows Small stock
	Cash		Transportable	Beef cattle, sheep, goats
			More costly to transport (relative to value)	Poultry, pigs
			Perishable	Dairy production
				Fish farming
Forestry	Subsistence	Perennial	NA	Collection of forest products for home use
	Cash		Transportable	High value forest products (e.g., hardwood for furniture)
			Less transportable	Low value forest products (e.g., fuel wood)
Rural Industry	Linked to agricultural production	NA	NA	Coffee processing Cotton milling Sugarcane mills Grain milling Cassava milling Input and output marketing
	Not linked to agricultural production			Mining Construction Services Crafts
Urban Employment	Linked or not linked to agriculture			Many types

Source: Sserunkuuma et al. (2001)

Geographically the analysis is stratified according to the main agro-climatic zones of Uganda with respect to the length of the growing period for annual and perennial

crops. This classification distinguishes between uni-modal and bimodal rainfall patterns, and within each pattern, whether rainfall is high, medium or low (Figure 3), and through the temperature variable, between the eastern and western highlands and the rest of the country (not shown). Population density and market access are the other stratifying variables used (see Section 2.3).

[Figure 3. Major Agro-Climatic Zones of Uganda]

Analysis of the community survey data included descriptive statistics to identify general patterns and trends of development and land management in the study region (presented in Section 4 of Appendix B), factor analysis to identify the development pathways and econometric analysis to test the research hypotheses (both in Section 5 of Appendix B). The factor analysis used data on the primary activities of men and changes in the top three activities since 1990 to identify the development pathways.[6] The preliminary results from this analysis follow below.

Current Development Pathways and Land Use Changes in Uganda

Dominant Development Pathways

The analysis of the community survey identified six dominant development pathways in the study region. These are: 1) increasing production of cereal crops, 2) increase of banana and coffee production, 3) increase of non-farm activities, 4) increase of horticulture, 5) increase of cotton, and 6) stable coffee production. The first five development pathways represent a pattern of increasing specialization in an already important activity. Given the extent of market liberalization in Uganda during the 1990's, it is not surprising that increasing economic specialization based upon local comparative advantages took place. No forms of livestock production came out as a major development pathway. Yet the analysis did reveal, among other changes, an increase in the adoption of crossbred dairy cattle, especially in the bimodal low and high rainfall zones and in the eastern highlands, and a decline in the ownership of small ruminants.

The factors associated with these different development pathways were investigated using econometric analysis. Explanatory variables were selected that represented factors believed to determine an areas' comparative advantage with respect to common development pathways. The factors are agricultural potential, market access, population density, development of infrastructure, and social capital

(as measured by organizational presence). The variables are listed in Table 5. Because all variables used to identify development pathways are spatially dependent and geo-referenced (their geographical coordinates are known), it is possible to map the current development pathways and associated land uses using GIS technology. Such maps will be produced in phase II of the assessment. GIS maps of potential pathways are presented in Section 2.3.

Table 5. Explanatory Variables Used for Identifying Determinants of Development Pathways

Agro-Climatic Zones (cf. Unimodal)
- Bimodal low
- Bimodal medium
- Bimodal high
- Southwest highlands
- Eastern highlands
High market access
High population density (> 100/km^2)
Irrigation in village
Change in population density (number of households)
Change in distance to tarmac road (miles)
Change in distance to rural market (miles)
Number of government programs
Number of NGO programs
Number of community-based organizations

The analysis of the determinants of the six dominant development pathways gave the following results:

1. Increased importance of cereal production is most common in the bimodal medium rainfall agroclimatic zone and in higher population density areas. It is also associated with greater numbers of community-based organizations, most of which focus on income generation or poverty reduction. Apparently promoting increased cereal production is part of the activities of some of these organizations.

2. Increased banana and coffee production is more common in the bimodal high and bimodal low rainfall zones than in other agroclimatic zones, and more

common where rural markets have developed (though these associations are only weakly statistically significant).

3. Increased non-farm activities are, not surprisingly, more common where roads and rural markets have developed. Non-governmental organization programs (NGO's) are also associated with increased non-farm activity. In many cases, such programs focus on reducing poverty through promoting income diversification, education and training. Non-farm development is also weakly associated with higher population density.

4. Increased horticultural production is not surprisingly associated with access to irrigation, and is more common in the bimodal medium rainfall zone than in several other zones. It is also weakly associated with higher population density, probably because of the high labor intensity involved in producing horticultural crops.

5. Increased cotton production is not strongly associated with any of the factors investigated. It is only weakly negatively associated with the presence of community-based organizations (CBOs). Other more general factors, such as changes in cotton prices or development (or lack of development) of cotton processing facilities, may be more important in determining development of cotton production than the more localized factors that were investigated in the study.

6. The pathway of stable coffee production is most common in the bimodal high rainfall zone close to Lake Victoria and in the eastern highlands. In both of these zones coffee has long been a dominant economic activity, and this has not changed since 1990. Stable coffee production is also more common in higher market access areas. The presence of CBOs is negatively associated with stable coffee production, though this result is not robust.

As with the development pathways, changes in ownership and use of different types of livestock are affected by different factors. Agroclimatic conditions and changes in market access strongly influence adoption of crossbred dairy cattle. Market access also favors intensive livestock such as pigs and poultry, but reduces extensive livestock activities such as shepherding. Government programs have also

apparently contributed to intensive livestock activities while reducing sheep production. Below we look at patterns and changes in land use in the surveyed communities since 1990 and the factors and development pathways associated with these changes.

Changes in Land Use

Patterns and determinants of land use changes were analyzed with respect to the explanatory variables and six dominant development pathways just presented. The types of land uses considered are cultivated land, fallow land, grazing land, natural forests, planted woodlots, and wetlands. The most common use of land is for cultivation. Cultivated area has been expanding in all zones outside of the highlands. However, controlling for other determinants of change, increases in cultivated area are more common in the southwest highlands than in other zones. Other factors that have a statistically significant influence on cultivated land use include the presence of irrigation (reduces expansion), banana and coffee expansion (increases expansion), and improved access to roads (increases expansion). Surprisingly, population growth is not significantly associated with increased use of land for cultivation.

Fallow land is declining everywhere. We find few factors that lead to a statistically significant difference in this tendency. The one exception is expansion of horticultural production, which is (weakly) associated with decrease in fallow. The findings are similar for grazing land, which is also declining everywhere, but more so in horticultural communities. Interestingly, grazing land use is declining less where road access is improving, perhaps due to increased use of land for dairy production.

Natural forest area has been declining in all zones, and is no longer very common in any zone. Improvement in road access is strongly associated with reduced forest area while, surprisingly, population growth is associated with less deforestation. This puzzling result may be due to the fact that some areas where population growth is rapid, such as the bimodal low rainfall zone, are areas where there was relatively less natural forest to begin with, and so less deforestation despite rapid population growth.

Planted woodlots are becoming more common, especially in areas of lower market access; in coffee, cereals and non-farm pathways; where NGO programs are operating; and where road access has improved. They are less likely to be increasing in horticultural areas, perhaps because the value of land is too great in these areas.

Wetlands are declining, especially in areas of better market access, where road access has improved, or where coffee production is the development pathway. They are declining less in the cotton pathway. Irrigation is weakly associated with preservation of wetlands and forest, probably because it reduces pressure to expand cultivated area.

Overall, of the factors influencing changes in land use, improvement in access to roads appears to have had the most effect, contributing to expansion in cultivated land, grazing area and woodlots, and to reductions in forests and wetlands. Road development may thus be helping to stimulate economic activity at the expense of conserving natural resources. Irrigation favors more intensive land use and therefore less expansion of cultivated area and greater preservation of forest and wetlands. The development pathways have differential associations with land use. Development of banana and coffee production is associated with expansion of cultivated area; while horticultural production is associated with declining (or less increase in) fallow, grazing and woodlot area; and stable coffee production areas more commonly have increasing areas of woodlots but declining area of wetlands.

2.3. BEST "PRIVATE" LAND USE OPTIONS FOR UGANDA: CHARACTERIZATION OF DEVELOPMENT STRATEGY DOMAINS

The previous section outlined common patterns of change in livelihood and land use in Uganda today. In this section we tentatively suggest development pathways and land uses that have economic potential in Uganda, i.e. that are profitable for rural people, given the socioeconomic and biophysical preconditions found in different areas of the country, and taking into consideration existing patterns of livelihood and land use. Next, through a spatial analysis of these development pathways and their preconditions, we map out a mosaic of 'development strategy domains' in Uganda, i.e. "private" scenarios of rural development and land use in Uganda. Table 6 lists the many possible land use options for a developing country such as Uganda, their biophysical and socioeconomic preconditions (including the variables in Table 5), and their possible environmental and socioeconomic impacts (in both social and private terms). The analysis of land use options for Uganda presented in this report is necessarily much simpler, in particular regarding the number of preconditions and impacts that it is possible to include.

Table 6. Land Use Options, Their Preconditions and Potential Environmental and Socioeconomic Impacts

Example Land use Options	Biophysical Preconditions		Socioeconomic Preconditions			Potential Environmental Impacts	Potential Socioeconomic Impacts
	Production Potential	Conservation Potential	Markets & Infrastructure	Institutions	Human Capital		
High Input Cropping Low Input Cropping Perishable Cash Crops Storable Cash Crops Intensive Dairy / Livestock Extensive Livestock Plantation Agriculture Agroforestry Forestry Aquaculture Ecoagriculture Ecotourism Nonfarm Activities	Temperature & radiation Water availability - quantity - variability - quality Soil quality Terrain Pest & disease incidence	Plant & animal abundance, diversity & rarity Habitat fragmentation Water yield	Physical market access Credit & input Accessibility Market information Trader concentration Storage capacity Communication Electrification Transport	Capacity for collective action - cooperatives - NGOs - associations - local govern. Land tenure Security Research capacity Extension services	Labor availability - numbers - structure - education	Change in soil quality Change in biomass Change in biodiversity Change in land cover Change in carbon storage Change in water quantity & timing Change in water quality & sediment load Change in air quality Change in recreation value	Change in income Change in equity Change in gender equality Change in food security Change in health & nutrition Change in vulnerability Change in human capital Change in employment Change in migration Change in trade patterns

Development Pathways with Potential in Uganda

In this section we lay out informed hypotheses about which development pathways and land uses have potential in Uganda. The identification of development pathways for Uganda that most effectively can increase rural incomes is based on two criteria, among which the first is most important: i) considerations of Uganda's and its sub-regions' international and regional comparative advantage for different commodities, and ii) current patterns and changes in livelihood and land use as outlined in the previous section. The analysis of these potential development pathways follows the classification of economic activities outlined in Table 4 (type of occupation, orientation of activity, crop type, and marketability).

Crops

The main perennial food crop produced in Uganda is *matooke* (cooking banana / plantain). Among the many annual food crops produced are sorghum, millet, cassava, and sweet potatoes. Most of these foods are produced mainly for home consumption ('subsistence') but they are also (increasingly) produced for cash purposes, in which case their marketability becomes relevant. Matooke is perishable and costly to transport relative to its value, due to its high water content. Thus cash crop production of matooke is expected to be more suited to areas of relatively good market access, where production conditions are suitable.[7] Fruits and vegetables are highly perishable and must therefore either be processed close to the farm or produced close to markets. Many annual food crops, such as cereals and pulses, can be dried and stored for extended periods and are somewhat higher in value per unit volume than matooke. They can therefore be produced further from markets. High value storable crops such as coffee and cotton may be profitable even far from markets, although they may also have a comparative advantage in areas of high market access.

Available estimates of domestic resource costs of production for different crops suggest that Uganda still has an international comparative advantage in its traditional export crops, including coffee, cotton (with use of improved technologies), tea and tobacco (NEMA, 1998).[8] Uganda also appears to have a comparative advantage in several non-traditional export crops, including cocoa, cashew nuts, pyrethrum, groundnuts and various vegetables and spices. It does not have a comparative advantage in maize for the world market, but does in the East African regional market. Uganda has a marginal comparative advantage in rice production for the regional market. These estimates depend of course upon prices in regional or international markets, which may turn against

Uganda's competitiveness, but barring that, improvements in productivity and marketing efficiency are expected to increase Uganda's comparative advantages in most of these products (Ibid.).

These considerations of comparative advantage suggest potentials for several types of crop-oriented development pathways in Uganda. These include: expansion and intensification of high-value storable traditional export crops like coffee and cotton and non-traditional export crops like cocoa in areas with climate and soils suited to their production; expansion and intensification of perishable crops like fruits and vegetables in areas of high market access and sufficient rainfall (horticulture); and expansion and intensification of maize for the regional market in areas with sufficient rainfall. Expanding and intensifying production of other bulky food crops for subsistence purposes or for the local market (e.g., matooke, cassava, sweet potatoes) may also be viable development pathways, even if Uganda does not have a regional or international comparative advantage, since such commodities tend not to be tradable over long distances. Such products may have potential as cash crops close to urban centers or for subsistence purposes in more remote areas. Whether the development pathways used for crops are extensive (involving mainly area expansion without significant intensification in use of labor or other inputs) or intensive will depend upon whether land of suitable potential is available for expansion, which depends upon population density and agricultural potential of particular areas, and the availability of suitable technologies for extensification or intensification.

Livestock

Similar considerations apply to production of livestock and livestock products. Intensive production of perishable products such as dairy and fish farming are likely to be suited mainly to areas of high market access and high population density. Extensive production of high value livestock that are relatively easy to transport, such as cattle and small ruminants, can occur in areas far from markets, and tends to have a comparative advantage in areas that are low in potential for crop production. Dairy products may also be produced in such extensive systems in lower potential areas, but high access to collection and processing facilities or to urban markets is essential. Other animals such as pigs and poultry can be raised in many areas, but intensive production for the market is likely to occur mainly close to urban areas, due to economies of scale in production, relatively high costs of transporting them relative to their value, the perishability or ease of damage of some of the products (e.g., eggs) and the use of purchased compound feeds (especially for poultry). In areas where subsistence food production continues to be important (especially more

remote areas of relatively high population density), mixed-crop livestock production is likely to continue (or may develop as population density rises in pastoral systems), with farmers keeping small numbers of animals for plowing, home consumption and as a form of savings. This is because the benefits of exploiting complementarities between crop and livestock production rise as population density rises, particularly where markets are not well developed (McIntire et al., 1992).[9]

Forestry

Forestry production is likely to be suited to areas of low population density, since land scarcity in high-density areas usually causes intensive food or cash crop production to have higher value and higher priority. Production of high value forest products such as timber or pine resin may be economical in remote locations (if suitable road and transport infrastructure exists), while low value products such as fuel wood must be produced close to markets, unless they are used only for subsistence purposes. Conversion of fuel wood to charcoal can extend the marketable range of fuel wood products, however.

Non-Farm

Rural non-farm activities may also offer valuable livelihood opportunities. In most cases, rural employment activities are linked to agriculture. This includes industries processing agricultural commodities (e.g., coffee processing, cotton milling, sugarcane processing, leather tanneries), commodity traders, and individuals and firms providing agricultural inputs. The potential for development of these activities thus depends on agricultural development. Non-farm activities are also more likely to be significant sources of employment in higher population density areas close to urban centers and towns. There are also potentials for rural people to be employed in rural non-farm activities that are not linked to agriculture, such as mining and construction, and in urban areas. Mining activities are presently very limited in Uganda and the overall potential is probably not very large, though there are a few places with notable mineral potential in southwest and southeast Uganda (NEMA, 1998). Construction is likely to be an important source of income in developing urban areas and towns. Urban employment is obviously potentially important mainly close to urban centers.

Classification of Development Domains in Uganda

A development domain is the spatial representation of preconditions (factors) considered important for rural development. In this section we characterize development domains in Uganda using three stratification criteria that we believe (based on theory and previous research) broadly

determine the comparative advantage of rural areas with respect to common livelihood strategies: agricultural potential, market access and population pressure/density. These factors also show a high degree of spatial dependency and therefore lend themselves to spatial analysis (mapping).

Agricultural potential is an abstraction of many factors—including rainfall, altitude, soil type and depth, topography, presence of pests and diseases, and others—that influence the absolute (as opposed to comparative) advantage of producing agricultural commodities in a particular place. There are of course variations in potential depending upon which commodities are being considered. Furthermore, agricultural potential is not a static concept but changes over time in response to changing natural conditions (such as climate change) as well as human-induced conditions (such as land degradation). For simplicity of exposition, however, we will sweep aside these important considerations and discuss agricultural potential as though it was a one dimensional and fixed concept. In reality, the multi-dimensional and dynamic nature of agricultural potential should be considered when developing more specific strategies of development. We have classified agricultural potential in Uganda based on agro-climatic conditions (length of growing season) and altitude, considering production requirements for bananas as an indicator of potential for perennial crops and requirements for maize as an indicator for potential for annual crops. Agro-potential is thus assessed according to whether rainfall is bimodal (two seasons) or unimodal (one season), and within each of these regimes, whether rainfall levels are low, medium or high. The eastern and western highlands have special biophysical conditions for crop and livestock production, due in part to high altitude and steep slopes and are therefore given a unique category.

Access to markets is critical for determining the comparative advantage of a given location, given its agricultural potential. For example, a community with an absolute advantage in producing perishable vegetables (i.e., total factor productivity in vegetable production is higher there than anywhere else), may have little or no comparative advantage (low profitability) in vegetable production if it is far from roads and urban markets. As with agricultural potential, market access is also a multi-dimensional and dynamic concept (distance to roads, condition of roads, distance to urban centers, degree of competition, access to transport facilities, access to international markets, etc.), but we will treat it as a single predetermined variable (though subject to change through investments in roads, for example). To classify market access in Uganda, we used the measure of potential market integration estimated by Wood et al. (1999), which is a measure of travel time from any location to the nearest five towns or cities, weighted by the population of the towns or cities.

Population pressure affects the labor intensity of agriculture by affecting the land/labor ratio, and may induce innovations in technology, markets and institutions, or investments in infrastructure (Boserup 1965; Binswanger and McIntire 1987). Population pressure thus affects the comparative advantage of labor-intensive pathways of development, as well as returns to various types of investments. We take average population density as an indicator of population pressure. Population density was classified based upon rural population density of parishes in 1991 (greater or less than 100 persons per square km., which is about the average rural population density in Uganda).[10]

These three factors interact with each other in complex ways. Population density tends to be higher where there is greater agricultural potential or greater market access, since people tend to move to such areas in search of better opportunities. On the other hand, population pressure may have contributed to land degradation, reducing agricultural potential from what it once was. Market access tends to be better where there is higher population density, since the per capita costs of building roads are lower and the benefits higher in such circumstances. Market access also tends to be better where agricultural potential is higher, since the returns to developing infrastructure are greater. Despite these interrelationships, there is still substantial independent variation of these factors in Uganda. Given such variations, and the fact that these factors change relatively slowly over time, it is useful to classify the regions of Uganda into different development domains according to the spatial distribution of these three factors.

Overlaying these three dimensions of agricultural potential, market access and population density, we can classify different development domains for Uganda (Figure 4). There are 24 possible domains (combining the unimodal medium and low potential), though only 16 are represented to any significant extent in Uganda. Because of correlation among the other factors, some possible combinations do not occur. For example, it is difficult to find places with low market access and high population density (except in parts of the highlands) or high market access and low density (except in lower potential areas).

[Figure 4. Development Domains in Uganda]

Selected Development Strategy Domains / Land Use Options for Uganda

In this section we identify (map) the areas where each development pathway is most profitable from a private perspective. We do this based on spatial variations in the three dimensions of population density, market access and agricultural potential (development domains) described above, which determine the comparative advantage of an area with respect to a certain pathway. We

call these spatial representations of potential pathways “strategy domains”. Strictly speaking, strategy domains are only equal to land use options if the pathway in question involves the use of land-based resources. It is nevertheless useful to map other pathways that do not occupy or make use of substantial land resources, since these may influence land use indirectly. For example, growth in rural industry can influence agricultural land use by providing farm households with alternative incomes.

Figure 6 and 7 depict a sample of ten land use options for Uganda. The different colors represent different aggregated development domains (shown in Figure 5), i.e. unique combinations of market access, population density and agricultural potential. Areas that enjoy high levels of agricultural potential and market access are suitable for several strategies (e.g. those represented by the green color in Figure 6, left map), while others can only support a single strategy (e.g. the red-colored area). Conversely, ‘flexible’ strategies (e.g. intensification of subsistence food crops) can be pursued in larger and more diverse spatial contexts than strategies more demanding in terms of climatic, market or other enabling factors (e.g. intensification of perennial cash crops).

[Figure 5. Aggregated Development Domains - Components for Selected Potential Land Use Strategies]

[Figure 6. Sample of Agriculture Based Potential Land Use Strategies (Extensification & Intensification)]

[Figure 7. Sample of Non Agriculture-Based Potential Land Use Strategies (Forestry and Rural Industry)]

Figure 6 shows the spatial extents of eight agriculture-based potential land-use strategies. For clarity of exposition, the strategies were aggregated into those based on subsistence crops, annual and perennial cash crops, and livestock. The left map in Figure 6 thus shows locations of low population densities (< 100 persons/km2) where extensification strategies are most profitable and the right map shows locations where intensification strategies appear more profitable and feasible. Extensive crop and livestock strategies are expected to have comparative advantage mainly in low population density areas, while intensive strategies are appropriate to high-density areas. This is because area expansion normally requires lower labor inputs per hectare and per unit output than does agricultural intensification, which among poor farmers depends on high labor inputs. The maps show that the primary areas for agricultural intensification are located in southwestern Uganda, and in a widening band of 50 to 100 km around Lake Victoria from the Tanzanian border

to the Kenyan border, respectively ("the Lake Victoria band"). The primary areas for extensification, by contrast, are located in a band starting from the shore of Lake Albert and heading eastward to encompass the Lake Kyoga basin ("the Lake Albert – Lake Kyoga band"), as well as in much of the far north and northwest (orange and light-green colors).

The distinction between agricultural intensification and agricultural expansion is especially important from an environmental perspective. The new SO7 strategy emphasizes investments in sustainable agricultural intensification, with the dual purpose of raising rural productivity and slowing down (avoiding) agricultural expansion into areas with fragile soils and high levels of biodiversity. However, environmentally responsible agricultural expansion may be the only feasible option in areas of low population density, where intensive land-use practices is likely to be less feasible due to labor shortages. Instead, labor saving and 'expansionary' technologies such as animal traction may be promoted, given that they do not conflict with environmental conservation objectives.

In terms of market access, perishable crop and livestock products must be produced close to markets, while storable crops may be produced in areas of either high or low access (the distinction between storable and perishable crops and livestock products is not shown on the maps). Subsistence food crops may be produced either close to or far from markets. As for agricultural potential, perennial crops are expected to be suited more to the bimodal rainfall regions while longer duration annuals (such as maize) are suited to all regions except the bimodal low rainfall region (though having higher potential in the areas classified as high rainfall than those classified as medium or low).

Forestry and rural industry pathways are shown on Figure 7. Forestry activities are expected to have comparative advantage mainly in low population density areas of at least medium rainfall, with low value products requiring good market access (if production is for cash purposes) while high value products may be produced in areas of either high or low access. Rural industry (whether or not linked to agriculture) will be most common in more densely populated areas close to markets and towns, while urban employment is likely to be common mainly close to Kampala.

The development pathways and land uses outlined in this section should be seen as positive predictions of rural development in Uganda. They are based on secondary data sources, a rapid appraisal of major farming systems in Uganda, and the characterization of development domains based on research and experience from other regions (Ethiopia, Honduras, East African Highlands).

Further analysis is needed to validate and refine these potential pathways and land use options. The analysis of current pathways and land uses in section 2.2 is the first step of this work.

2.4. PLANS FOR PHASE II

The current development pathways and land use changes in Uganda identified in Section 2.2 are based on a preliminary analysis of IFPRI's community survey, as mentioned earlier. In phase II we plan to validate the results of the community survey with detailed information at the household and plot level collected by IFPRI in the 107 communities, as well as with secondary sources. It is also planned to produce GIS maps of current development pathways and land use changes. Amongst other things, we will be able to validate the best land use options against the current land use practices of the more successful farmers and communities in different types of areas. This will result in more narrowly defined strategy domains (land use options), based on a finer analysis of constraints and opportunities for land use development in Uganda. These domains will possibly also be more fragmented, reflecting more accurately the spatial heterogeneity of development pathways and their preconditions in rural Uganda.

We also plan to conduct in-depth case studies in selected areas where the development pathways and land use patterns identified so far seem particularly promising or concerning in terms of their impact on the environment, economic growth, and/or poverty. Such studies would be formulated together with USAID/Uganda and its partners to ensure that they address issues and cover regions that have high priority. For example, results from the community survey suggest that the "increase in coffee and banana production" pathway is associated with improvements in agricultural productivity (at least for bananas), human welfare, and natural resource conditions. Yet to fully understand the magnitude, causes and strategic planning implications of these apparent synergies require that we apply more intensive research methods focused on that particular pathway. Another type of case study would examine the interactions of several emerging pathways in a specific region of high priority for USAID (e.g. southwestern Uganda), and their combined impact on rural productivity growth, poverty, and the environment. Finally, building on findings of the community survey (reported in: Jagger, 2001; Jagger and Pender, 2001; Nkonya, 2001), a set of case studies would specifically assess the importance of social capital (particularly the effectiveness of local government, local property rights arrangements, and the ability of communities to organize successfully for collective action to manage natural resources and to access markets) for different types of development pathways and land uses, and the implications for policy and program design.

Finally, phase II will involve a geographical expansion of the community, household, plot and marketing surveys to the "insecure" West Nile, western, and northern regions of Uganda. The surveys will be conducted in the districts of Nebbi, Arua/Yumbe, Gulu, Kitgum/Pader, Hoima, Masindi, and Bundibugyo, and include 40 communities, 160 households, and 150 traders. Analyses of the survey results will emphasize land use and livelihood options related to coffee and cotton.

3. CHARACTERIZING THE NATURE AND VALUE OF ECOSYSTEM GOODS AND SERVICES AT DIFFERENT LOCATIONS

3.1. INTRODUCTION

The second step or component of the framework is a spatially explicit characterization of the services and, to a lesser extent, goods provided by managed and natural ecosystems in Uganda.[11] The "ecosystem goods and services" approach emphasizes how people depend on ecosystems on a daily basis, and that ecosystems produce a wide array of goods and services (aside food and raw materials), which are essential to human welfare (WRI, 2000). Thus, while Section 2 focused on the direct benefits (i.e. food and raw materials) that local people derive from managed agroecosystems, in this section we are mainly concerned with the indirect benefits that society at large derives from both natural and managed ecosystems, and with the direct benefits that may be derived from natural ecosystems without destroying the latter. This set of analyses is placed in the framework at the same level as the analyses identifying the best "private" land use options outlined in Section 2.[12] The two clusters of analyses form the basis of identifying areas of potential conflict or complementarity between individually-desired land use options and social concerns for conserving or rehabilitating important ecosystems and their physical and biological attributes. This will in turn help us to identify the "best" mix of improved land use options for Uganda, and a corresponding "best" spatial mosaic of productive and biodiverse ecosystems.

The main purpose of the ecosystem characterization is thus to locate and characterize ecosystem goods and services that benefit or are of interest to larger groups of people ("stakeholders", "actors", or simply "society") in the medium and longer term, as compared to goods and services that are appropriated now or in the immediate future by individuals, households, or firms. We will locate and identify the most important among such ecosystem goods and services, and determine the temporal and spatial scales of their impact. This involves locating and characterizing the various biological and physical components or attributes of ecosystems (vegetation, soils, water, etc) that enter into the provision of ecosystem goods and services.[13] In order to systematically assess and compare the importance of different ecosystem goods and services across space, we will also assign relative, and where appropriate, absolute values to ecosystem goods and services in different places.

Identifying "public" ecosystem goods and services implies a focus on the *indirect* benefits of ecosystems (WRI, 2000: 11). Indirect benefits take mainly the form of services, such as water and nutrient cycling, erosion control, carbon sequestration, and provision of habitat for wild plants and animals, but they include also ecosystem goods such as wild plant and animal genetic resources. Indirect benefits are rarely assigned explicit opportunity costs or market values because they are not (yet) traded in the marketplace and cannot easily be substituted for goods and services that are. Indirect benefits therefore seldom influence private land-use decisions. Direct benefits of (natural and managed) ecosystems are "harvested" largely from plants and animals in the form of food and raw materials. They are thus the most familiar 'products' of ecosystems: crops, livestock, timber, fuel wood, fodder, minerals, etc (WRI, 2000: 11). The vast majority of these goods are traded in the market, especially those provided by agroecosystems, or have a high degree of substitutability with traded goods, and so are explicitly valued by land users and factored into their land use decisions.[14] This being said, ecosystem goods provided by *natural* ecosystems, such as medicinal plants and other nontimber forest products, are often ignored in land-use planning and program design. This is because their circulation and use are restricted to local communities; to the informal sector; and to "traditional" forms of consumption (e.g. herbal medicines); and because they are traded through informal channels. Yet experiences from e.g. SAFIRE and SANProTA[15] projects in southern Africa show that some of these goods have much larger commercial and export potentials than are currently realized, which may be tapped by their transformation into marketable products and the establishment of effective marketing chains (Gus Le Breton, p.c.). In the present assessment we will therefore locate and assess actual and potential direct benefits to local people of the goods and services of natural ecosystems in situations that sustain the capacity of the ecosystem to provide the goods and services. We term such benefits nature-based livelihood options. Like the indirect benefits of ecosystems, these potential direct benefits will be factored into the analysis establishing the "best" land use mixes from a societal point of view.

Let us briefly outline the background for why it is so important to characterize ecosystems and their goods and services as a means to promote sustainable land use in Uganda. Here, as elsewhere in the World, the intensification and expansion of agriculture is by far the most important process affecting the capacity of managed and natural ecosystems to provide goods and services. In very general terms, under agricultural expansion natural ecosystems are converted into managed agroecosystems. Through this process the provision of goods is reduced to a few products of higher value to local people, but with the effect that indirect benefits and the provision of services is

reduced in quality and quantity. Agricultural intensification, in most cases, reduces the capacity of agroecosystems to provide services and indirect benefits, while the value of goods and direct benefits is increased. The problem, however, is that agricultural expansion and intensification in Uganda appear to be conducted in ways that result in socially sub-optimal land uses, in the sense that more indirect benefits and services are sacrificed (for the present and the future) than is "technically" necessary to obtain the desired increase in the value of direct benefits. To assist planners in reversing this trend, analyses of ecosystems goods and services must thus locate, identify and evaluate the goods and services provided by natural and managed ecosystems in order (a) to establish the potential cost of land conversion and land use intensification in different areas in terms of reduced indirect benefits, and (b) to identify ways in which local people can increase the value of direct benefits from natural ecosystems through improved management and business strategies.

In summary, locating and evaluating *indirect* benefits of natural and managed ecosystems will be used in the analysis of potential environmental impacts (changes in soil quality, biodiversity, habitats, carbon levels, etc.) of land use changes, especially the threat to natural ecosystems posed by the expansion and intensification of agriculture and forestry ("threat" analysis). In this regard we are particularly concerned with identifying "hot spot" areas where the potential tradeoffs between agricultural development and natural ecosystem conservation are especially high. Locating and evaluating potential *direct* benefits of natural ecosystems will be used to identify those ecosystem attributes and areas, which present favorable conditions for nature-based livelihood options ("opportunity" analysis).

3.2. SCALE ISSUES IN ECOSYSTEM ANALYSIS

Scale is a key factor in land-use and ecosystem analysis. The temporal and spatial scales at which we study patterns and dynamics of land use and land cover directly affects our evaluation of the performance, resilience, sustainability, and severity of degradation of land use systems in different areas (Reenberg, 1998). The evaluation in turn influences policies and investments directed at raising the productivity and sustainability of land use.

Scale is important because different ecological processes occur at a continuum of different spatial and temporal scales. There is also a correspondence between the temporal and the spatial scales of the processes (Izac and Sanchez, 2001: 9). Processes occurring at the macro spatial level, such as biochemical changes in the atmosphere that influence global climates, tend to occur over

longer periods of several decades or centuries. Meso-level processes, such as the competition for space and light and nutrient uptake by trees in a forest patch, may occur over one or a few years, and micro-level process, such as nutrient mineralisation in soils and photosynthesis in leaves, have faster process rates of days. Processes at one level (e.g. forest patch) are influenced by higher-level processes (e.g. climate change) and are determined by what happens at lower levels (e.g. nutrient mineralisation). These interdependences among ecological processes occurring at different scales means that we must adopt multiple levels or scales of analysis, and at least include the levels immediately above and below the level of focus (Izac and Sanchez, 2001).

Ecosystem goods and services likewise have important spatial and temporal dimensions, since they are expressions of, or result from, ecological processes. In other words, ecosystems attributes yield goods and services at different spatial scales. For example, fruit trees produce food/incomes and enhance erosion control (among other services), which have impact at the local (farm, micro-watershed) level, and they contribute to carbon storage, which affects global climate regulation.

It is practical to organize the local-global continuum of the World's ecological systems and processes in a hierarchy of levels, where each system or process is 'nested' in a higher-level system and in turn encompasses systems of a lower order. The term 'hierarchy' here may be understood as having the structure of a living tree or river system: a multi-leveled, stratified, out-branching pattern of an organizational system, dividing into subsystems of lower order (Reenberg, 1998, citing Naveh & Lieberman, 1994).

Socio-economic processes or systems that influence or are influenced by ecosystem processes may likewise be ordered in a spatial hierarchy of levels, such as that comprised of the local, regional, national, and International levels. Yet there is rarely a perfect or even good match between the levels where interrelated socioeconomic and ecological processes occur. This reinforces the need to examine such interrelationships at and across different scales. A starting point may be to examine how the scale impact of a particular ecosystem good or service relates to the social distribution of the benefits derived from it. For example, the beneficiaries of fruit production are local tree owners and consumers of marketed fruit; the beneficiaries of soil erosion control include the landowner and farmers living down-slope from the fruit tree stand; and the beneficiaries of the carbon sequestered by fruit trees include the World population.[16] Different groups of people in different places thus have different types and levels of interest in particular stocks of natural capital and will therefore value their associated ecosystem goods/services differently.

3.3. IMPLEMENTING THE ECOSYSTEM GOODS AND SERVICES APPROACH

How do we apply the above concepts and principles to analyses of ecosystem goods and services that are useful for the assessment of strategic land use options at the national and regional levels in Uganda? Implementing the ecosystems goods and services approach in this case involves a number of tasks and methodological choices: classification and delineation of ecosystems based on relevant and uniform criteria; identification of relevant ecosystem attributes; identification and evaluation of the goods and services provided by these components; choice of appropriate scales for data analysis; and methods for extrapolation of information to higher scales or other systems at the same scale. The feasibility and soundness of such analyses also depends on data availability and quality, including the geographical coverage, resolution and grain of the data. The organization of data in a hierarchical, spatial database is a key factor for all these tasks. Below we provide a preliminary discussion of these questions in relation to the assessment of strategic land use options for Uganda. The phase II reports will treat them in further detail.

Our general task is to characterize the primary ecosystem goods and services in Uganda in terms of their type, magnitude, relative or absolute value, location, spatial and temporal scales of impact, and social beneficiaries. The primary goods and services provided by the World's terrestrial ecosystems may be broadly classified as follows: food/fibers production; water quality; water quantity; air quality; biodiversity; carbon storage; recreation; and wood fuel production (WRI, 2000). These types and the more detailed list goods and services provided in WRI (2000: 9), are useful guides for the identification of the goods and services provided by ecosystems in a particular region or country. In the present context we want to focus on those goods and services that are most important and critical for ecosystem maintenance and local livelihoods in Uganda. The characterization will thus emphasize, but not be limited to, goods and services that provide direct utilities and income opportunities for local people, and goods and services that have the strongest potential effect on Uganda's endangered and endemic animal and plant species.

We also need to define the major ecosystem types and subtypes in Uganda and outline their spatial boundaries. The overall classification of Ugandan ecosystems follows the terminology used by the Pilot Analysis of Global Ecosystems (PAGE) project (WRI, 2001): agroecosystems, grassland ecosystems (savannah), forest ecosystems, montane ecosystems, and fresh water systems. Adopting this terminology is useful for placing Ugandan ecosystems in a wider (regional and global) context.[17] However, we will in many cases further subdivide these major ecosystem classes

so as to enhance the relevance of the analysis for interventions at the national and sub-national levels. The definition and delineation of Ugandan ecosystem subtypes are, however, to some extent governed by the structure of available, spatially explicit data with a national coverage. Two such data sources exist for Uganda: the National Biomass Study (1996) land cover/use classification (13 major land cover classes), and the Langdale-Brown (1964) vegetation classification (22 major vegetation types). While the former data have a higher spatial resolution and are more up-to-date (1989-91), the Langdale-Brown data are more useful for the characterization of natural ecosystems, since they describe the distribution of many different natural plant communities. Also, the National Biomass Study land cover/use classes were defined with the primary objective of assessing and monitoring biomass stocking levels, which is why the thematic resolution is coarse compared with the richness of ecosystem types found in Uganda. We use these two data sources in combination to produce ecosystem subtype 'base maps' to which we can add and link other environmental information.

We will then identify and locate the specific ecosystem components that are known or likely to provide the goods and services we are interested in. In this regard we draw on several biological data sources: biodiversity data bases, plant and animal inventories, biodiversity assessments of protected areas, listings of endemic and endangered plant and animal species (these lists include mainly trees, birds, and mammals since there is only little information on other species in Uganda), listings of critical habitats, counts of tourism-related mammals, and so on. We will also use data on the different elements of the physical environment: temperature and rainfall, soil, hydrology, relief, and so on. From this information we will be able to identify the major types of ecosystem goods and services provided by Ugandan ecosystems. And by using GIS we can establish the actual or likely geographical location of these goods and services: directly by mapping those data that are already georeferenced, and indirectly by associating non-georeferenced information with already mapped biophysical attributes such as ecosystem subtypes, vegetation classes, soil units, climate zones, etc.

The perhaps most difficult aspect of the characterization is the valuation of ecosystem goods and services. In this regard we will mainly assign relative values (high, medium, low), but in a few cases we will estimate the 'dollar' value of ecosystem goods (e.g. revenues from nontimber forest products) and services (e.g. value of carbon sequestration). The characterization of ecosystem goods and services will relate to several geographical levels: international, regional, national, and subnational. The regional and subnational levels of analysis do not necessarily follow political and

administrative boundaries but rather the larger spatial units commonly used in environmental analysis: ecoregion (e.g. the Albertine Rift), ecosystem type (e.g. grasslands), landscape (e.g. the southwestern highlands), and watershed.

Many of the analyses described above will be carried out in phase II, while more detailed, sophisticated or data-demanding analyses will await a third phase of research and may cover only selected areas and ecosystems. Phase I includes two very simple characterizations of ecosystem goods and services, which will be used in the identification of environmental impacts in Section 4: land cover and protected areas (as a proxy for plant/animal communities or biodiversity), and soil quality (as an example of the physical environment of plant/animal communities and natural resources for production).

3.4. BIODIVERSITY: LAND COVER AND PROTECTED AREAS

Spatial information on land cover/use and protected areas is a useful first step towards (i) assessing the potential negative impacts on biodiversity and other biological ecosystem attributes of agricultural expansion; (ii) identifying potential opportunities for nature-based livelihoods; and (iii) identifying areas suitable for environmental rehabilitation. Figure 8 maps such information for Uganda. It is based on data generated by the National Biomass Study (1996) and Uganda Wildlife Authority (Lamprey et al., 1999), and on spatial data on Uganda's national parks and major forest reserves (Corbett, 1999). The aggregated land cover/use classes shown in the map are: broadleaved tree plantations; coniferous plantations; well-stocked tropical high forest; depleted tropical high forest; woodland; bushland; grassland (incl. rangelands, pastureland, open savannah); wetland; subsistence farmland; commercial farmland; built up areas; open water; and impediments. Figure 8 also highlights areas that we find may have special environmental significance in Uganda. These are forests, woodlands, and wetlands (boxed in the legend); and protected areas classified according to their conservation importance, following UWA's assessment (Lamprey et al., 1999). These categories should be seen as crude approximations of environmentally-desired land uses. They do not, for example, help us identify areas suitable for environmental rehabilitation, or locate the occurrence of endangered and endemic species.[18] In phase II we will enrich this analysis by using more detailed information on land cover, ecosystems, and biodiversity, and we will standardize and link this information to more detailed mapping units.

[Figure 8: Land Cover and Protected Areas in Uganda]

3.5. PHYSICAL ENVIRONMENT: SOIL QUALITY AND RELIEF

The attributes of the physical environment, which are important for the productivity and stability of ecosystems, include climate, relief, soils, hydrology, physical structures, and fire. In phase I, the assessment of the physical environment of plant/animal communities (including crops and livestock) is limited to spatial information on soils and relief. Such information is useful for assessing the potential soil degradation effects of agricultural expansion and intensification. In phase II we will enrich the mapping of Uganda's physical environment, using better, spatially referenced data on soil constraints (e.g. soil nutrient balances), rainfall, relief, and other physical attributes for which data is available.

Soil physical properties are used as a proxy for inherent soil quality. In this example we use sand content, i.e. the proportion of sand in the soil, as a simplified measure of (poor) soil physical properties and hence (low) soil quality. Compared with clayey soils, sandy soils have lower inherent fertility and water holding capacity, and they tend to be more susceptible to water erosion.[19] Figure 9 shows the sand content of soils for different areas in Uganda. Darker colors indicate a larger share of sand and hence soils that are less fertile, less drought resistant, and more easily erodible. A quick glance at the map suggests that about half of Uganda's soils contain between 55 and 85 percent sand. Most sandy soils are situated in northern Uganda, while lands around Lake Victoria have relatively high quality (loamy / clayey) soils.

[Figure 9: Sand Content in Ugandan Soils]

Relief affects soil conditions by influencing soil erosion (up slope) and soil deposition (down slope). Soil erosion also causes siltation of waterways and wetlands down slope and reduces/alters thereby the hydrological services/functions of freshwater systems. The left-hand map in Figure 17 (Section 4.2) shows the distribution of slope classes in Uganda. Relatively large land areas with steep slopes are found in the southwestern highlands, in the Rwenzori mountains in western Uganda, on Mount Elgon in eastern Uganda, and along the northeastern border to Kenya. The coarse grain of these data limit their practical value because slope is a land attribute that varies greatly and abruptly over small distances. Higher-resolution data would thus reveal many more, smaller areas of steep-sloping lands and associated risks of soil erosion. Such data are available for Uganda and will be applied in phase II analyses for selected areas – particularly southwestern Uganda.

4. IDENTIFYING THE POTENTIAL ENVIRONMENTAL IMPACTS OF "PRIVATE" LAND USE OPTIONS AT DIFFERENT LOCATIONS

4.1. INTRODUCTION

Building on the previous sets of analyses, the third step in the framework identifies and locates the potential environmental impacts (positive or negative) of different land use options at different locations. The key analysis here is the systematic assessment of the potential environmental threats (negative impacts) associated with different land use strategies, such as decreases in soil quality, biodiversity, habitats, water availability, and carbon levels brought about by the expansion or intensification of agriculture. In particular we want to identify "hot spot" areas where there is a high degree of conflict between individually-preferred ("private") land use options and environmental goals. But we are also interested in identifying the areas that present the most favorable conditions for "win-win" strategies that reconcile local livelihood and environmental interests. In phase I we focus on the identification of negative environmental impacts, while phase II will also examine the natural environment in terms of its economic resources (e.g. medicinal plants).

4.2. POTENTIAL ENVIRONMENTAL CONFLICTS BY LAND USE OPTION

By overlaying maps of the best "private" land use options (Section 2) with maps of environmentally-desired land uses (Section 3), we can identify areas with different degrees of potential conflict between these two goals. We distinguish here between three types of areas: (i) those where there is no conflict between private and environmentally-desired land uses but where environmental rehabilitation may be desired; (ii) those where there is a direct conflict with existing protected areas; and (iii) areas where there would be a potential conflict if environmentally valuable but currently unprotected areas were threatened. Below we provide some examples of these situations. As an approximation of environmentally-desired land uses we use the map in Figure 8, which depicts existing land cover/uses and highlights environmentally significant areas. We define the latter as protected areas (forest reserves, national parks, wildlife reserves) and ecosystems of high conservation potential (forests, woodlands, and wetlands).[20] The "private" land use options are those identified in Section 2 and spatially represented in Figures 6 and 7, i.e. the land uses that are most profitable for individual farmers given the comparative advantages of the areas they live in.

[Figure 10: Environmental Feasibility of Agriculture-based Land Use Options ("Hot Spots")]

Figure 10 shows an overlay of existing land cover/uses and land-use options based on the expansion and intensification of agriculture respectively. The orange color in the maps indicates areas of high feasibility for agricultural expansion or intensification that do not conflict with potential or existing conservation areas, but where environmental rehabilitation and improved natural resource management nevertheless might be desirable. The purple color shows 'feasible' areas of intensification or expansion that conflict with potential conservation goals but not with existing protected areas. The green color represents a clear case of conflict between agricultural expansion or intensification and environmental conservation (low feasibility areas or "hot spots"). The maps suggest that Uganda, and particularly northern Uganda, has large areas where agriculture may be expanded without degrading areas that are environmentally very significant according to the above definition. As expected, agricultural intensification does not conflict with the conservation of forests, wetlands and protected areas. Agricultural expansion options, on the other hand, are in potential conflict with virtually all protected areas in the country (green colored areas). The highest pressures on protected areas are likely to be in southwestern and western Uganda (along the Albertine Rift) where the agricultural potential is relatively high (bimodal medium and high rainfall), while the protected areas in northern Uganda are situated mainly in areas of low rainfall. In the latter areas most conflicts are likely to be between pastoralism and wildlife and forest conservation, although this combination of land uses does offer potential win-win arrangements.

The maps also suggest potential conflicts between agriculture-based land use options and the conservation of unprotected natural ecosystems such as wetlands, forests, and woodlands (purple color or "warm spots"). Such areas require special attention because of their lower degree of legal protection and because they tend to be ignored by environmental interest groups. There are, for example, many small patches of high or semi-depleted tropical forest scattered throughout Uganda, whose exact locations and conditions are largely unknown (Robert Buzzard, personal communication). Area-wise they are dominated by woodlands, while forests and wetlands cover a smaller area. They are situated mainly in the west-central (e.g. Luwero, Kiboga, Kibale, and Masindi districts) and northeastern (Kitgum, Moyo and Arua districts) parts of the country. The highest pressures from agricultural expansion on these areas is likely to be in the west-central parts due to better rainfall conditions and shorter distance to urban markets for agricultural produce.

Figures 11-15 illustrate similar analyses for each type of agricultural expansion strategy and for livestock and forestry land uses. These maps are particularly useful at the stage when planners have

to choose among more specific types of land-use strategies and will thus help in the geographical targeting of interventions.

[Figure 11. Environmental Feasibility of Expansion of Annual Cash Crops ("Hot Spots")]

[Figure 12. Environmental Feasibility of Expansion of Perennial Cash Crops ("Hot Spots")]

[Figure 13. Environmental Feasibility of Expansion of Subsistence Food Crops ("Hot Spots")]

[Figure 14. Environmental Feasibility of Expansion of Livestock Production ("Hot Spots")]

[Figure 15: Environmental Feasibility of Expansion of Forestry ("Hot Spots")]

It is well known that agriculture profoundly effects soil quality, in most cases negatively through soil fertility depletion and/or soil erosion. Soil degradation has long-term negative economic effects on farmers and local communities, through declining yields and lower returns to labor (which is not always the case for the loss of biodiversity), although such effects may be felt only very slowly. The potential impact on soil quality of altered land use practices depends on the inherent physical, chemical and biological properties of the soil, as well as on the relief (slope) and climate of the land. The interactions between changes in land use and changes in soil properties are thus extremely complex. In this report we give a simple example of how information about the properties of soils in different locations can be used to assess the potential environmental impact of different land use options. We use sand content, i.e. the proportion of sand in the soil, as a simplified measure of (low) inherent soil quality. Compared with clayey soils, sandy soils have lower inherent fertility and water holding capacity, and they tend to be more susceptible to water erosion.[21] The map on the left in Figure 16 shows the sand content of soils for different areas in Uganda. Darker colors indicate a larger share of sand and hence soils that are less fertile, less drought resistant, and more easily erodible. It suggests that about half of Uganda's soils contain between 55 and 85 percent sand. Most sandy soils are situated in northern Uganda, while lands around Lake Victoria have relatively 'good' (loamy / clayey) soils.

On the maps in the center and right-hand side of Figure 16, we have overlaid the "sand content" map with the maps in Figure 6 showing potential areas for agricultural expansion and agricultural intensification respectively (the light-blue color indicates areas that are not suitable for agricultural expansion or intensification). Thus, if using "high sand content" as an approximation of high soil fragility/low soil fertility, agricultural expansion is in potential conflict with soil conservation objectives especially in the far north of Uganda, and, in economic terms, is particularly constrained by low inherent fertility in that area. This being said, most potential areas for agricultural expansion

are characterized by soils with a relatively high sand content, which is to say that farmers, not surprisingly, so far have kept out of these lands. The map on the right suggests that agricultural intensification is in potential conflict with soil conservation especially in Eastern Region and to a lesser extent in southwestern Uganda. Conversely, it appears environmentally sound to intensify agricultural land use along the shores of Lake Victoria and in the extreme southeast of the country.

The same type of analysis can be made for the potential soil-erosion risks associated with expanding or intensifying agriculture on steep sloping lands. In the center and right-hand maps of Figure 17 we have overlaid the slope map on the left with the maps in Figure 6. The maps show, for example, that large areas in southwestern Uganda with potential for agricultural intensification are situated on steep hillsides and are thus highly prone to soil erosion. And in Central Uganda (Mubende District) we find conflicting overlaps between steep-sloping lands and areas with potential for agricultural expansion.

[Figure 16. Potential Soil Degradation Effects of Agriculture-based Land Use Options (“Hot Spots”)]

[Figure 17: Potential Soil Erosion Effects of Agriculture-based Land Use Options (“Hot Spots”)]

5. IDENTIFYING INTERVENTIONS FOR MORE PRODUCTIVE AND ENVIRONMENTALLY SOUND LAND USE SYSTEMS

5.1. INTRODUCTION

Steps 4 and 5 of the framework identify and analyze response options for improved growth, environment, and poverty reduction outcomes, i.e. responses that are likely to achieve socially-desired land uses that reconcile socio-economic and environmental objectives. This section presents the analyses comprising step four, which identifies policy instruments (regulations, compensation, new technologies) and associated public investments to promote more productive and environmentally sound land use systems. Step five, presented in Section 6, assesses the likely local and aggregate socioeconomic and environmental impacts of the these improved land use options and land use "mixes". The results from the latter analyses are likely to suggest that we go back and adjust the interventions and incentives identified in step four; an iteration of the two sets of analyses are thus required. These analyses will result in the identification of the best land uses for each area: either the best private use, or the best compromise between private and environmental interests.

The general question addressed here is what society can do to change incentive structures and investment patterns so as to promote more sustainable development pathways without jeopardizing local livelihoods. Our phase I analysis is largely intuitive in this respect and serves to outline the approach that will be implemented fully in phase II. We find that there are three types of policy instruments that can be deployed to achieve more environmentally sustainable land uses. These are regulation (including collaborative and participatory arrangements and local collective action), compensation (any form of external support that compensates farmers for the costs of adopting more sustainable practices), and new technology.

As an illustration of how one might reconcile private and environmental goals, we select two of the environmental "hot spot" areas identified in Section 4 for further analysis. The first example is about the potential effects on fragile soils of agricultural intensification in a densely populated area. The second example examines the potential impact on natural vegetation of agricultural expansion in an area of low population density. In each case we discuss the suitability and effectiveness of the three policy instruments.

5.2. EXAMPLE I: SUSTAINABLE AGRICULTURAL INTENSIFICATION IN THE SOUTHWESTERN KIGEZI HIGHLANDS

In the densely populated southwestern highlands, soil conservation on steep hillsides is in potential conflict with agricultural intensification. This conflict is complicated by the fact that livelihood-enhancing agricultural intensification would be one of the ways to prevent the expansion of farmland into the region's forests that are very rich in biodiversity and provide habitat for a unique population of mountain gorillas. Southwestern Uganda is characterized by high market access (low in a few locations), high population density, and high to medium bio-modal rainfall (see Figure 4 and 5). Soils are of volcanic origin and hence of high inherent quality/fertility; yet continuous cultivation on steep slopes and with little use of external inputs have resulted in severe soil erosion and soil fertility depletion. The area has potential for several "private" land use strategies, including the intensification of subsistence food crops, annual and perennial cash crops, and dairy production. Rural industry is also a suitable option given the combination of very high population densities and high market access.

Intensifying agriculture on steep hillsides without causing severe soil erosion normally requires terracing and a cropping system that ensures that soils are continuously covered with vegetation or mulch. Yet both types of practices require considerable skills, labor and/or capital investments, and land for terracing and "green fallows". We cannot therefore expect that resource-poor and time-constrained farmers are able or willing to maintain soil quality in the longer term. Indeed, in areas such as the southwestern highlands where farming conditions are difficult and fields are small and fragmented, farmers may well find it most profitable to choose a livelihood strategy that combines low input and soil-eroding agriculture with off-farm work and extraction of wild plants and animals from surrounding forests.[22] Such a development pathway is obviously not desirable from a social perspective (which factors in the value of environmental services and the forgone income of future generations) but it is a very likely scenario if no action is taken. The question is therefore what can be done to achieve more sustainable development pathways in southwestern Uganda without jeopardizing local livelihoods, i.e., how private and environmental objectives can be reconciled under the particular conditions prevailing in that area.

The development of agroforestry practices in the southwestern Kigezi highlands by AFRENA, AFRICARE and other organizations is a good example of how the "new technology" type policy instrument may be applied to reduce the trade-offs between agricultural productivity and soil

degradation. The AFRENA project is promoting contour hedges of exotic shrubs such as *Calliandra calothyrsus* for soil erosion control, and rotational woodlots/fallows of *Calliandra*, *Sesbania sesban* and *Alnus acuminata* for fertility replenishment and wood production (Siriri and Raussen, unpublished). As a result farmers are now modifying the traditional terrace use systems to incorporate tree/shrub planting with crops. Terrace bunds are increasingly being planted with hedgerows while the upper degraded terrace part, which produces negligible crop yields, is being put under rotational woodlots and fallows. In terms of the private benefits from these 'conservation' strategies, a financial analysis of improved tree fallows shows net benefits of 53-111 US$ per hectare per year and 0.6-0.8 US$ per man day (Ibid.). This estimation factors in the cost of labor and seedlings but not the public funds invested in promoting and developing the tree fallow technologies. Public (social) benefits of adoption of improved tree fallows such as consumer benefits from increased crop and wood production, and increased carbon sequestration should also be estimated when balancing private and social cost and benefits of changes in land use. In this regard, Siriri and Raussen (unpublished) reports on an AFRENA-led study from the region estimating that soil carbon changes under rotational woodlots increase by approximately three tons of carbon per hectare per year. So, if an international system of carbon credits was established, wood producing farmers in southwestern Uganda could also be rewarded for their carbon-sequestering services (Ibid.). This would increase the private incentives for adopting sustainable land use practices and create a true win-win situation, which integrates community livelihood goals with global environmental concerns.

The question now is of course to what extent new farm technologies such as agroforestry are sufficient instruments to preserve soils and soil fertility while reducing poverty, given the constant pressure on very scarce land resources caused by population growth, and the increased role of cash in farm household economies to cover e.g. children's health and education. Experiences from other densely populated areas in Africa, e.g. Western Kenya and the Machakos district in Kenya (Tiffen et al, 1994), suggest that access to off-farm incomes can positively influence sustainable land use by providing farm households with cash for land investments and reproductive needs without using local natural resources. Such a development pathway (rural industry / off-farm diversification) requires investments in infrastructure (e.g. roads and electricity), vocational training, marketing services, etc. While such interventions may seem very expensive, the cost per household of infrastructural development decreases with rising population densities and therefore appears appropriate for southwestern Uganda.

5.3. EXAMPLE II: WOODLAND CONSERVATION UNDER AGRICULTURAL EXPANSION IN CENTRAL REGION

The second example is from Luwero and Kiboga Districts in Central Region, which contain a large area of woodlands / wooded savannas and some forests. The area is characterized by low population density, bio-modal medium rainfall, and high to low market access. From a private perspective it is therefore potentially suitable for several extensification land-use strategies, including expansion of annual and perennial cash crops (storable, and perishable in the locations of good market access), expansion of subsistence food crops, expansion of livestock production, and forest-based production. The current land use system includes cropping and extensive livestock production. The area also serves as an important source of fuel wood, which is converted into charcoal before being exported out of the area, mainly to Kampala. As discussed earlier, in Uganda the expansion of farmland onto land covered with forests and woodlands and other natural vegetation is the prevailing method of increasing food and cash crop production in areas where uncultivated land is available. Expansion is more prevalent than intensification because it is less costly for the individual farmer (in terms of labor and capital inputs) to increase production by expanding his/her fields than it would be to increase production on existing fields. Another factor contributing to agricultural expansion is that individual farmers and local communities benefit relatively little (or so it appears) from the services of natural vegetation compared with what they gain by converting it into farmland or fuelwood.

Therefore, to reverse the imbalance between agricultural expansion and intensification in places like Luwero District, we must introduce measures that, on the one hand, lower the cost of intensification and, on the other hand, increase the benefits to communities and farmers of the services of natural vegetation while making individuals bear the social cost of clearing this vegetation. For example, lowering the price that farmers pay for chemical fertilizers through policy instruments such as subsidies and improvement in marketing services and infrastructure will reduce the cost of intensification. This may be combined with the assisted development and dissemination of new technologies that improve the efficiency of nutrient regeneration and N-fixation on existing farmland without requiring large inputs of labor. (Because uncultivated land is available, to be profitable for farmers the returns to labor and capital of these 'intensification' technologies must be higher than the potential returns to labor and capital in area expansion). The value to local communities of the services of woodlands and forests may be increased for example by setting up systems of production and marketing of high-value tree crops (e.g., fruits and timber) suited to these

ecosystems. Finally, to be effective these investments must be supported by strengthened or new local institutional arrangements, e.g. community land use plans, that regulate the use of and access to local natural resources, and which effectively enforce these regulations and solve conflicts over resource access and use. It is essential that such arrangements effectively reconcile the interests of different groups in society and, in particular, do not exclude the poor and vulnerable from access to resources and benefits.

5.4. PLANS FOR PHASE II

The two examples from southwestern and central Uganda indicate that several policy instruments are potentially available for the reconciliation of private and environmental goals in environmental "hot spot" areas, and that some are already being applied by USAID's partners and others. These and other examples also suggest that a unique mix of technologies, institutional arrangements, and forms of compensation are required for each local situation, depending on the specific social and environmental conditions and dynamics found there. Nevertheless, it seems worthwhile to make a general assessment of the suitability of each instrument for different types of development pathways and environmental problems in Uganda, while focusing on the pathways and problems of priority to USAID and its implementing partners.

We find that the great complexity and magnitude of environmental degradation and poverty in Uganda and like countries require a continued search and further development of promising new technologies, forms of compensation, and institutional arrangements that better combine local livelihood needs with environmental goals, and that can suit a variety of situations. In other words, we will analyze and identify "best practice" land uses for different areas. This activity will involve synthesizing the experiences of government and non-governmental organizations in different parts of the country. In phase II we plan to initiate this work in collaboration with USAID's other partners, amongst others, combining conceptual and empirical work with local practical experiences such as those gained by the AFRICARE and AFRENA projects over the years.

In phase II we will also explore the potential of the "landscape" approach (Clausen, 2001) (and possibly other meso- and micro-level approaches to land use and natural resource management) and how it might be integrated into the approach described in this report. This is in light of the fact that one of the USAID/Uganda SO7 investment programs, the "Resource Investments for Managing the Environment / Western Region (PRIME/West) Program", is meant to utilize "a "landscape" approach …. as a means of examining the scope and magnitude of the problem areas within the

selected geographic region, and organize interventions accordingly" (PRIME/West Request for Proposal (RFP) No. 617-02-003, Section C-1).

6. ASSESSING THE SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS OF THE BEST "SOCIAL" LAND USE OPTIONS

6.1. INTRODUCTION

Balancing private and environmental goals, e.g. by excluding or modifying agricultural expansion and intensification options in "hot spot" areas of high biodiversity and fragile soils, results in a revised land use pattern showing the best "social" land use options. The next step is then to (i) check that this revised land use pattern is still consistent with national goals for agricultural growth, food security, poverty alleviation and the like, and that the market consequences still lead to returns at the local level that are attractive to farmers and communities; and (ii) assess the environmental impacts (positive or negative) at different scales of the revised land use patterns.

As a basis for understanding the incentives for individuals and communities to engage in any specific land use, it is essential to gain insights into the likely economic benefits that each land use option might provide. We term these the "private" benefits, since we deal with incentives based only on the balance of benefits accruing to and costs incurred by such land users themselves. In Section 6.2 below we describe the phase I analysis made to assess the likely private payoffs to enhancing the productivity of farming systems that produce a range of agricultural commodities in Uganda.

The broader "external" or "social" costs that land use might incur – such as increased sediment load in streams, loss of habitat and natural biodiversity, and degradation of forest through depletion of fuel wood supplies - must also be considered. The basis in this framework for assessing such environmental costs (and benefits in some cases) is the characterization of ecosystem goods and services outlined in Section 3, and in particular the valuation of ecosystem services or support functions. This present report does not include any concrete environmental impact assessments of potential land use options aside those presented in Section 4. In phase II we will improve the methods and information basis for carrying out such assessments at different, relatively large geographical scales, and carry out assessments for selected options and regions.

6.2. SECTOR-WIDE IMPACTS OF LAND USE OPTIONS

We are currently using IFPRI's DREAM model to approximate the sector-wide impacts of alternative land use strategies. The model can provide regional and national estimates of changes in production, consumption, trade, food prices, and producer and consumer welfare, as a consequence of changes in productivity (or price policies). The model is useful for informing priority setting for investment options that impact potential "private" benefits – for example, which crops to promote through investment in R&D and technology adoption, and where to promote a certain (crop-specific) land use strategy. In phase I we used the model to calculate producer and consumer benefits for 14 crops and 39 districts in Uganda. Appendix C reports in detail on this study. Below we provide a summary.

Figure 18 depicts for each region in Uganda the gross economic benefit of a single-shot 1% increase in the productivity of the selected crops. A productivity increase could be brought about by an array of land management changes such as the adoption of improved seeds, improved agronomic practices, more nutrient application or animal traction. The gross economic benefits are the sum of producer benefits (through increased net income per unit of input) and consumer benefits (through reduced prices as a result of increased supply). The graph shows that Northern Region and Eastern Region will benefit more from productivity increases in cereal (maize, millet, rice, sorghum) production than districts in the other regions. Western Region enjoys larger benefits from technology-induced supply shifts in sweet potato and Irish potato, while districts in Central Region will benefit from technology targeting Robusta coffee. By far the largest share of the benefits is attributed to producers. This is because the price of most crops is assumed to be heavily influenced by the world market in this initial assessment. The results of the simplified phase I model parameterization are driven mainly by the quantity and value of current production and demand growth projections in each district. The relatively high potential benefits of Robusta coffee in Central Region are thus due to its large production of Robusta coffee and the high price of coffee compared to the other crops.

[Figure 18. Potential Economic Benefits of Increased Agricultural Productivity]

The spatial distribution of potential economic benefits of land use options is visualized in Figure 19 and 20, which show producer benefits for selected food and cash crops at the district level. The spatial extent of production is assumed to correspond to the agricultural extent derived from the 1km grid land cover database for Uganda. Cassava and maize have the highest benefits in northern

and eastern Uganda. The benefits are generally higher for cassava than for maize (note that the two maps have different color codes). Coffee has high benefits in the Lake Victoria crescent, in particular in Central Region, along Lake Albert in the West (Masindi and Hoima districts), and in the southwestern highlands. Benefits for cotton are generally lower than for coffee. The highest benefits can be realized in Apac, Lira and Pallisa districts. One may also see a large cluster of districts of high to medium cotton benefits stretching across the country from Lake Albert along the Lake Kyoga Basin and down into the Eastern Region.

[Figure 19. Potential Producer Benefits of Improved Productivity for Selected Food Crops]

[Figure 20. Potential Producer Benefits of Improved Productivity for Selected Cash Crops]

The maps are useful to get a better sense of the spatial patterns of potential benefits than is possible with tabulations. These maps can assist the planning process, e.g. by identifying clusters of areas of high economic potential with respect to a certain land use option that cut across regional boundaries. For example, potential producer benefits for coffee cluster along the Lake Victoria crescent, while maize benefits are much more evenly spread across the country. The coarse spatial resolution (district level) of the production data that is available for the DREAM simulations does not at this point allow us to relate benefits directly to the private land use options (strategy domains) outlined in Section 2. However, the model offers considerable scope for a more refined analysis in the more detailed planning process, especially if combined with field surveys in the areas of priority.

6.3. **PLANS FOR PHASE II**

In phase II we plan to develop a more refined DREAM model and add complementary models that can do a better job in: (1) Providing a consistent framework for balancing alternative production scenarios with demand (including trade) and market prices. This is necessary to ensure that land use plans are consistent with private profitability at the farm level and with sector-wide goals for growth, food security, employment, exports and the like. The framework will also be used to analyze the impact of agricultural sector and trade policy reforms on agricultural production and prices, which can then be linked back in an iterative way to the spatial and community level analyses to explore the implications for development and land use pathways and their environmental and social outcomes. (2) Reflecting the within-district homogeneity in farming conditions - both biophysical and socioeconomic. This will be done by describing a range of “representative producer” conditions within districts, and will result in a richer and more reliable

assessment of the likely impacts of productivity change at a higher level of spatial and socioeconomic resolution. (3) Reflecting the impediments to supply and demand growth and marketing (national, regional and international) that lead to short-term instability. This will be done by undertaking short and long run analyses of productivity change.

In phase II we will also be able to use our household and community survey data to evaluate the local level impacts of alternative land uses on production, incomes, poverty, and livelihood strategies. And we will use the household and community data and the refined sector model to quantify the tradeoffs between the welfare of local communities and the broader social value of ecosystem services. In particular, we will: quantify the local income and poverty impacts of alternative privately- and environmentally-desired land uses; calculate national values for the ecosystem services provided by different land use options; and then use these calculations to undertake a social vs. private cost benefit analysis of alternative land uses. In addition to highlighting areas of real conflict between goals, this approach will also provide estimates of the levels of compensation that communities might need to find the environmentally-desired land uses most attractive.

7. TARGETING USAID'S STRATEGIC INVESTMENTS

7.1. CRITERIA-BASED TARGETING OF USAID INVESTMENTS BY LOCATION AND SUB-SECTOR

Given a map of feasible and desirable land use options across the country, it still remains for USAID to select those areas in which to focus its own development efforts. To assist this identification process we are developing a matrix that shows how different geographic areas score with regard to several criteria that are key to USAID's strategic objectives in Uganda. These criteria may be factors related to the objectives under the SO7 (*Expanded Sustainable Economic Opportunities for Rural Sector Growth*) or factors that influence how effectively USAID can achieve these objectives in an area. The criteria included in phase I are: economic growth potential; environmental hot spots; density of poor people; population density; infrastructure and markets; and type of commodity produced. The most practical spatial unit for scoring is likely to be a district or cluster of districts, since the district is the key sub-national administrative unit in Uganda. For small-scale or very site-specific interventions, a sub-county, the next significant administrative unit down, may be more preferred.

The matrix provides a basis for selecting specific areas for development priority. And because many of these goals will not be complementary (e.g. growth in "hot spot" areas; poverty vs. ease of development), then the matrix can be a useful tool in making choices that involve some trade-off between goals. In the following we discuss each of the criteria in the matrix. We emphasize the "infrastructure and markets" criteria for which a separate phase I study has been made. In phase II other criteria may be added depending on the priorities of the investment programs under the SO7.

Table 7. Scoring Matrix

District A	score A	score A	score A	score A	score A	score A	
District B	score B	score B	score B	score B	score B	score B	
etc…							

Geographic Area (e.g., District)	Score for Criteria Related to USAID Strategic Goals						District Weighted Score
	Economic Growth Potential	Environ -mental Hot Spot	Incidence of poverty	Population Density	Infra-structure and Markets	Major Commodity Produced	
	weight	*weight*	*weight*	*weight*	*weight*	*weight*	*1.0*

7.2. ECONOMIC GROWTH POTENTIAL

To achieve USAID's goal of contributing to economic growth, it is important to increase production, employment, productivity, incomes, and so on. Districts with high growth potential would, consequently, score well on this criterion.

7.3. ENVIRONMENTAL "HOT SPOTS"

USAID's SO7 seeks to attain economic growth in an environmentally sound manner, as well as protecting or rehabilitating environmentally sensitive areas. Thus, the extent to which an area presents significant environmental problems or opportunities is of strategic interest to USAID and would score highly on this criterion. In practice, USAID might be particularly interested in areas with, say, *both* high economic growth and environmental potential, the so-called "win-win' situations, as these might present the most critical development challenges.

7.4. INCIDENCE OF POVERTY

Poverty reduction is a key goal of USAID interventions. USAID would thus wish to be aware of the distribution of the poor in prioritizing its target areas. Poverty incidence (share or head count) can be scored in the fourth column of the matrix, and Figure 21 illustrates the poverty density measure by district. The map is based on population data from the 1991 population census projected to year 2000 and expenditure-based poverty estimates from the 1992/93 Integrated Household Survey (Chemonics, 2000a). It shows that Uganda's poor people are concentrated in southwestern and northwestern Uganda, in Eastern Region, in the districts west of Lake Victoria (Mpigi, Masaka,

Sembabule), and to a lesser extent in Apac and Lira districts in northern Uganda. This pattern follows closely the distribution of the population, with a few exceptions such as the densely populated but relatively well-to-do Mukono district. (The spatial distribution of the incidence of poverty in Uganda, i.e. the share of people in a district who are poor (not factoring in the total number of poor), shows a very different pattern. The highest incidence of poverty is in northern and northeastern Uganda and the lowest in the Western and Central regions.) In phase II we will produce a more up-to-date map of the density of poor people, using poverty data from the 1999/2000 Uganda National Household Survey.

[Figure 21. Poverty Density in Uganda]

7.5. POPULATION DENSITY

USAID is also concerned about the total number of people it reaches in rural areas – since this will condition the likely aggregate impact of change it can bring about in the Ugandan economy. Thus focusing investments in areas of highest total population (density or head count) would be relevant for this purpose, and is listed in the fifth column of the matrix. Figure 22 shows population density in Uganda. Most people live along the shores of Lake Victoria and in the southwestern highlands, where population densities are higher than 150 persons/km2 in most locations. Patches of high population densities are also found in the northwestern corner of the country and around Mount Elgon in Eastern Region. Lira and Apac districts in Northern Region also have fairly high population densities of 51-100 persons/km2.

[Figure 22. Population Distribution in Uganda]

7.6. MARKETS AND INFRASTRUCTURE

The feasibility of implementing identified development strategies will vary according to the level of rural infrastructure, market access, and the performance of marketing institutions (sixth column of matrix). USAID might want to target the areas that offer the most promise for achieving their objectives, thereby potentially offering a larger and speedier impact of their investment. In Figure 23 “market access” is estimated using the measure of potential market integration developed by Wood et al. (1999), which is a measure of travel time from any location to the nearest five towns or cities, weighted by the population of the towns or cities. Areas of high market access are mainly in the Lake Victoria region, the densely populated southwestern and eastern highlands, and parts of the north and west close to major roads and towns.

[Figure 23. Market Access and Transport Infrastructure]

Yet market access as estimated above is not a sufficient criterion to determine the market feasibility of land use options in the precise way needed to guide investments. To assess the options in terms of their market feasibility, we need to use empirical evidence on the availability and quality of market services. Characterizing regions in terms of market services adds a richer dimension to the process of selecting target regions and appropriate development and investment strategies for those regions.

Appendix D presents a study based on IFPRI's marketing survey in selected, mainly southern regions of Uganda, which estimates the market feasibility of private land use options in these areas. We focus on three main characteristics of the market: market competition, volume of marketed products, and status of market infrastructure (storage, transport, credit, communication and market information services). More competitive markets imply lower marketing costs, better prices for farmers and consumers, and more efficient market services. Higher volumes traded reduce market thinness, result in better coordination and more fluid market activities, and reduce unit marketing costs because of economies of scale. Transport, storage, and communication networks are essential for farmer and traders to conduct their marketing activities effectively. Access to credit institutions and market information services are also important, especially for large-scale traders – such as wholesalers and importers/exporters – that typically require large working capital and timely information about external markets.

The market feasibility of the land-use options is determined by comparing the private extensification and intensification land use options with some of the market characteristics mentioned above. We concentrate on market and infrastructure related factors that could help promote the extensification and intensification of annual and perennial cash crops. In this summary of the study, we compare GIS maps representing the private agricultural land use options (Figure 6) with GIS maps representing market characteristics variables related to competition (number of purchase and sales competitors) and infrastructure (e.g., transport problems and restrictions, and communication). Other variables are mapped in Appendix D.

Competition

Figure 24 provides an indication of the number of trader competitors when purchasing and selling their various commodities. As shown in this map, the number of purchase and sale competitors in the Lake Albert - Kyoga band is low. Also, there appear to be less competition in

purchasing from farmers than from selling to other traders and consumers in this band. Although competition tends to be higher along the Lake Victoria band, it tends to become less vigorous as one moves away from the main commercial and population centers of Kampala, Mukono, Jinja, Tororo, Busia, and Masaka. Therefore, a strategy of intensifying or expanding cash crop production in these two bands may not be feasible if trader entry in these areas remain limited, particularly in such districts as Masindi, northern Luwero, Apac, and Lira, and to a lesser extent in such central and eastern districts as Mpigi, and less accessible parts of Kamuli, Iganga, and Mbale.

[Figure 24. Average Number of Competitors]

Transport Constraints

Figure 25 illustrates the areas where traders experience difficulties transporting their goods. Traders in the Lake Albert - Kyogu band chiefly site poor infrastructure as their principal transport related problem, while to the east and in Masaka, traders site delays in delivery caused by such factors as periodic road impassability and seasonal transport bottlenecks. Although restrictions on the transport of goods are low, the relatively high incidence of theft in these areas of eastern Uganda may in part explain the increased number of road inspections in these districts. A strategy to promote cash cropping in the extensification and intensification bands will need to include measures to enhance and improve the quality of the road, rail, and air freight networks. In addition, measures to improve the effectiveness and efficiency of the transport system through Kenya and Tanzania to seaports, and to improve access to other regional markets would help to make Ugandan goods more competitive and help to get the products to market more quickly.

[Figure 25. Percentage of Traders Reporting Transport Problems and Restrictions]

Communication

Only 29 percent of traders have a telephone. Although telephone infrastructure exists along the Lake Victoria belt, access to telephones is relatively limited or nonexistent in the intensification areas of Kamuli, Pallisa, and Mbale, and in the Lake Albert - Kyogo agricultural extensification band (Figure 26). Telephone ownership is mainly limited to the environs of the main population, commerce, and transport centers and nodes, such as Kampala, Busia, Mbale, Tororo, Masaka, and Mukono. Despite the relatively low use of telephones and other communication means, the introduction of mobile phone communication infrastructure has played an important role in expanding telephone usage into new areas and in improving and extending access in already covered areas. Trader entry into cash crop extensification and intensification areas is constrained by

access to local, domestic, regional, and export price and market information, and to improvements in communication infrastructure. The dominance of face-to-face communication, the low access and use of telephones, and the limited availability and use of other communication technologies can, thus, hamper the expansion of trader activity.

[Figure 26. Telephone Access and Usage by Traders]

7.7. TYPE OF COMMODITY

USAID and their implementation partners might also want to focus on specific commodities for which they see particular promise or have special expertise. Examples are maize and beans, high-value crops such as cut flowers and vanilla, all of which are being promoted by the IDEA project, and milk, which is being supported by USAID through Land O'Lakes and Heifer Project International. In a hypothetical scoring exercise, areas where these commodities are dominant would get a higher score than areas where land use options involve other commodities.

7.8. PLANS FOR PHASE II

In phase II we will work with the USAID Mission to refine and perhaps expand this matrix to include, for example, farmers' access to various rural services such as credit, based mainly on results from the community and household survey.

More work will also be needed in order to operationalize the scoring matrix in terms of identifying appropriate weighting options for each of the criteria, and to examine ways of standardizing scores if, as is shown in the example matrix, it is deemed important to generate a single weighted index of the likely priority of USAID's interest in any specific geographic area.

8. HOW CAN PROGRESS BE MONITORED

This question will be addressed in phase II and in a possible phase III. We will identify community, market, sector, resource, and ecosystem level indicators to be monitored through conventional and participatory survey methods. These indicators will help track changes in socio-economic and environmental conditions and enable linkages to be established with underlying investment programs and policy reforms.

9. CONCLUSIONS

Good progress was made in phase I in developing and articulating the conceptual framework for integrating economic and environmental goals into a land use development approach for rural Uganda that can guide public policy and investment decisions. Many aspects of the framework were also illustrated with a first round of empirical work. In phase II the priorities will be to flesh out the empirical side of the approach using data sources that have not yet been fully tapped (e.g. IFPRI's community and household survey data sets); refining some of the analytical tools (e.g. the market model and the characterization of ecosystem goods and services); and refining the decision-aid matrix after more careful analysis of the decision support needs of USAID and national policy makers have been undertaken. Phase II will also begin work on institutionalizing the data sets and the approach within one or more local institutions.

10. BIBLIOGRAPHY

Binswanger, H.P. and J. McIntire. 1987. "Behavioural and material determinants of production relations in land-abundant tropical agriculture". *Economic Development and Cultural Change*. 36:73-99.

Boserup, E. 1965. *The conditions of agricultural growth.* Allen & Unwin. London.

Chemonics International. 2001a. USAID/Uganda SO7 assessment of strategic agriculture and environment options. Report submitted to USAID/Uganda. Washington, DC, Chemonics International.

Chemonics International. 2001b. Environmental threats and opportunities assessment for Uganda. Biodiversity assessment. Report submitted to USAID/Uganda. Washington, DC, Chemonics International.

Chemonics International. 2001c. Land use profiles by district, region and agroecological zone. Data File submitted to USAID/Uganda. Washington, DC, Chemonics International.

Clausen, R. 2001. A landscape approach for reviewing USAID/Uganda activities in the Southwest. Report submitted to USAID/Uganda.

Corbett, S. 1999. Spatial database for Ethiopia, Kenya, Tanzania, Uganda, Zambia and Zimbabwe. (USAID's Country Almanac Series.). Texas, ESRI and Texas A&M University System. Data File.

Gold, C.S., E.B. Karamura, A. Kiggundu, F. Bagamba, and A.M.K. Abera. 1999. "Geographic shifts in the highland cooking banana (Musa spp., group AAA-EA) production in Uganda". *International Journal of Sustainable Development and World Ecology* 6(1): 45-59.

International Food Policy Research Institute (IFPRI). 2001a. Assessment of strategic land use options for Uganda. Project proposal from the International Food Policy Research Institute to USAID/Uganda. IFPRI. Washington, DC.

International Food Policy Research Institute (IFPRI). 2001b. Draft outline of activities for phases II and III of the spatial framework for the strategic evaluation of land use and livelihood

options. Project proposal from the International Food Policy Research Institute to USAID/Uganda. IFPRI. Washington, DC.

Izac, A.M. and P.A.Sanchez. 2001. "Towards a natural resource management paradigm of international agriculture: the example of agroforestry research". *Agricultural Systems.* 69:5-25.

Jagger, P. 2001. Evolving roles for programs and organisations: Promoting sustainable land management in rural Uganda. International Food Policy Research Institute, Environment and Production Technology Division, Washington, D.C. Mimeo.

Jagger, P. and J. Pender. 2001. "Policies for improved land management in Uganda". *Environment and Production Technology Division Workshop Summary Paper* No.10. International Food Policy Research Institute. Washington, D.C.

Johnston, R.J. 1994. *The dictionary of human geography*. Blakwell. Oxford.

Lamprey, R., E. Buhanga, and J. Oketcha. 1999. Wildlife protected area system plan for Uganda - Volume 1. Uganda Wildlife Authority. Kampala.

Langdale-Brown,I., H.A.Osmaston, and Wilson J.G. 1964. *The vegetation of Uganda and its bearing on land use*. Government of Uganda. Entebbe. Book and GIS Data File.

McIntire, J., D. Bourzat, and P. Pingali. 1992. *Crop-livestock interactions in Sub-Saharan Africa*. The World Bank. Washington D.C.

National Biomass Study. 1996. 1:50,000 Land cover/use data sheets for Uganda. Kampala, Forest Department, Ministry of Natural Resources. Data File.

National Environment Management Authority (NEMA). 1998. *State of environment report for Uganda*. NEMA. Kampala.

Nkonya, E. 2001. Soil conservation by-laws – perceptions and enforcement among communities. International Food Policy Research Institute, Environment and Production Technology Division, Washington, D.C. Mimeo.

Pender, J.L. 1998. “Population growth, agricultural intensification, induced innovation and natural resource sustainability: an application of neoclassical growth theory”. *Agricultural Economics*. 19:99-112.

Pender, J. 1999. “Rural population growth, agricultural change and natural resource management in developing countries: A review of hypotheses and some evidence from Honduras”. *Environment and Production Technology Division Discussion Paper* No. 48. International Food Policy Research Institute. Washington, DC: .

Pender, J., P. Jagger, E. Nkonya, and D. Sserunkuuma. 2001. “Development pathways and land management in Uganda: causes and implications”. *Environment and Production Technology Division Discussion Paper* No. 85. International Food Policy Research Institute. Washington, D.C.

Reenberg, A. 1998. “Analytical approaches to agricultural land use systems in the Sahel”. *SEREIN Occasional Paper* No. 8. SEREIN, Institute of Geography, University of Copenhagen. Copenhagen.

Sneddon, C.S. 2000. “ ‘Sustainability’ in ecological economics, ecology and livelihoods”. *Progress in Human Geography*. 24:521-549.

Ssali, Henry. 2000. Soil resources of Uganda and their relationship to major farming systems. Resource paper for the ‘Policies for Improved Management in Uganda’ project. NARO and International Food Policy Research Institute. Kampala.

Sserunkuuma, D., J. Pender, and E. Nkonya. 2001. Land management in Uganda: characterization of problems and hypotheses about causes and strategies for improvement. International Food Policy Research Institute, Environment and Production Technology Division, Washington, D.C. Mimeo.

Tiffen, M., M. Mortimore, and F. Gichuki. 1994. *More people, less erosion. Environmental recovery in Kenya*. John Wiley & Sons. Chichester.

United States Agency for International Development (USAID). 2001. *Integrated strategic plan for USAID’s program in Uganda 2002-2007: assisting Uganda to reduce mass poverty. Volume 1-3*. USAID. Washington, D.C.

Wood, S., K. Sebastian, F. Nachtergale, D. Nielsen, and P.S. Dasgupta. 1999. “Spatial aspects of the design and targeting of agricultural development strategies”. *Environment and Production Technology Division Discussion Paper* No. 44. International Food Policy Research Institute. Washington, D.C.

World Resources Institute. 2001. *World Resources 2000-2001*. World Resources Institute. Washington, D.C.

ENDNOTES

[1] The other SOs in the ISP 2002-2007 are SO8 – *Human Capacity Improved*, and SO9 – *More Effective and Participatory Governance*.

[2] The other framework, "Competitiveness", will grow out of SO7's U-TRADE program (USAID, 2001:42).

[3] Phase I activities also included a more direct service function to USAID and the project, particularly support to the Chemonics team during March and April in their initial assessment of land use options, and the preparation of presentation materials (power point slides and accompanying text) for the Uganda Missions' discussions with USAID, Washington and the Ugandan Government.

[4] Reenberg (1998: 96), citing Turner et al. (1989) offers some useful working definitions of scale-related terminology that we reproduce here. *Scale* is the spatial or temporal dimension of an object or process (characterized by both grain and extent). *Resolution* is the precision of measurement (grain size). *Grain* indicates the finest level of spatial resolution possible with a given data set (e.g., pixel size for raster format data). *Extent* measures the size of the study area or the duration of time under consideration. *Extrapolate* means to transfer information (a) from one scale to another (either grain or extent) or (b) from one system to another at the same scale. The *critical threshold* is the point at which there is an abrupt change in a quality, property or phenomenon. Spatial units of analysis, such as a field or a landscape, are different from functional units of analysis, such as households, which do not have an extent. But functional units do have a (or several) location and so can be analyzed spatially. The issue of scale is further discussed in Section 3.

[5] The districts included in the project study area include Kabale, Kisoro, Rukungiri, Bushenyi, Ntungamo, Mbarara, Rakai, Masaka, Sembabule, Kasese, Kabarole, Kibale, Mubende, Kiboga, Luwero, Mpigi, Nakasongola, Mukono, Kamuli, Jinja, Iganga, Bugiri, Busia, Tororo, Pallisa, Kumi, Soroti, Katakwi, Lira, Apac, Mbale, and Kapchorwa.

[6] We did not use information on women's occupations for the classification. This was not because we regard women's occupations as less important, but because women's primary occupation is dominated by household maintenance activities, with little variation across communities, while changes in women's occupations were quite similar to changes in men's. Using only men's occupation was thus a reasonable way to simplify the classification problem.

[7] Paradoxically, matooke production has been shifting from areas close to the urban market in Kampala to southwest Uganda. This is reportedly due to pest problems (especially banana weevils and nematodes) and soil fertility problems in the Lake Victoria crescent (Gold, et al., 1999), but higher returns to alternative uses of land and labor in this area may also be critical. These issues illustrate that other factors besides distance to market are also important determinants of the location of food production.

[8] The domestic resource cost (DRC) ratio is the ratio between the cost of producing and marketing a commodity (in units of local currency spent per unit of foreign exchange earned) and the exchange rate (local currency per unit of foreign exchange). A DRC ratio of less than one for a commodity implies that the country has an international comparative advantage in the commodity.

[9] These changes can be affected by cultural perceptions. For example, in Ankole farmers are reluctant to use cattle for plowing, preferring not to use them as "beasts of burden". The nature of the soil (i.e., how heavy or light) also affects whether animals can be used for tillage.

[10] One could argue that population density per unit of arable land would be a better indicator, but absence of comparable data on this latter indicator makes it difficult to use in practice. To some extent, differences in agricultural potential will account for differences in arable land per total area of land (i.e., the fraction of arable land is likely lower in areas with lower agricultural potential, controlling for population density).

[11] The term managed ecosystems refers in this context to agroecosystems. Natural ecosystems in Uganda include grassland (savannah) ecosystems, forest ecosystems, montane ecosystems, and fresh water systems. An ecosystem has been defined as "any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to … exchange of materials between living and non-living parts of the system" (Odum, 1969, in Johnston, 1994). Living parts include all organisms from microorganisms to large mammals and humans. The non-living parts, or the physical environment, can be described in terms of climate, soil, topography (relief), man-made physical structures, and fire. Ecosystems must be understood in an aggregative hierarchy: individuals aggregate into populations, populations come together in communities, and a community plus its physical environment comprises an ecosystem. The essential features of the concept of ecosystem are that (a) it implies a functional and dynamic relation between the components going beyond a frozen mosaic of species; and (b) that it is holistic, implying that the whole possesses emergent qualities which are not predictable from our knowledge of the constituent parts. The latter means that it is important to be specific about the spatial and temporal scales at which we analyze ecosystems, and that we must include several scales in the analysis.

[12] The analysis of individually-desired land use options outlined in the previous section focuses on the economically most important goods and services provided by agroecosystems, i.e. food, fiber (including timber and fuel wood), genetic resources, and employment, and pays less attention to agroecosystem services, such as watershed functions, soil maintenance, and habitat provision. This is related to the way the "development pathways" was conceived and operationalised. Building on the idea of the comparative advantage of areas with respect to specific livelihood strategies, major development pathways were established in relation to factors, such as the land/labor ratio (population density), market access, and rainfall, that are mainly relevant to agricultural production and income generation by local households.

[13] Ecological economics conceptualize such ecosystem components as *natural capital*, as a way of integrating the concern for ecological processes into economic calculations (Sneddon, 2000: 526). Izac and Sanchez (2001: 9) define

natural capital as 'stocks of resources generated by natural biochemical processes and solar energy that yield useful flows of services and amenities into the future'. Examples of natural capital within a given ecosystem are soil nutrients and soil organic matter, germplasm in plant and animal communities, or stocks of biomass held in trees. According to this approach, different instances of natural capital in ecosystems produce ecosystem goods and services at different scales (e.g., trees in forest ecosystems produce timber at the local scale and carbon sequestration at the global scale).

[14] Indirect and direct benefits of ecosystems correspond largely to what Izac and Sanchez (2001: 11) term 'support' and 'utilitarian' functions of natural capital, respectively. Support functions of natural capital are "functions that may or may not be of immediate and direct utility to local people, but that are essential for the maintenance of ecosystems in the longer term and/or at larger scales" (Izac and Sanchez, 2001: 11). Examples of ecosystem support functions are water and nutrient cycling, carbon sequestration, pollution assimilation, and habitat for wild plants and animals. Utilitarian functions of natural capital, on the other hand, are functions that are of immediate and direct interest to local people, i.e. food, raw material, and other services yielding local incomes or amenities (Ibid.), such as tourist revenues derived from wildlife or shade derived from trees.

[15] Southern Alliance for Indigenous Resources (SAFIRE). The Southern African Natural Products Trade Association (SANProTA).

[16] In comparison, the ecosystem goods services of, for example, a cassava field are less diverse (they fall mainly in the direct benefit or 'utilitarian' category) and are mainly of interest to local producers and local/national consumers.

[17] PAGE ecosystem definitions: Agroecosystems are "areas where at least 30% percent of the land is used for cropland or highly managed pasture". Grassland Ecosystems are "areas dominated by grassy vegetation and maintained by fire, grazing and drought". Using this broad definition, grasslands encompass nonwoody grasslands, savannas, woodlands, shrublands, and tundra. Forest Ecosystems are "the area dominated by trees forming a closed or partially closed canopy" (definition used by the International Geosphere-Biosphere Programme). Forest ecosystems include tropical, subtropical, temperate, and boreal forests as well as woodlands. Freshwater Ecosystems are those found in rivers, lakes, and wetlands.

[18] Also, the NBS land cover data is based on imagery from 1989-1991. Since then important changes in land use and land cover have occurred in Uganda; for example has large parts of the bush- and woodlands in Central Uganda been converted into farmland.

[19] Other variables obviously affect soil fertility and fragility. A composite measure including several variables (properties or types of constraints) could be used in a very general assessment of agricultural land use options. Such variables include slope, as well as soil property-related constraints such as poor drainage, low CEC, aluminum toxicity, acidity, high phosphorous fixation, low potassium reserves, salinity, and low organic matter content. When assessing the potential (soil-related) environmental impact of particular land use strategies, the choice of variables included in the analysis of potential soil degradation impacts should depend closely on the types of crops and farm practices involved in the land use strategy in question.

[20] This classification is clearly a simplification of the complexity of ecological systems and relationships. For example, natural ecosystems such as grasslands and bushlands are not valued here for their ecosystem goods and services, and the desirability of local diversity in ecosystem goods and services is not captured either. Ecosystems such as wetlands and high tropical forest cover relatively small areas and so seem relatively insignificant in a spatial representation, despite their critical importance for biodiversity conservation and other ecosystem services (e.g. aquifer in the case of wetlands). As mentioned, such shortcomings in the analysis of environmental services will be addressed in phase II.

[21] Other variables of course affect soil fertility and fragility. A composite measure including several variables (properties or types of constraints) could be used in a very general assessment of agricultural land use options. Such variables include in particular slope, as well as soil property-related constraints such as poor drainage, low CEC, aluminum toxicity, acidity, high phosphorous fixation, low potassium reserves, salinity, and low organic matter content. When assessing the potential (soil-related) environmental impact of particular land use strategies, the choice of variables included in the analysis of potential soil degradation impacts should depend closely on the types of crops and farm practices involved in the land use strategy in question.

[22] It is revealing that pit sawing is a common off-farm occupation among farmers in southwestern Uganda.

ASSESSMENT OF STRATEGIC LAND USE OPTIONS FOR UGANDA

Phase I Draft Completion Report

APPENDIX A

Research Project on Improved Land Management in Uganda

Project Activities and Data Collected

Ephraim Nkonya

Environment and Production Technology Division

Submitted to USAID/Uganda

The International Food Policy Research Institute
2033 K Street, N.W. Washington, D.C. 20006

March 2001

Research Project for Improved Land Management in Uganda

The major activities of the project are to collect primary and secondary data aimed at identifying and analyzing the issues related to land degradation. Primary data collected using a series of surveys as listed below:

Agricultural Marketing Studies

The ag. marketing studies were conducted to address the following issues:

i) High cost of input distribution

ii) Farmers have limited access (physically and financially) to input distribution.

iii) Limited availability of breeder and foundation seeds.

iv) Low participation of retailers in the input distribution system.

v) Effectiveness of credit guarantee scheme and role of credit in input distribution is not well known. Additionally, the cost of financial services is very high. For instance, interest rate in the formal banking sector is above 25%.

vi) Impact of government intervention in the input sector not well documented.

vii) Lack of adequate infrastructure

viii) Information asymmetry between output traders and producers

Surveys implemented are listed below:

(i) *Input Marketing Survey*:

Covered 148 ag. input traders in 17 districts (Table 1)

Survey completed in January 2000 and Final draft due next week

(ii) *Seed Multipliers Survey*:

Covered about 200 seed producers in districts reported in Table 2

Survey completed in January 2000 and report writing in progress

(iii) *Output Survey*:

Covered 354 Ag output traders as shown in Table 3.

Survey completed in January 2001 and data cleaning in progress

(iv) *Ag. Output Processors*:

Covered 86 ag. processors as reported in Table 4

Survey completed in January 2001 and data cleaning in progress

In all four surveys, the data collected were related to:

- Characteristics of business and trader/processor/seed farmer
- Commercial relationships and networks
- Input/Output production and trading
- Transportation, storage and investment
- Information and marketing intelligence
- Extension services
- Impact of government interventions in input and output trade

Community, Household and Plot Surveys and Community Resource Mapping

The main issues addressed in these surveys are related land degradation. Specifically the surveys were conducted:

- To identify the main factors affecting land management and its linkages to agricultural productivity, poverty, and resource sustainability in Uganda;
- To identify the major current and potential pathways of development in Uganda, their causes and implications; and
- To identify and assess policy, institutional and technological strategies to promote more productive, sustainable and poverty-reducing pathways of development and land management.

(v) *Community (LC1) and Village Surveys*:

Covered 107 Communities as shown in Map

Sampling procedure followed: Stratified sampling based upon a classification of Uganda according to agricultural potential (Hi, Med., & Lo), market access (Hi & Lo) and population density (Hi & Lo). Identified a total of 18 strata (Table 5)

Survey completed in June 2000 and report writing in progress

(vi) *Community Resource Mapping (CRM) Survey*:

Covered about 107 Communities as shown in Map

Survey completed in July 2000 and report writing in progress

CRM would generate maps showing spatial distribution of resources in all sampled communities

(vii) Household and Plot Surveys

Survey started in December 2000 and is on going. Expected to cover all 107 communities where the community and CRM surveys were conducted. Expected to cover 500 households and over 2000 plots (four plots per households)

Data collected include:

(a) Community survey

- Infrastructure and services
- Programs and Organizations
- Land, use, tenure and land markets
- Collective resource management
- Livelihood strategies
- Human welfare and natural resource changes and conditions
- Factor markets
- Crop, livestock and forest production, commercialization and management

(b) Community Resource Mapping (CRM)

- Transect walks to identify landscape, soil types/variability and fertility, land use, vegetation, soil fertility management and SWC
- Changes in land condition, land use, vegetation, and their consequences on crop production and resource base
- Changes in climate for the past 10 years and their effect on agriculture
- Draw community resource maps showing the changes in land resources

(c) Household and plot survey

- Household social characteristics
- Household assets
- Factor acquisition/disposition
- Income and expenditure
- Agricultural technologies and practices
- Participation in collective action

(d) Plot Survey

- Inventory of plots and their sketch showing area, land use, SWC, and land degradation
- Crop production technologies, and productivity for each plot

Ph.D. Students Research work

The project also sponsors dissertation for four Ph.D. students (two Ugandans and two Germans) who are doing in depth study in some selected communities. The in depth studies are aimed at generating data for bioeconomic and landscape modeling. One student is conducting soil fertility trials in the eastern parts of Uganda which would generate data for bioeconomic modeling and nutrient balance studies.

Table 1: ***Districts and Number of input traders sampled in each region***

Central		East		North		West	
District	*Sample*	*District*	*Sample*	*District*	*Sample*	*District*	*Sample*
Kampala	45	Iganga	8	Apac	4	Kasese	4
Luweero	8	Mbale	8	Lira	5	Mbarara	10
Mukono	10	Tororo	4	Soroti	2	Masindi	10
Mpigi	8	Busia	4				
Masaka	10	Kamuli	4				
Rakai	4						
Region	85		28		11		14

Total 148

Table 2: ***Districts and Number of Seed Multipliers sampled in each region***

Central		East		North		West	
District	*Sample*	*District*	*Sample*	*District*	*Sample*	*District*	*Sample*
Kampala	0	Iganga	7	Apac	8	Kasese	40
Luweero	17	Mbale	0	Lira	5	Mbarara	0
Mukono	19	Tororo	6	Soroti	7	Masindi	60
Mpigi	8	Busia	2				
Masaka	13	Kamuli	0				
Rakai	6						
Region	63		15		20		100

Total 198

Table 3: ***Districts and Number of Ag. Output traders sampled in each region***

Central		East		North		West	
District	*Sample*	*District*	*Sample*	*District*	*Sample*	*District*	*Sample*
Kampala	44	Iganga	25	Apac	38	Kasese	1
Luweero	12	Mbale	34	Lira	31	Masindi	16
Mukono	33	Tororo	19	Soroti	2		
Mpigi	16	Busia	2				
Masaka	22	Kamuli	19				
		Jinja	8				
		Pallisa	32				
Region	127		139		71		17

Total 354

Table 4: ***Districts and Number of Ag. Processors sampled in each region***

Central		East		North		West	
District	*Sample*	*District*	*Sample*	*District*	*Sample*	*District*	*Sample*
Kampala	5	Iganga	4	Apac	6	Masindi	4
Luweero	9	Mbale	4	Lira	6		
Mukono	10	Tororo	5				
Mpigi	7	Kamuli	4				
Masaka	12	Jinja	5				
		Pallisa	5				
Region	43		27		12		4

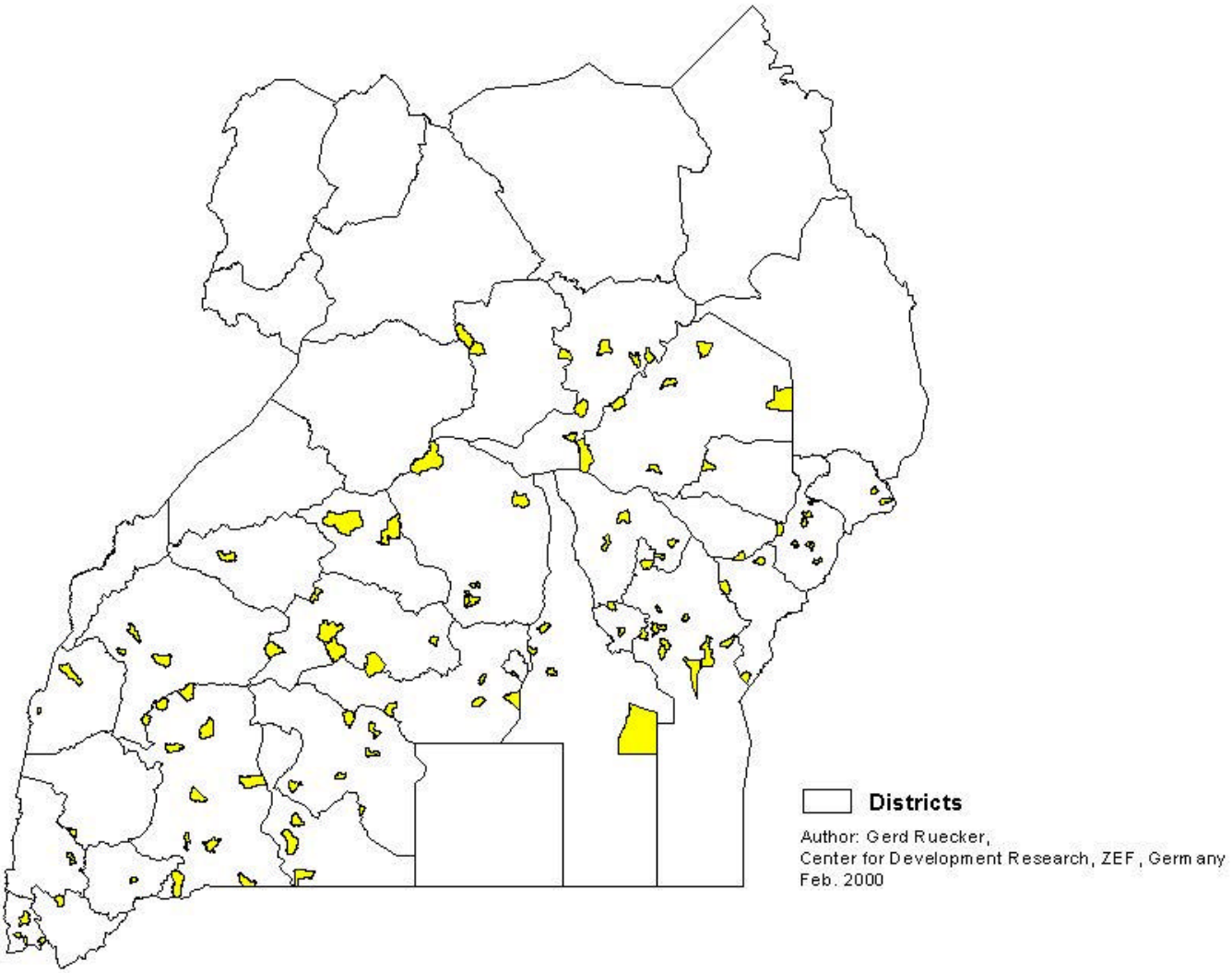
Total 86

Table 5: *Uganda Community Survey:* ***Sample Stratification***

Ser. #	Highland/ Lowland	Population Density	Market Access	Agricultural Potential	No. of LC1's in Sample
1	Lowland	Low	Low	Unimodal rainfall	4
2	Lowland	Low	Low	Bimodal low rainfall	4
3	Lowland	Low	Low	Bimodal medium	7
4	Lowland	Low	Low	Bimodal high	4
5	Lowland	Low	High	Unimodal rainfall	4
6	Lowland	Low	High	Bimodal low rainfall	4
7	Lowland	Low	High	Bimodal medium	4
8	Lowland	Low	High	Bimodal high	4
9	Lowland	High	Low	Bimodal medium	6
10	Lowland	High	Low	Bimodal high	4
11	Lowland	High	High	Unimodal rainfall	4
12	Lowland	High	High	Bimodal low rainfall	4
13	Lowland	High	High	Bimodal medium	10
14	Lowland	High	High	Bimodal high	15
15	Highland	High	Low	Southwestern highlands	4
16	Highland	High	Low	Eastern highlands	4
17	Highland	High	High	Southwestern highlands	10
18	Highland	High	High	Eastern highlands	4
				Total number	100

Sample Parishes

Project: Policies for Improved Land Management in Uganda



EPTD DISCUSSION PAPER NO. 85

DEVELOPMENT PATHWAYS AND LAND MANAGEMENT IN UGANDA: CAUSES AND IMPLICATIONS

John Pender, Pamela Jagger, Ephraim Nkonya, and Dick Sserunkuuma

Environment and Production Technology Division
International Food Policy Research Institute
2033 K Street, N.W.
Washington, D.C. 20006 U.S.A.

Paper presented at a Workshop on
Policies for Improved Land Management in Uganda
Africana Hotel, Kampala
June 25-27, 2001

Project on Policies for Improved Land Management in Uganda

A Collaborative Project of:

International Food Policy Research Institute
Makerere University Faculty of Agriculture
National Agricultural Research Organization
Agricultural Policy Secretariat
Center for Development Research, University of Bonn

December 2001

EPTD Discussion Papers contain preliminary material and research results, and are circulated prior to a full peer review in order to stimulate discussion and critical comment. It is expected that most Discussion Papers will eventually be published in some other form, and that their content may also be revised.

ABSTRACT

This paper investigates the patterns and determinants of change in livelihood strategies ("development pathways"), land management practices, agricultural productivity, resource and human welfare conditions in Uganda since 1990, based upon a community-level survey conducted in 107 villages. The pattern of agricultural development since 1990 involved increasing specialization and commercialization of economic activities, consistent with local comparative advantages and market liberalization. This pattern was associated with changes in land use and agricultural practices, including expansion of cultivated area, grazing lands and woodlots at the expense of forest and wetlands; increased ownership of cattle but declining ownership of other livestock; and increased adoption of purchased inputs (though still low) and some soil and water conservation practices. Despite some agricultural intensification, crop yields, food security, and a wide range of natural resource conditions (especially soil fertility) appear to have degraded throughout most of Uganda. At the same time, many indicators of human welfare and access to goods and services have improved.

Six dominant development pathways emerged, all but one of which involved increasing specialization in already dominant activities: expansion of cereal production, expansion of banana and coffee production, non-farm development, expansion of horticultural production, expansion of cotton, and stable coffee production. Of these, expansion of banana and coffee production was most strongly associated with adoption of resource-conserving practices and improvements in resource conditions, productivity and welfare. Other strategies are needed for less-favored areas not suited for this pathway.

Road development appears to have contributed to improvements in many welfare and some natural resource conditions, except forest and wetland availability. There are thus likely trade-offs among resource and welfare outcomes when pursuing road development where forests or wetlands are important. Elsewhere, road development can be a "win-win" development strategy. Irrigation was found to reduce pressure to expand cultivated area at the expense of forest, wetland and fallow, and is associated with improvement in several welfare and resource indicators; it may also be a "win-win" strategy. Government and non-governmental organization programs were also found to contribute to improvements in several indicators of productivity, resource and welfare, though there were some mixed results. Such programs may cause declines in one area (e.g., yields of a traditional crop or energy availability) by focusing on improvements in another area (e.g., improvement of another crop or protection of forests). Thus, trade-offs appear to be inherent in many efforts to improve agriculture or protect resources.

Population growth had an insignificant impact on most indicators of change, though there is some evidence of population-induced agricultural intensification. Population growth had an insignificant association with changes in resource conditions, and mixed association with welfare indicators. In general, the findings support neither the pessimism of some neo-Malthusian observers or the optimism of some neo-Boserupian observers regarding the impacts of population growth.

KEYWORDS: Sustainable development, land management, development pathways, Uganda

ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support of the German Federal Ministry of Technical Cooperation, the Norwegian Ministry of Foreign Affairs, and the U.S. Agency for International Development for this research. We are also grateful to the Makerere University Faculty of Agriculture, the National Agricultural Research Organization of Uganda, the Agricultural Policy Secretariat of Uganda, and the Center for Development Research of the University of Bonn, which are collaborating in this research project; to the policy makers, representatives of government and non-government organizations, international research organizations and other stakeholders who participated in the workshops for this project and provided valuable ideas and feedback on the research findings; and especially to the many farmers and other community representatives who graciously agreed to participate in the study. Any errors or omissions are solely the responsibility of the authors.

TABLE OF CONTENTS

1. Introduction..... 1

2. Research Questions and Methodology..... 4

3. Development Trends and Land Management Practices in Uganda 32

4. Determinants and Implications of Development Pathways and Land Management ... 49

5. Conclusions and Implications 85

References 89

Appendix Tables 93

DEVELOPMENT PATHWAYS AND LAND MANAGEMENT IN UGANDA: CAUSES AND IMPLICATIONS

John Pender,[1] Pamela Jagger,[1] Ephraim Nkonya,[1] and Dick Sserunkuuma[2]

1. INTRODUCTION

Land degradation, low and declining agricultural productivity, and poverty are severe interrelated problems in Uganda. Although Uganda's soils were once considered to be among the most fertile in the tropics (Chenery 1960), problems of soil nutrient depletion, erosion, and other manifestations of land degradation appear to be increasing. Stoorvogel and Smaling (1990) estimated annual average soil nutrient losses in Uganda of more than 70 kg. of nitrogen, phosphorus and potassium (NPK), among the highest rates of depletion in sub-Saharan Africa. Wortmann and Kaizzi (1998) estimated even higher rates of soil nutrient mining for most cropping systems in central and eastern Uganda in the mid-1990s, based upon farm level data. Soil erosion is also viewed as a serious problem, especially in highland areas, though the evidence is limited (Magunda and Tenywa 1999; Zake and Magunda 1999; Zake et al. 1997; Bekunda and Lorup 1994; Bagoora 1988). Other forms of land degradation, including soil compaction, surface crusting, water logging, leaching and declining vegetative cover, are also reported to be serious problems in different parts of the country (Sserunkuuma et al. 2001).

Land degradation undoubtedly contributes to the low and in many cases declining agricultural productivity in Uganda. Farmers yields are typically less than one-third of potential yields found on research stations, and yields of most major crops have been stagnant or declining since the early 1990's (Ibid.). *Matooke* (banana) yields have reportedly been declining in central

[1] International Food Policy Research Institute
[2] Makerere University, Faculty of Agriculture

Uganda for the past decade, contributing to a shift in production to the southwest; while farmers in the densely populated southwest highlands have been abandoning land and in some cases leveling conservation bunds to harvest the fertile soil they contain (FAO 1999). Such changes may be due to other factors besides land degradation, such as pest and disease problems, changes in climate patterns, or rising labor costs and off-farm opportunities (Sserunkuuma et al. 2001; Gold et al. 1999). Nevertheless, land degradation is an important part of the story, and may interact with such other factors to accelerate declining agricultural productivity.

Low and declining agricultural productivity contributes to poverty and food insecurity in Uganda. Forty-four percent of Ugandans lived below the poverty line in 1997 (APSEC 2000). Although poverty rates are declining they are still very high, especially in rural areas, and the poorest fifth of the population (most of whom live in rural areas) have become poorer (Ibid.). Food insecurity is reportedly increasing in many rural parts of the country, with low and declining yields of food crops seen as a primary cause (Sserunkuuma 2001; results reported later in this paper).

Poverty and food insecurity can in turn contribute to land degradation. Poor and food-insecure households may be unable to afford to keep land fallow, invest in land improvements that reduce land availability or are expensive to construct and maintain, or use costly inputs such as fertilizer. Poverty and food insecurity may also cause farmers to take a short-term perspective or expand crop production on steep and fragile terrain (Ibid.). However, poverty does not inevitably cause land degradation. For example, poor people may have more incentive to manage their land well, since this may be their only significant asset, and the opportunity cost of investing in land improvement may be lower for poorer people. Nevertheless, the constraints

imposed by poverty and food insecurity often outweigh these factors, thus completing a vicious cycle of land degradation-declining productivity-poverty-further land degradation.

Finding and implementing ways to break out of this cycle is an urgent need in Uganda. Much has already been accomplished since the mid-1980s as a result of improved peace and security, macroeconomic stabilization, market liberalization, privatization and decentralization of many functions formerly controlled by the central government. These policy changes have contributed to substantial economic growth and poverty reduction since the late 1980's (APSEC 2000). However, as recognized by the Plan for the Modernization of Agriculture, much more remains to be done to achieve sustainable agricultural development and modernization in rural Uganda.

The key to further development is for both public and private stakeholders to invest in an appropriate and socially profitable mix of physical, human, natural and social capital in rural areas, taking into account the diversity of situations in Uganda. In order to do that, information is needed to help identify the key development opportunities and constraints in different parts of the country, the factors affecting farmers' ability to overcome the constraints and exploit the opportunities for sustainable development, and the role that government policy makers, government and non-governmental organizations and other stakeholders can play in helping to achieve these potentials. Helping to fulfill this information need is the primary objective of this paper and of the larger research project of which this is a part.

This paper identifies the development pathways, changes in land use and land management practices occurring in the selected region of Uganda since 1990, based upon a

community-level survey conducted in 107 LC1's and villages.[3] It tests hypotheses about the determinants and impacts of these changes on agricultural productivity, natural resource conditions and human welfare, drawing upon the hypotheses identified in the earlier characterization phase of the work and discussed by Sserunkuuma et al. (2001).

The remainder of this paper is organized as follows: Section 2 presents the key questions, conceptual framework and hypotheses being addressed in this paper, and the research methods used to address them. Section 3 reviews the patterns and trends of agricultural development and land management in the study region and the factors hypothesized to affect these trends, based upon descriptive analysis of the community survey data. Section 4 identifies the development pathways occurring in the study region and tests hypotheses about the factors causing these development pathways and changes in land management, and implications for agricultural productivity, resource conditions and human welfare. Section 5 discusses conclusions and policy implications.

2. RESEARCH QUESTIONS AND METHODOLOGY

A central hypothesis of this study is that the opportunities and constraints for sustainable development depend upon the comparative advantages that exist in a particular location. For example, opportunities for development of high value perishable commodities, such as horticultural crops or dairy, are likely to be greatest in areas with relatively high market access and agricultural potential. In such areas, investments in appropriate forms of infrastructure (e.g.,

---

[3] The districts included in the project study area include Kabale, Kisoro, Rukungiri, Bushenyi, Ntungamo, Mbarara, Rakai, Masaka, Sembabule, Kasese, Kabarole, Kibale, Mubende, Kiboga, Luwero, Mpigi, Nakasongola, Mukono, Kamuli, Jinja, Iganga, Bugiri, Busia, Tororo, Pallisa, Kumi, Soroti, Katakwi, Lira, Apac, Mbale, and Kapchorwa.

irrigation, roads), human capital (e.g., extension programs focusing on horticulture or dairy livestock management), and institutions (e.g., development of contract farming or dairy cooperatives, market information systems) may yield high social returns and facilitate a process of sustainable development. The agricultural and land management practices that are most profitable and sustainable are also likely affected by such comparative advantages. For example, where dairy development is occurring, there are likely greater opportunities to promote zero grazing livestock systems linked to intensive crop production and based on confined feeding and recycling of animal wastes than in areas where more extensive livestock production is practiced. Efforts to promote sustainable land management practices are thus more likely to be effective if they take into account such comparative advantages.

To focus on the concept of comparative advantage and its relationship to sustainable development broadly as well as to adoption of sustainable land management practices, we use the concept of "development pathways." We define a development pathway as a common pattern of change in livelihood strategies, such as expansion of intensive dairy production (Sserunkuuma et al. 2001). This concept is similar to the concepts of farming systems and livelihood strategies, but is more general than farming systems since it incorporates non-farm as well as farm activities (as does the concept of livelihood strategies), and is dynamic since it refers to changes and not merely livelihood strategies pursued at a particular point in time.

We use this concept to guide the research questions and key hypotheses addressed by this research, the conceptual framework used to generate the hypotheses, and the methods used to test the hypotheses and answer the research questions.

RESEARCH QUESTIONS

The key research questions for this study relate to the development pathways that exist in the study region of Uganda, their relationship to land use and land management, their causes and implications:

- What are the dominant development pathways occurring in the study region of Uganda since 1990 and their relationship to land use and land management?

- What factors determine the development of particular development pathways and changes in land use and land management? In particular, how have government policies, technical assistance programs, and other policy relevant factors affected these changes?

- What are the implications of different development pathways, policies, programs and other causes of change for agricultural productivity, natural resource and human welfare conditions?

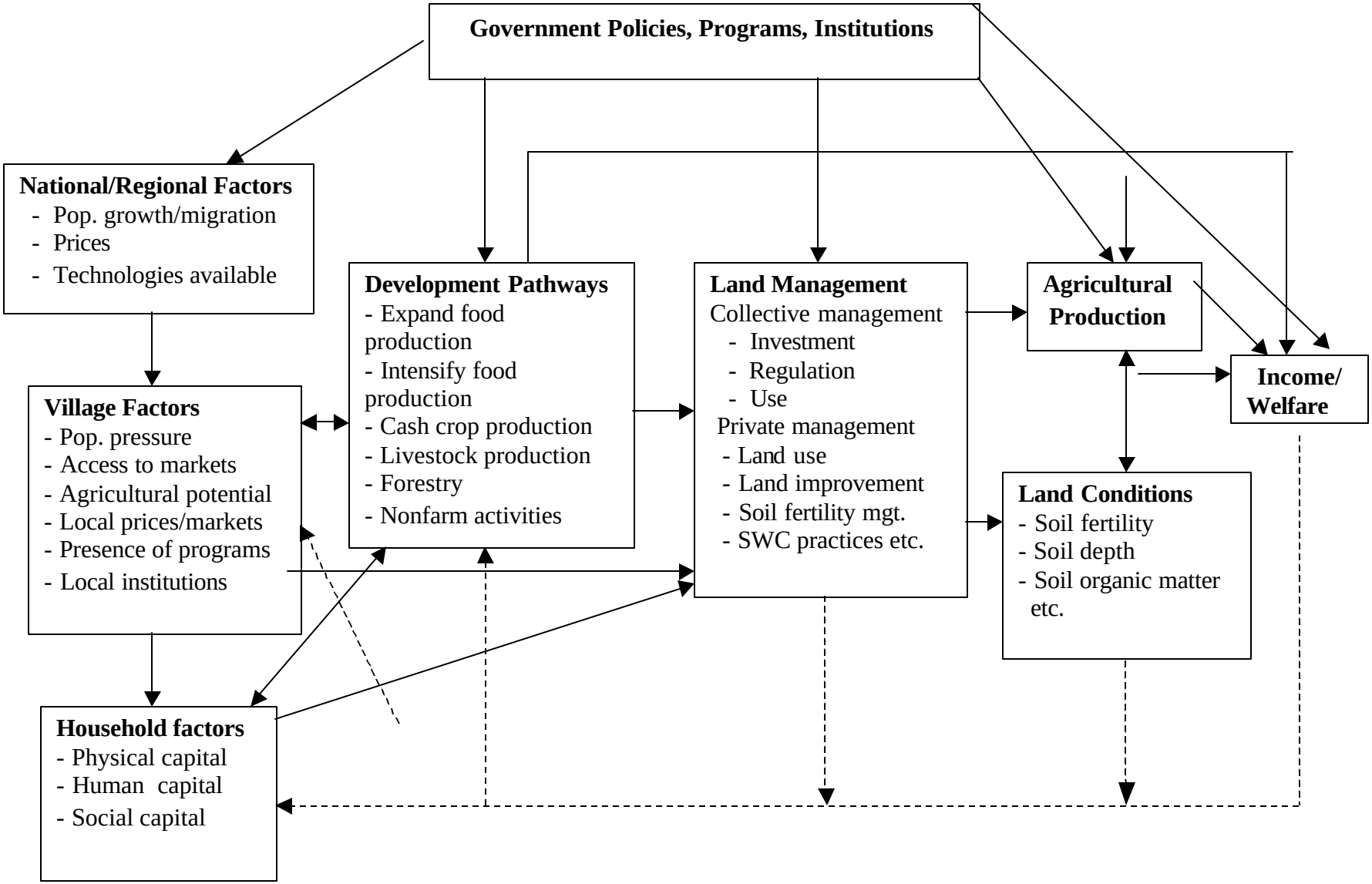
To address these questions, we have developed a conceptual framework to guide our development of hypotheses and choice of research methods.

CONCEPTUAL FRAMEWORK[4]

The conceptual framework is illustrated in Figure 1. Land management is determined by private decisions made at the farm household level, as well as by collective decisions made at the village or higher levels.

[4] This section is adapted from Sserunkuuma et al. (2001).

Figure 1--Factors affecting Development Pathways, Land Management, and their Implications



For example, farm households choose what crops to plant and how to manage soil fertility or conserve soil and water on their own land; but these decisions may be affected by regulations on land use set by local councils. Communities may also regulate use of communal grazing areas or other common lands, or may make collective investments in improving such resources, such as planting improved grasses or trees.

These household and collective decisions will determine current agricultural productivity and affect the condition of land resources (thus influencing future agricultural productivity), which in turn affect the level of farm income and household welfare. It is important to recognize that it is such outcomes (productivity, resource wealth, and household welfare), and not adoption of specific land management practices *per se*, that are likely to be of most concern to rural people and to policy makers. It is thus critical to consider the ultimate impacts of any policy or technology on these outcomes, and the extent to which there may be trade-offs or complementarities among these objectives. For example, a strict regulatory approach (e.g., preventing farmers from planting annual crops on steep lands) may be effective in reducing soil erosion but may also have severe implications for agricultural production, food insecurity and poverty. On the other hand, there may be "win-win-win" strategies available that promote greater productivity and incomes as well as improved resource conditions. For example, promoting intensification of annual crops in less steep areas and perennial production on steep lands may reduce land degradation while increasing agricultural productivity and farm incomes.

Land management decisions are determined by many factors operating at different scales (plot, household, village, region, nation, and international). Many of these factors influence land management directly; for example, the type of soil, topography of the land and the climate will have a large impact on whether soil erosion is likely to be a problem and what options are

feasible to address it. Demographic and socioeconomic factors—such as population density and access to markets—also influence land management. Some of these effects are direct; for example, access to markets determines the profitability of alternative practices. But some effects are indirect. For example, population pressure leads to smaller farm sizes and often to more fragmented holdings, which may reduce farmers' ability or incentive to fallow or to invest in land improvements.

One important indirect way in which biophysical and socioeconomic factors affect land management is by determining which development pathways are pursued in a particular location and by particular households. Development pathways may be influenced by many village level factors, such as agricultural potential, access to markets, population density, and presence of government programs and organizations. These factors largely determine the comparative advantage of a location by determining the costs and risks of producing different commodities, the costs and constraints to marketing, and the opportunities and returns to alternative activities, such as farming vs. non-farm employment. These factors may have generalized village level effects on development pathways, such as through their impact on village level prices of commodities or inputs, or they may affect farm household level factors, such as average farm size. Household level factors such as households' endowments of physical assets (farm size, land quality, livestock, savings), "human capital" (education, training, farming experience), and "social capital" (cultural norms, family and ethnic relations) may also determine the development pathway and land management practices pursued by particular households.

Government policies, programs and institutions may influence development pathways and land management and their implications for productivity, resource conditions, and household welfare at many levels. Macroeconomic, trade, and market liberalization policies will affect the

relative prices of commodities and inputs in general throughout a nation. Agricultural research policies affect the types of technologies that are available and suitable to farmers in a particular agro-ecological region. Infrastructure development, agricultural extension, conservation technical assistance programs, land tenure policies and rural credit and savings programs affect awareness, opportunities, or constraints at a village or household level. Policies or programs may seek to promote particular development pathways (e.g., non-traditional export cash crop production), or may seek to address constraints arising within a given development pathway (e.g., credit needs arising in cash crop production). Programs may attempt to address land management approaches directly, for example by promoting particular soil fertility management practices. Policies and programs may also be designed to affect development outcomes directly, for example, through direct management of land by the government, or through nutrition or income enhancement programs.

Currently available information does not provide policy makers with much guidance as to which of these intervention points will be most effective in achieving better land management, improving agricultural productivity, ensuring sustainable use of resources, and increasing incomes and food security. Much public action aimed at improving land management focuses on influencing household adoption of particular technologies. Yet this may be ineffective if the technologies are not suited to the development pathways that have potential in a given location. It may be more effective in many cases to first focus on the larger development strategies for particular development pathways, before focusing too much on particular land management technologies.

In the next section we discuss our hypotheses about the potential development pathways in rural Uganda, the factors determining them, and the implications of development pathways

and other key factors for land management, agricultural productivity, and resource and human welfare outcomes.

RESEARCH HYPOTHESES

First we consider hypotheses about the development pathways that exist in rural Uganda, their causes and implications. Then we consider hypotheses about other factors that may have important impacts on land management, productivity and resource and welfare outcomes.

Development Pathways and their Causes[5]

Sserunkuuma et al. (2001) hypothesize nineteen possible development pathways that may exist in rural Uganda, based upon consideration of the types of economic activities possible (crop production, livestock, forestry, non-farm activities), the orientation of agricultural production (subsistence vs. cash), the period of production for crops (perennial vs. annual crops), the costs of storing (storable vs. perishable) and marketing the commodities produced (transportable or not), and the labor intensity of land/labor use (extensive vs. intensive). These pathways include expanding (without significant intensification) or intensifying (without area expansion) subsistence perennial food production (e.g., *matooke*), expanding or intensifying subsistence annual food production (e.g, sorghum or millet), expanding or intensifying storable perennial cash crop production (e.g., coffee), expanding or intensifying perishable perennial cash crop production (e.g., *matooke* or fruits), expanding or intensifying storable annual cash crop production (e.g., cotton, maize, beans), expanding or intensifying perishable annual cash crop production (e.g., vegetables), expanding extensive livestock production (e.g., cattle, small ruminants in grazing systems), increasing intensive livestock production (e.g., dairy, pigs,

---

[5] This subsection is adapted from Sserunkuuma et al. (2001).

poultry), increasing production of high value forest products (e.g., timber), increasing production of low value forest products (e.g., fuelwood and charcoal), rural industry linked to agriculture (e.g., coffee processing, input supplies, trading), rural industry not linked to agriculture (e.g., crafts, mining, construction), and migration to urban areas for employment.

Many factors may determine the comparative advantage of these development pathways in different locations. Three factors are hypothesized to be particularly important: agricultural potential, access to markets, and population density. These factors can thus be used to identify different "development domains" in Uganda, each having somewhat different potentials in terms of feasible development pathways.

Agricultural potential is an abstraction of many factors—including rainfall level and distribution, altitude, soil type and depth, topography, presence of pests and diseases, presence of irrigation, and others—that influence the absolute (as opposed to comparative) advantage of producing agricultural commodities in a particular place. There are of course variations in potential depending upon which commodities are being considered. Furthermore, agricultural potential is not a static concept but changes over time in response to changing natural conditions (such as climate change) as well as human-induced conditions (such as land degradation). For simplicity of exposition, however, we discuss agricultural potential as though it were a one dimensional and fixed concept.

Access to markets is critical for determining the comparative advantage of a given location, given its agricultural potential. For example, a community with an absolute advantage in producing perishable vegetables (i.e., higher productivity in vegetable production) may have little or no comparative advantage (low profitability) in vegetables if it is far from roads and urban markets. As with agricultural potential, market access is also a multi-dimensional and

dynamic concept (distance to roads, condition of roads, distance to urban centers, degree of competition, access to transport facilities, access to international markets, etc.).

Population density affects the labor intensity of agriculture by affecting the land/labor ratio, and may also induce innovations in technology, markets and institutions, or investments in infrastructure (Boserup 1965). Population pressure thus affects the comparative advantage of labor-intensive pathways of development, as well as returns to various types of investments.

Consideration of these factors suggests potentials for several types of crop-oriented development pathways in Uganda. These include expansion and intensification of high value storable traditional export crops like coffee and cotton in areas with climate and soils suited to their production, expansion and intensification of perishable crops like fruits and vegetables in areas of high market access and sufficient rainfall or irrigation, and expansion and intensification of maize for the regional market in areas with sufficient rainfall. Expanding and intensifying production of other bulky food crops for subsistence purposes or for the local market (e.g., *matooke*, cassava, sweet potatoes) may also be viable development pathways, even if Uganda does not have a regional or international comparative advantage, since such commodities tend not to be tradable over long distances. Such products may have potential as cash crops close to urban centers or for subsistence purposes in more remote areas. Whether the development pathways used for crops are extensive or intensive will depend upon whether land of suitable potential is available for expansion, which depends upon population density and agricultural potential of particular areas, and the availability of suitable technologies for extensification or intensification.

Similar considerations apply to production of livestock and livestock products. Intensive production of perishable products such as dairy and fish farming are likely to be suited mainly to

areas of high market access and high population density. Extensive production of high value livestock that are relatively easy to transport, such as cattle and small ruminants, can occur in areas far from markets, and tends to have a comparative advantage in areas that are low in potential for crop production. Dairy products may also be produced in such extensive systems in lower potential areas, but high access to collection and processing facilities or to urban markets is essential. Other animals such as pigs and poultry can be raised for subsistence purposes in many areas, but intensive production for the market is likely to occur mainly close to urban areas, due to economies of scale in production, relatively high costs of transporting them relative to their value, the perishability or ease of damage of some of the products (e.g., eggs) or the use of purchased compound feeds (especially for poultry). In areas where subsistence food production continues to be important (especially in annual cropping systems where tillage by draught animals is suitable), mixed-crop livestock production is likely to be important (or may develop as population density rises in pastoral systems), with farmers keeping animals for plowing, consumption purposes and as a form of savings. This is because the benefits of exploiting complementarities between crop and livestock production rise as population density rises, particularly where markets are not well developed (McIntire et al. 1992).[6]

Forestry production is likely to be suited to high rainfall areas of low population density, since land scarcity in high-density areas usually causes intensive food or cash crop production to have higher value and higher priority. Even in low-density settings, there are often conflicts between extensive livestock production and forest preservation (NEMA 1998). Production of high value forest products such as timber or pine resin may be economical in remote locations (if

[6] These changes can be affected by cultural views. For example, in Ankole farmers are reluctant to use cattle for plowing, preferring not to use them as "beasts of burden." The nature of the soil (i.e., how heavy or light) also affects whether animals can be used for tillage.

suitable road and transport infrastructure exists), while low value products such as fuelwood must be produced close to markets, unless they are used only for subsistence purposes. Conversion of fuelwood to charcoal can extend the marketable range of fuelwood products, however.

In most cases, rural non-farm activities are linked to agriculture. This includes activities related to processing agricultural commodities, commodity trading, and provision of agricultural inputs. Potential for development of these activities thus depends on commercial agricultural development. These activities are more likely to be significant sources of employment in higher population density areas close to urban centers and towns.

There is also potential for rural people to be employed in rural non-farm activities that are not linked to agriculture, such as making crafts, construction, and employment in urban areas. All of these activities are more likely to be important in areas with relatively good road and market access.

Development Domains in Uganda[7]

We mapped different development domains in the study region of Uganda (excluding parts of the west, northwest, north and northeast) based upon available secondary information related to agricultural potential, market access and population density (Ruecker, 2001), and used this information in selecting our survey sample, and analyzing the results.

For this study, Ruecker (2001) classified agricultural potential based upon the agro-climatic potential for perennial crop production, based upon the average length of growing period, rainfall pattern (bimodal vs. unimodal), maximum annual temperature, and altitude (Figure 2). Potential for annual crop production was also mapped and the maps were found to be

[7] This subsection is adapted from Sserunkuuma et al. (2001).

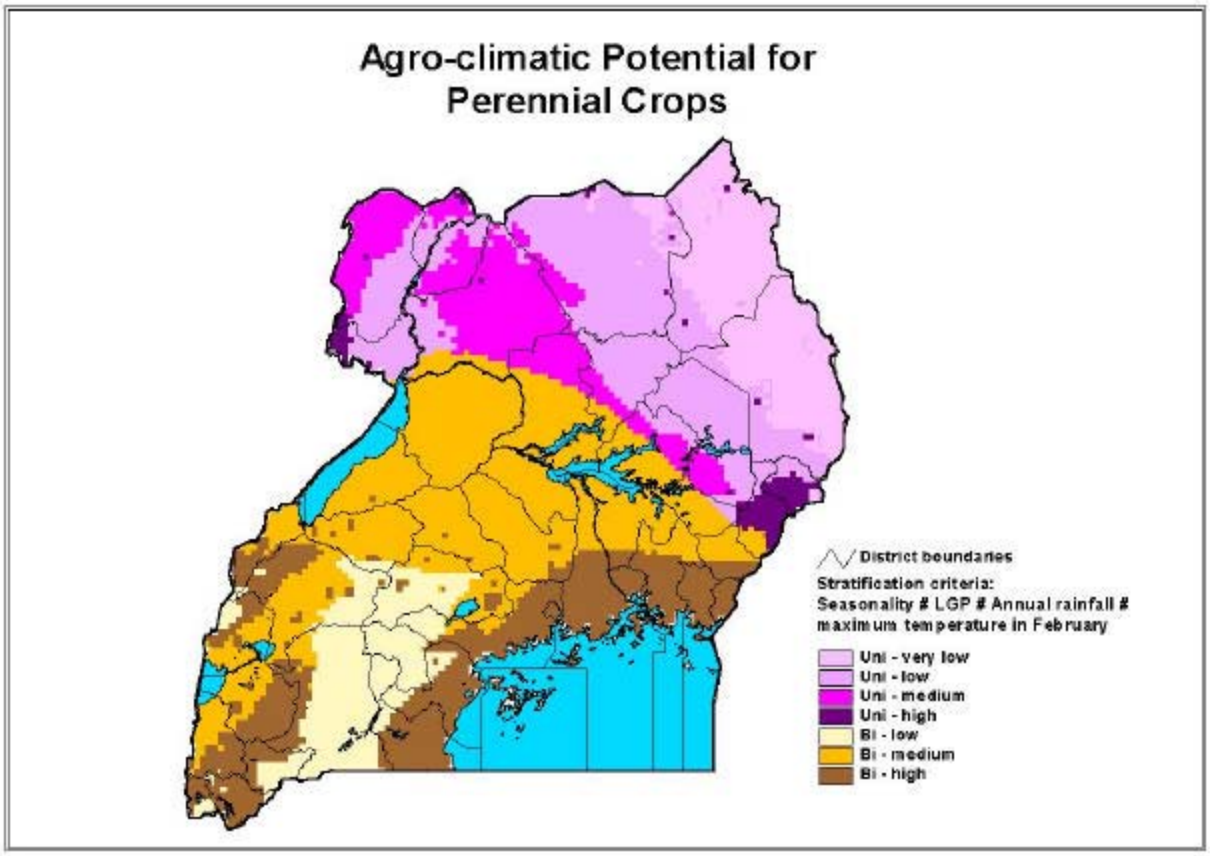
very similar. Seven zones were identified within the study area: the high potential bimodal rainfall area at moderate elevation (the Lake Victoria crescent), the medium potential bimodal rainfall area at moderate elevation (most of central and parts of western Uganda), the low potential bimodal rainfall area at moderate elevation (lower elevation parts of southwestern Uganda), the high potential bimodal rainfall southwestern highlands, the high potential eastern highlands, the medium potential unimodal rainfall region at moderate elevation (parts of northern and eastern Uganda), and the low potential unimodal rainfall region at moderate elevation (much of northeastern Uganda). In the stratification used for the survey and in the analysis and discussion of the results, we combined the unimodal low and unimodal medium potential regions, since we expect that similar development pathways and land management practices will be pursued in these areas.

These regions of Uganda were also classified according to the level of market access and population density. To classify market access, we used the measure of potential market integration estimated by Wood et al. (1999), which is a measure of travel time from any location to the nearest five towns or cities, weighted by the population of the towns or cities. Areas of high market access are mainly in the Lake Victoria region, the densely populated southwestern and eastern highlands, and parts of the north and west close to major roads and towns. Population density was classified based upon rural population density of parishes in 1991 (greater or less than 100 persons per square km., which is about the average rural population density in Uganda).

Overlaying these three dimensions of agricultural potential, market access and population density, we can classify different development domains of Uganda (Figure 3). There are 24 possible domains (combining the unimodal medium and low potential zones), though only 16 are

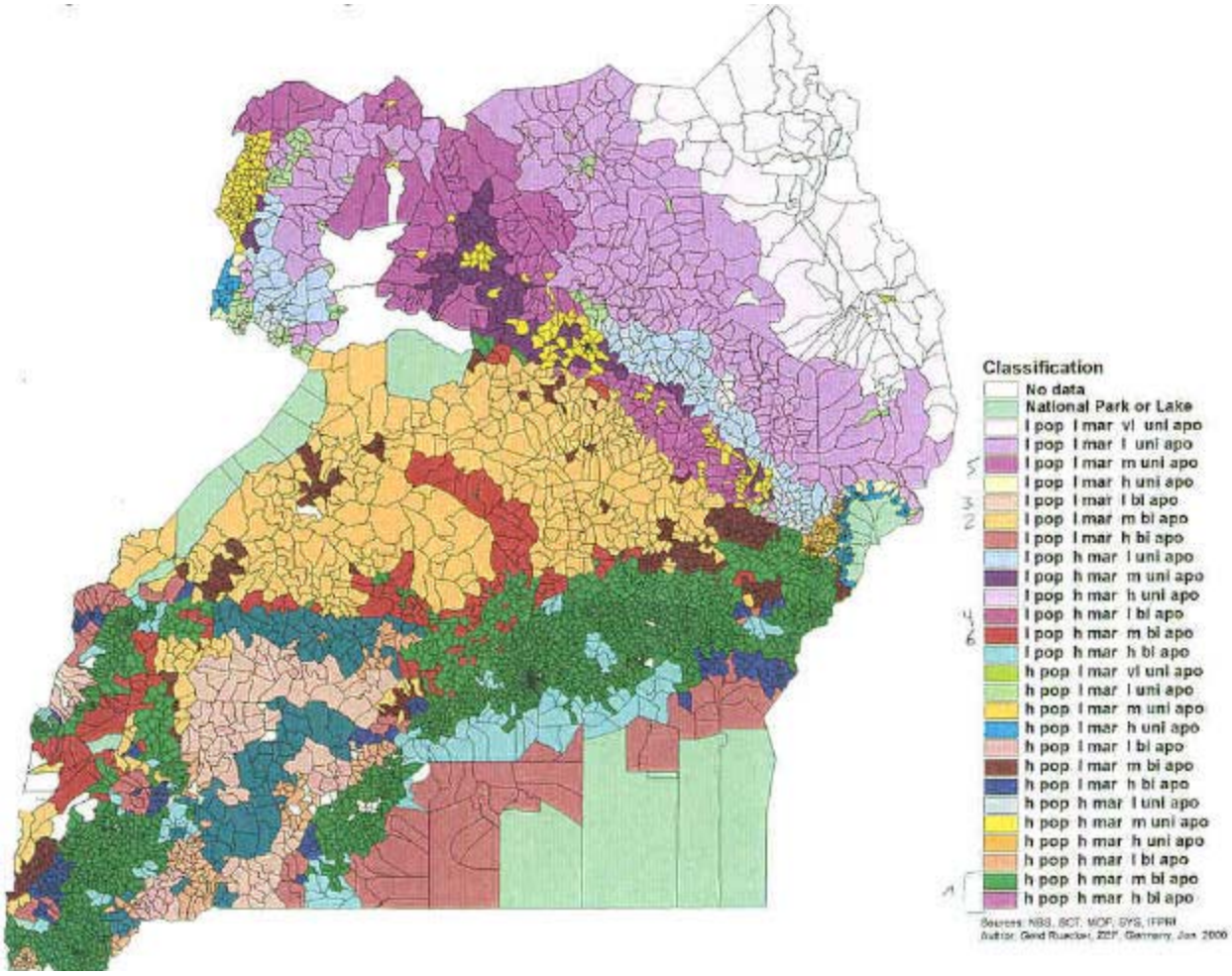
represented to any significant extent in Uganda. Because of correlation among the factors, some possible combinations do not occur. For example, it is difficult to find places with low market access and high population density (except in parts of the highlands) or high market access and low density (except in lower potential areas).

Figure 2--Agro-climatic Potential for Perennial Crops



Source: Gerd Ruecker, Center for Development Research, 2000

Figure 3--Development Domains in Uganda



Source: Data from Gerd Ruecker, Center for Development Research, 2000

Impacts of Development Pathways

Different development pathways may have many different impacts on land management, productivity, and resource and welfare outcomes. We will not attempt to provide an exhaustive set of hypotheses about these impacts, but rather illustrate general principles with some examples.

In less densely populated low market access areas, such as in much of the bimodal low and medium rainfall zones and unimodal rainfall zones to the north and west, expansion of subsistence food production using traditional methods is likely to be a common strategy, and adoption of labor-intensive means of land management such as constructing soil bunds or composting is likely to be limited. Adoption of purchased agricultural inputs such as fertilizer and improved seeds is likely to be lower in lower in these areas than where cash crop production for the market is important. Expansion of cultivation and livestock in these areas is likely to create pressure on forests, grazing lands and wetlands, with negative impacts on these resources. Improvement in per capita incomes and welfare are likely to be limited in such areas.

In densely populated remote areas, such as in parts of the highlands, opportunities for area expansion are much more limited, and intensification of subsistence production is likely to be an important pathway. In this situation, labor-intensive methods of land management are more likely to be adopted than in more extensive development pathways. There may be opportunities for increased integration of crop, livestock and forestry or agroforestry activities on the farm, particularly in higher potential areas where production of leguminous trees or cover crops in spatial or temporal niches can enhance the productivity of crop and livestock production. Such practices can help to conserve and improve land conditions; nevertheless, pressure on land and limited opportunities for fallowing may still lead to problems of land

degradation and declining productivity. Unless there is also significant development of market-oriented development pathways (such as intensified production of storable cash crops) or adoption of more productive technologies, stagnation or decline in per capita incomes and human welfare in such intensive systems is likely (Pender 1998 and 1999).

In densely populated areas with good market access and high rainfall, as in most of the Lake Victoria crescent, many development pathways are possible, but the most profitable ones likely involve intensive production of high value perishable annual crops, perennial crops or livestock products, or development of non-farm activities. Where such development pathways are being pursued, commercialization and cash incomes are likely to be increasing, facilitating farmers' ability to purchase inputs such as fertilizers, improved seeds and pesticides. Adoption of such inputs is thus expected to be associated with these development pathways. The effect of these pathways on the labor intensity of production depends on their effect on relative costs of land and labor, both of which are likely to be increasing in these areas. Where land values are rising faster than labor costs, intensification of labor per unit of land can be expected, thus facilitating adoption of labor-intensive methods such as mulching, manuring and composting. The types of land management practices pursued also will depend on the types of commodities produced. For example, in perennial banana-coffee systems, the availability of crop waste materials and the need to conserve soil moisture may promote the use of mulching and composting. Where intensive livestock production is occurring, such as dairy development, increased use of stall feeding and recycling of animal wastes to the soil through manuring and composting is likely. Such changes can bring about improvements in soil fertility, though this is not assured given increasing export of nutrients via commercialization, and there can be negative impacts on water quality and other environmental conditions (particularly where agro-chemical

use is rapidly increasing). Incomes and human welfare indicators are more likely to be improving in areas where these development pathways are being pursued than in most other areas.

In areas with good market access but lower rainfall, as in parts of the bimodal low and medium potential zones close to roads, similar development pathways are possible as in the higher rainfall areas, provided there is adequate investment in irrigation or water management, especially for perennials or horticultural crops. Given water constraints, production of annual cash crops more suited to lower rainfall conditions, such as cotton or cereals, may be more important than in higher rainfall areas. Land management practices are likely to give priority to water management and soil moisture conservation in such areas. Given production of cash crops and good market access, farmers are likely to be able to use purchased inputs, though use of inorganic fertilizer may be limited by soil moisture considerations in more drought-prone areas. There is likely good potential for integrating livestock with crop production, particularly in annual crop systems where draft animals can be used for tillage, and this can contribute to use of manure and compost for soil fertility management. Such land management practices can contribute to improvements in soil fertility and other land conditions to the extent that they are adopted. Nevertheless, there is risk of declining soil fertility as commercialization proceeds in such areas, since more soil nutrients will be exported and these may not be adequately replenished by recycling of manure and other nutrients alone. Increased use of fertilizer is likely to be needed in such circumstances. To the extent that water, soil fertility and other production constraints can be overcome, yields and incomes may improve in these areas as a result of increased production for the market.

Impacts of Other Factors

Many other factors besides the development pathway pursued can also affect land management practices and outcomes. Of particular importance are likely to be population pressure, market access, irrigation, and technical assistance programs and other programs and organizations influencing land management directly or indirectly.

Population Pressure

As mentioned previously, population growth is expected to cause expansion of cultivated area in less densely populated areas where expansion is feasible, or to increase the labor intensity of agriculture where expansion is less feasible (Boserup 1965). Increases in the labor intensity of agriculture can take the form of declining use of fallow, adoption of more labor-intensive methods of cultivation (e.g., increased hoeing and hand weeding, composting, mulching), labor-intensive investments in land improvement (e.g., construction of soil bunds, tree planting), or adoption of more labor-intensive commodities (e.g., horticultural crops) (Pender 1999).

Population pressure may also induce increases in the capital intensity of agriculture, particularly in forms of capital that are complementary to labor (e.g., use of draft animals and some inputs); increases in the "knowledge intensity" of agriculture, through adoption or adaptation of technologies (e.g., improved seeds, integrated pest or soil nutrient management); or have more indirect (but still important) effects by stimulating migration, changes in livelihood strategies, investments in infrastructure, or inducing technical or institutional change (Ibid.). In general, intensification is expected to lead to increases in yields, unless accompanied by land degradation. However, it is expected to lead to declining labor productivity, per capita income and welfare (as a result of diminishing returns to labor), unless population growth induces

technical change, improvement in infrastructure and market access, or other improvements in opportunities (Ibid.).

The impacts of population growth on resource conditions may be mixed. At low levels of population density, population growth likely leads to worsening resource conditions as cultivated and grazing area expands at the expense of forest, woodland, and other land uses. As intensification proceeds, however, land conditions may improve as farmers invest in labor-intensive land improvements (Ibid; Tiffen et al. 1994; Scherr and Hazell 1994). However, population pressure may also encourage farmers to abandon conservation measures, particularly those such as terraces that reduce cultivated area (Herweg 1992); as well as encouraging production on steeper and more fragile terrain, degradation of common property resources, overuse of inputs, and other problems. Thus the impacts of population growth on resource conditions may be either positive or negative, depending on the context.

Market Access

Increases in the profitability of agricultural products resulting from infrastructure investment, market development, or changes in market prices will promote expansion of agriculture into marginal areas if the costs of productive factors or outputs are unaffected by the change (Angelsen 1999). However, if the costs of factors rise (as a result of constrained supply of some factors), a reduction in agricultural area is possible as productive factors are concentrated on the most profitable lands (Ibid.). If expansion of agricultural land is limited, increased profitability will cause intensification of labor and/or capital per unit of land, though the effects on capital relative to labor depend on the nature of factor markets and the nature of the change. Improved market access and market development will tend to promote production of cash crops and lead to increased farm incomes and wealth. Market access can also contribute to

human welfare in other ways, by increasing access to goods and services. The implications for resource management and environmental conditions may be mixed. For example, changes in commodity prices have a theoretically ambiguous effect on soil conservation investments (LaFrance 1992; Pagiola 1996). Market development may increase externalities associated with demand for water and agricultural chemicals.

Irrigation

As with improvements in market access, irrigation can enable production of higher value crops such as horticultural crops, as well as enabling multiple crops per year and higher yields of food crops. If this increases the costs of productive factors, it may limit expansion of agricultural production, as in the case of improved market access. Irrigation may promote investments in complementary soil and water conservation investments and practices, such as investments in terracing and drainage (Pender and Kerr 1998). It may also encourage farmers to adopt productive inputs such as fertilizer, particularly where soil moisture constraints limit farmers' willingness to use fertilizer (Pender et al. 1999). Irrigation is likely to contribute to increased food production and/or incomes and thus to food security of those with access to it. It also tends to increase demand for labor (as a result of multiple cropping and adoption of labor intensive crops and practices) and thus can also benefit farm laborers. However, irrigation may have negative effects on people downstream, as a result of reduced access to water or increased use of agrochemicals. Poorly designed irrigation systems without adequate drainage can lead to salinity problems in the soil. Surface irrigation can also contribute to increased problems of malaria, by providing breeding sites for mosquitoes.

Programs and Organizations

Programs and organizations can have varied impacts on land management, agricultural productivity, and resource and welfare outcomes, depending upon the type and emphasis of the program or organization, the activities it pursues, the degree of participation achieved, the effectiveness of the participation, and other factors. Most programs and organizations operating in rural Uganda are either government sponsored, non-government organizations that are organized and financed external to particular communities (NGO's), or community-based organizations (CBO's).[8] These programs and organizations are usually focused on providing infrastructure or public services, agricultural extension, environmental protection, or poverty reduction (Jagger 2001). Government programs and NGO's are involved in all of these areas, though a larger proportion emphasize infrastructure and public services than other activities. CBO's in contrast, are mainly focused on poverty alleviation and providing community support services (for example, assistance with funeral arrangements).

Programs and organizations oriented towards technical assistance in agriculture and/or environmental protection likely have the most direct effects on land management. In some cases (e.g., Sasakawa Global 2000, the IDEA project, and the Ministry of Agriculture extension program) these programs are promoting increased use of purchased inputs such as improved seeds and fertilizer. In other cases, especially among NGO's (e.g., AT Uganda, Africa 2000 Network, African Highlands Initiative) they are promoting low external input agricultural technologies, such as mulching, composting, cover crops and agroforestry practices. We expect that NGO's are having a positive impact on adoption of such land management practices, though

[8] Other categories include religious organizations, research organizations, and private businesses and organizations.

this may be true of some government programs as well. We expect less direct impact of CBO's on land management, since they are less focused on this.

Programs and organizations oriented towards infrastructure and public service provision are expected to have direct effects on many aspects of human welfare, by increasing access to transportation, education, health, water, and other important goods and services. They may also have important indirect effects on land management and natural resource conditions. For example, improvements in education may increase farmers' receptiveness or ability to respond to technical assistance; while improvements in health can increase farmers' ability to undertake labor-intensive practices. By affecting land management, such programs can also indirectly affect natural resource conditions. We expect these kinds of effects to be important for both government and NGO programs, but less so for CBO's which are less focused on this.

Programs focused more on poverty reduction (emphasizing income generation activities, social development and assistance to disadvantaged people) also can have important direct effects on welfare and indirect effects on land management and resource conditions. Such programs may influence the development pathways of particular households, and thus influence land management and resource conditions as discussed above regarding impacts of development pathways. They also affect household level endowments of physical, human and social capital that can constrain or promote various land management practices (e.g., income generation and social development may increase farmers' access to credit and affect their ability to purchase inputs or acquire livestock). These impacts can in turn affect resource conditions. We expect these kinds of impacts to be most important for CBO's, but also important for some government programs and NGO's.

RESEARCH METHODS

Data Sources

Many of the above hypotheses are tested using analysis of survey data collected in 107 communities during 1999 and 2000. The communities were selected using a stratified random sample of communities from the different development domains shown in Figure 3.[9] One hundred LC1's were selected in this way. Additional communities were purposively selected in southwest Uganda, where the African Highlands Initiative is conducting research, and in Iganga, where the International Center for Tropical Agriculture (CIAT) is conducting research.

Within each selected LC1, a survey was conducted with a group of individuals representing the community. Respondents were selected to represent different ages, genders, occupations and villages of residence within the LC1 (if there was more than one village in the LC1). The LC1 survey collected information on the location of the community, the major concerns and priorities of community members, population change, access to infrastructure and services, presence and activities of programs and organizations, land rights and restrictions, local bylaws, and collective resource management.

A village-level survey was also conducted with a group of village representatives within each LC1. If there was more than one village in the LC1, one village was randomly selected for the village survey. The village survey collected information on livelihood strategies; perceptions of change in human welfare and natural resource conditions; land use and land tenure relations; factor markets (land, labor, credit); crop and livestock management, production and commercialization; and commercialization of tree products. Where information about changes was sought, the focus was on changes since 1990, and we also asked respondents for their

---

[9] At least four communities were selected from each stratum. Details on the numbers of communities selected in each stratum and the sampling weights are available from the authors.

perceptions of the reasons for change. We used a common method of ranking perceptions of change in all cases: +2 = major increase (or improvement), +1 = minor increase, 0 = no change, -1 = minor decrease, -2 = major decrease.

The survey information was supplemented by secondary information collected from the 1991 population census and available digitized map information incorporated into a geographic information system (GIS). The boundaries of the communities were also mapped with community members, digitized and incorporated into the GIS.

Analysis of Data

Analysis of the survey data included analysis of descriptive statistics to identify general patterns and trends of development and land management in the study region (presented in Section 3), factor analysis to identify the development pathways (Section 4) and econometric analysis to test the research hypotheses (Section 4).

The factor analysis used data on the primary activities of men and changes in the top three activities to identify the development pathways. We did not use information on women's occupations for the classification. This was not because we regard women's occupations as less important, but because women's primary occupation is dominated by household maintenance activities, with little variation across communities, while changes in women's occupations were quite similar to changes in men's. Using only men's occupation was thus a reasonable way to simplify the classification problem. We used the principal component factor method, and rotated the first six factors using the varimax method (Stata 1997). As discussed in Section 4, the first six factors have a clear interpretation as development pathways. After the first six factors, clear patterns were difficult to identify and interpret.

The econometric analysis focused on determinants of the development pathways (as measured by the factor scores from the factor analysis) and changes in livestock use, land use, land management practices, purchased input use, crop yields, and various indicators of change in natural resource conditions and human welfare. For the regressions explaining the development pathway factor scores, least squares regressions were used. For all other regressions, the dependent variable was an ordinal index measuring change (taking integer values from –2 to +2), and least squares regression was therefore inappropriate. We instead used ordered probit regressions, which is appropriate for ordered response data (Amemiya 1985).

The econometric model for the development pathways is given by:

1) $$d_{iv} = a_i + b_i \Delta x_v + c_i z_v + e_{iv}$$

where d_{iv} is the factor score on factor i (the ith development pathway) of village v, Δx_v is a vector of changes in explanatory variables (such as change in population and access to roads) between 1990 and 1999, z_v is a vector of fixed factors (such as the agro-climatic zone and market access classification), e_{iv} is an unobserved error term for factor i and village v, and a_i, b_i, and c_i are parameter vectors to be estimated by least squares regression.

The econometric model for the other response variables (changes in livestock use, land use, land management, crop yields, and resource and welfare indicators) is given by:

2) $$\Delta y^*_{jv} = h_j + k_j \Delta x_v + l_j z_v + \sum_i m_{ji} d_{iv} + v_{jv}$$

3) $$\Delta y_{jv} = -2 \;\; if \;\; \Delta y^*_{jv} < \alpha_{-2j}$$

4) $$\Delta y_{jv} = -1 \;\; if \;\; \alpha_{-2j} \le \Delta y^*_{jv} < \alpha_{-1j}$$

5) $$\Delta y_{jv} = 0 \;\; if \;\; \alpha_{-1j} \le \Delta y^*_{jv} < \alpha_{1j}$$

6) $$\Delta y_{jv} = +1 \;\; if \;\; \alpha_{1j} \le \Delta y^*_{jv} < \alpha_{2j}$$

7) $$\Delta y_{jv} = +2 \;\; if \;\; \Delta y^*_{jv} \ge \alpha_{2j}$$

where Δy_{jv} is the value of response variable j in village v, Δy^{*}_{jv} is an unobserved continuous variable that predicts Δy_{jv}, v_{jv} is an unobserved error term that is assumed to be normally distributed, and h_j, k_j, l_j, m_{ji}, α_{-2j}, α_{-1j}, α_{1j} and α_{2j} are parameters to be estimated, using maximum likelihood estimation. The other variables are the same as defined above.

The fixed explanatory variables included in these models (z_v) include dummy variables for the agro-climatic zones, market access class, population density class, and whether there is irrigation in the village. The explanatory variables representing changes include change in the natutal logarithm of household density, [10] change in distance to the nearest tarmac road, change in distance to the nearest rural market, the number of government programs, the number of NGO programs, and the number of CBO's operating in the village.[11]

There are some potential problems with these regression models. Population growth and presence of organizations may respond to development opportunities as well as being a causal factor affecting development. Thus there is the potential for reverse causality to affect the interpretation of our results. For example, we might find high population growth in communities pursing intensification of cash crops, not because population growth caused this development, but rather because this development potential attracted immigrants to such communities. The standard econometric approach to this problem is to use a two-stage model, in which the potentially endogenous explanatory variable (population growth in this case) is replaced by the

[10] We use household density rather than population density because we judge that our recall data on number of households is less subject to error than recall data on population. We take the natural logarithm of household density because this variable is more normally distributed than household density, which generally improves the specification in linear regression models (Mukherjee et al. 1998). Note that the change in ln(household density) is the same as change in ln(number of households), since the area does not change, so this eliminates any error associated with error in measuring area of the LC1.

[11] Ideally we should use the change in number of programs and organizations rather than simply the current number of programs. However, since there were few programs and organizations operating in 1990 (Jagger 2001), the current number will be highly correlated with the change, and thus a good proxy for change.

predicted value of that variable. If the predicted value is determined only by exogenous factors (i.e., factors not influenced by the response variable being considered), that will purge the regression of the problem of reverse causality. To address this problem we therefore used predicted values of growth in ln(number of households) and numbers of programs and organizations in one version of each of the regressions, and report the robustness of our statistically significant findings to this alternative specification.[12] In most cases we find that our results are robust (see Section 4).

The development pathway variables might also be subject to this problem of reverse causality in the regressions where they are included as explanatory variables. For example, declining yields of *matooke* may induce farmers to shift to other economic activities such as production of other crops or livestock. Unfortunately, we are not able to use the same approach to solve this problem, because the same variables that determine development pathways also can affect land management directly, controlling for the development pathway. Because of this, including predicted values for the development pathway in the other response regressions would lead to perfect multicollinearity and the model would not be estimable. We do not have any solution for this identification problem. Thus, our interpretation of the "effects" of the development pathway variables on land management and outcomes should be tempered by the

[12] The exogenous or predetermined factors used to predict change in ln(number of households) and number of organizations included the fixed factors mentioned above, the change in distance to the nearest tarmac road and to the nearest rural market, the number of households in the community in 1990, and whether community members used any of a variety of infrastructure and services in 1990 (tarmac road, murram road, seasonal road, bus, minibus, pickup truck, motorbike, trading center, or rural market). It was expected that earlier population levels and access to such infrastructure and services would affect opportunities and constraints in the villages, and therefore could affect migration to or from villages (hence population growth) and the likelihood of new organizations or programs locating there. This assumption was supported by the significance level and coefficient of variation for these auxiliary regressions, which were statistically significant in all cases and had R^2 values of 0.28 or higher. These regression results are available from the authors upon request.

realization that we are only reporting correlations, and that causality may go in the opposite direction.

Another potential problem is (imperfect) multicollinearity among the explanatory variables, which reduces the ability to disentangle the effects of particular variables. We tested for this problem using variance inflation factors, and found that the maximum variance inflation factor was less than 3, indicating that multicollinearity is not a major concern.[13] Heteroskedasticity also could be present, affecting the standard errors. We used the Huber-White estimator for standard errors, which is robust to heteroskedasticity. All means and regression coefficients were also corrected for sampling weights and stratification, so that the statistical results are representative of the study region as a whole.

3. DEVELOPMENT TRENDS AND LAND MANAGEMENT PRACTICES IN UGANDA

Uganda has undergone enormous change and revitalization since the mid-1980s. In general terms, human welfare has improved throughout the country, particularly with respect to the accessibility of health and education services. Along with a general improvement in various welfare indicators there are perceptions of worsening natural resource conditions. This general finding may be an emerging trend for developing countries (for example, see Pender et al. 1999; Pender et al. 2001) and has important implications for land management policy. However, although there is a general trend of improving welfare and declining natural resource conditions, there is a high degree of variability throughout the various development domains in Uganda.[14] In

[13] The variance inflation factor (VIF) measures the extent to which the variance of a coefficient is inflated by multicollinearity (Mukherjee, et al., 1998). According to one rule of thumb, a maximum VIF of less than 10 indicates that multicollinearity is not a major problem (Ibid).

[14] Recall that development domains are defined by agricultural potential, market access and population density.

this section we present evidence on some of the patterns and trends in development and land management in Uganda.

HUMAN WELFARE AND NATURAL RESOURCE CONDITIONS

Human welfare indicators for 1999 indicate that over 90% percent of primary school age children are in school, 61% of houses have a metal roof (an indicator of housing quality), and 65% of households have children eating at least two meals per day on average (Table A1). Since 1990 there have been significant improvements in many aspects of human welfare. Housing quality, literacy, school attendance, the quality of drinking water, child and maternal mortality, the availability of educational services, the average level of durable goods owned by households, the availability and quality of health services, the availability of energy sources for lighting, access to transportation and the availability of consumer goods are all perceived to have improved on average (Tables A2 and A3). However, farm sizes have declined and the proportion of households without adequate food, general food availability, households' ability to cope with drought, and availability of energy sources for cooking and heating are perceived to have declined on average.

While many aspects of human welfare are perceived to be improving, the condition of natural resources is perceived to be deteriorating in general. Since 1990, the availability and quality of cropland, grazing land, forests and woodland are reported to be decreasing in general (Table A4). Soil fertility is declining everywhere, and the decline is usually reported as major. Soil moisture holding capacity is also perceived as declining and soil erosion problems worsening. Natural water sources are reportedly becoming less available, and biodiversity of wild plants and animals is perceived to be deteriorating in most places.

Beyond these general findings some interesting and divergent trends in welfare and natural resource indicators are evident in the different development domains of the country. The unimodal rainfall areas of northern Uganda are characterized by lower rainfall and, in most cases, low market access and low population density. In these areas food security is below average for the country. Only 41% of households are reported to eat two or more meals per day on average. Only small changes in food security and housing conditions have been observed in unimodal areas since 1990. However, there have been major improvements in primary school education since 1990; almost all children of primary school age were in school in 1999. The availability of health services, transportation and consumer goods are also improving in this region, as in other parts of Uganda. Soil fertility in unimodal areas is decreasing, but has changed the least compared to other regions since 1990. Similarly, although grazing land and woodland are deteriorating, they are deteriorating at a lesser rate than elsewhere in the country.

The bimodal low agricultural potential zone includes mainly the southwest cattle corridor between the Lake Victoria region and the southwest highlands region. It is characterized by low rainfall and generally low population density, while much of this region has relatively good market access. There have been significant improvements in both primary and secondary education; the region has the second highest proportion of households with children of secondary school age in school (Table A1). As in many other parts of the country, the availability of educational services has substantially improved in this zone, as has availability and quality of health services, access to transportation, and several other indicators of welfare. However, food insecurity is serious and worsening in this region. In nearly two-thirds of households in this region, adults eat fewer than two meals per day on average, and this proportion has been increasing. Food availability is also decreasing in general. At the same time nutrition of

children and infant and child mortality have improved. These outcomes may be linked to good market access throughout much of the region and general improvements in the quality of health services. Soil fertility and soil moisture holding capacity are deteriorating, and the availability of grazing land is decreasing.

The bimodal medium and high potential zones, which include most of western and central Uganda and which have generally good market access (especially in the high potential Lake Victoria crescent), are experiencing more positive human welfare outcomes. In 1999, food security indicators were highest in these zones, with 24% (bimodal medium) and 33% (bimodal high) of households with children eating less than two meals per day. In both zones, adult literacy and school attendance were close to national averages. The bimodal high rainfall zone has experienced the most significant improvements of any zone in availability and quality of drinking water and availability of health services. In this favored region, high levels of market access are reflected in major increases in access to transportation, ownership of durable goods and availability of consumer goods.

High and rapidly growing population densities may be causing land degradation in the bimodal high potential region. Cropland degradation is reflected in declining soil fertility, declining soil moisture holding capacity, and worsening soil erosion. The availability and quality of grazing land are also deteriorating, as well as the diversity of wild plant and animal species. In the less densely populated bimodal medium potential zone, most indicators of land degradation are not as strong as in the bimodal high rainfall region. However, the availability and quality of forest and woodland resources is deteriorating more so than in other regions of the country.

Food insecurity is a severe and worsening problem in the densely populated southwest highlands. Ninety five percent of households reportedly do not have adequate food throughout the year (compared with an average of 61% country wide), food availability and child nutrition have declined the most in this zone, and the proportion of households without adequate food has increased substantially since 1990. The proportion of households with primary school age children in school is equivalent to the country average, though secondary school attendance is the lowest of any zone. Nevertheless, there has been major improvement in school attendance and housing quality in this zone. The availability and quality of health services are perceived to have improved in general in this zone, but the general health of people has declined. Natural resources in the southwest highlands have undergone major deterioration since 1990. There have been major declines in average farm size, availability of cropland, soil fertility and soil moisture holding capacity. Parts of the southwest highlands appear to be in a poverty and resource degradation trap, with poor and worsening human welfare and natural resource conditions.

In the relatively high potential and densely populated eastern highlands, most human welfare indicators for 1999 are close to averages for the country. However, there has been significant change in this region since 1990, including worsening of food security indicators coupled with general improvements in education, health, and transportation services. Changes in many welfare indicators in this region are similar to those of the southwest highlands. Also, like the southwest highlands, soil fertility depletion and erosion are worsening and contributing to food insecurity and poverty. The availability of grazing land is also decreasing, and the deterioration of biodiversity indicators is the worst in the country. However, the eastern highlands appear to be benefiting from emerging markets within the country as well as close proximity to Kenyan markets. Since 1990 the eastern highlands have experienced major

improvements in the average level of household durable goods, the availability of energy sources such as kerosene for lighting, and improvements in the availability of consumer goods.

In addition to comparing zones of different agricultural potential, it is instructive to examine human welfare and natural resource indicators in the context of variations in market access and population density. There is very little difference in indicators of education and educational change between low and high market access areas (Table A1), but there has been greater improvement in the availability of education in low population density areas than high density areas since 1990 (Table A2 and A3). Health services have improved more in low market access areas since 1990. Housing quality, particularly the proportion of households with metal roofs, has increased more in high market access and high population density areas, as has the availability and quality of drinking water. These trends suggest government investment is taking place in less-favored areas, but not in all sectors.

Indicators of natural resource conditions show land degradation occurring most intensively in high market access and population dense areas. In addition to major decreases in average farm size, soil fertility and moisture holding capacity are deteriorating more in these areas. Other resources are also being affected, with greater decline in the availability of energy for heating and cooking, the availability of grazing land, and plant and animal biodiversity in high market access and high population density areas (Tables A3 and A4). These trends suggest that population and market pressure are important factors affecting natural resource degradation.

LIVELIHOOD STRATEGIES

Examining data that reflect current occupations and occupational change allows us to say something about emerging trends in livelihood strategies. In 1999, cereal crop production, coffee production, root crop production, and banana production were the most common primary

activities undertaken by men (Table A5). Other important occupations for men in some communities include production of other storable annual crops such as pulses and oilseeds, horticulture, cash crops such as cotton and tobacco, keeping cattle and various non-farm activities (mainly trading, brewing beer and making charcoal) (Tables A6 and A7).

Women have less diversified occupations than men (Table A9). Eighty percent of villages indicated household maintenance activities as the primary activity for women. Women are also involved in producing other crops (especially food crops), tending livestock, and non-farm activities (crafts, brewing beer and trading) (Tables A10 and A11).

Livelihood strategies vary throughout the country. In the unimodal rainfall areas root crop production is the most common primary activity for men. Cereal crop production and cotton are also important livelihood strategies for both men and women. Occupations are not highly diversified in this zone. Trading, crafts and brewing beer are not important for men or women in this region, although keeping livestock other than cattle is a tertiary activity for some women. There has been very little occupational change for either men or women in this area since 1990 (Tables A8 and A12). This may be in part due to the fact that although yields for cassava, maize and other crops have decreased, they have decreased less so than in other agroclimatic zones (Table A13).

In the bimodal low rainfall zone the production of other storable annual crops, banana production and keeping cattle are important activities for men. For women, the production of storable annual crops is an important activity; second only to household activities and maintenance. The importance of fast growing crops such as pulses and oilseeds has increased since 1990, possibly due to increased problems of drought. Yields are decreasing in this region, with above average decreases in groundnut, cassava and sweet potato yields (Table A13). There

has been an increase in the importance of keeping cattle in this region, and the proportion of households owning either local and crossbred cattle has increased (Table A14). This area appears to be moving towards the intensification of dairy production (using crossbred cows) as well as expanded extensive livestock production (using local breeds), as hypothesized by Sserunkuuma et al. (2001). Trading in this region is an important secondary occupational strategy, likely due to relatively good market access in some parts of the southwest cattle corridor.

In the bimodal medium rainfall zone, the traditional coffee-banana system is declining while production of cereals, root crops, other annuals, and cattle are increasing in importance. By contrast, banana and coffee are increasing in importance in the high potential bimodal areas. Yields for food crops (including banana) are decreasing in the bimodal rainfall areas, though the use of purchased inputs (including fertilizer, pesticide and improved seed) has increased (Table A13 and A19). The importance of keeping cattle as a livelihood strategy has increased in both the bimodal medium and high potential zones. Ownership of crossbred cattle is increasing in the bimodal high rainfall areas, suggesting a movement towards dairy production (Table A14). Off-farm activities, including trading (in the bimodal high zone) and beer brewing (bimodal medium) are important activities for men, indicating more diversified livelihood strategies in these regions.

In both the southwest and eastern highlands production of cereals and bananas are the most common primary activities for men, though arabica coffee production is also a very important activity in the eastern highlands (Table A6 and A7). Women in the southwest highlands have the most diversified livelihood strategies of all regions, with cereal production being their most important activity. Cereal crop yields are declining the most in the southwest

and eastern highland agricultural potential zones, supporting the hypothesis of persistent land degradation in these areas. Keeping cattle is an important secondary activity for men in both highland regions, but the proportion of households with crossbred cattle has increased in the eastern highlands while not in the southwest highlands (Table A14). Proximity of the eastern highlands to markets may be facilitating the development of dairy production. Ownership of other livestock has decreased in both highland areas, but especially in the southwest highlands.

Areas with good market access and high population densities appear to have similar trends in livelihood strategies. For example, coffee production is clearly associated with high market access and high population density areas. Conversely root crop production (mainly cassava) is most common as a main activity in the less-favored low market access and low population density areas. Production of other storable annual crops (pulses and oilseeds) is a primary occupational strategy for women only in high market access and high population density areas, and has increased in importance as a livelihood strategy for both men and women in these areas (Tables A8 and A12), even though yields for beans in these areas have decreased since 1990 (Table A13). Keeping cattle is more common in low market access and low population density areas. Crossbred cattle are increasing in high market access areas. Keeping other livestock (including goats, chickens, sheep and rabbits) is decreasing in high market access and high population density areas. Many of these changes support the hypotheses about comparative advantages of different livelihood strategies in different development domains proposed by Sserunkuuma et al. (2001).

LAND USE AND LAND MANAGEMENT

Significant changes in land use and land management have occurred since 1990. The area under cultivation, settlements and planted woodlots is increasing, while fallow area, grazing

land, natural forest, woodlands and wetlands are decreasing (Table A15). A wide variety of soil and water conservation methods are used throughout the country, though the proportion of households using even the most common methods is relatively low. For example, on average only 30% of households incorporate crop residues, 22% use mulching, and 22% use trash lines (these being the most common conservation practices) (Table A16). Tree planting, use of animal manure, mulching, and composting have increased significantly since 1990, while use of fallow, fallow strips and zero tillage are declining (Table A17). Use of some purchased inputs, particularly improved seeds, animal vaccines and medicines is relatively common, with more than half of farm households estimated to use these inputs (Table A18). Use of fertilizers and herbicides is uncommon, with fewer than 10% of households using them. Use of all kinds of purchased inputs is generally increasing, but especially use of purchased animal feed/fodder and improved seeds.

In the unimodal rainfall areas land under fallow is perceived to have declined significantly, yet fallows were still averaging 1.1 years in the late 1990s, the longest in the country. Grazing land has also declined in this area while settlements and cultivated land are increasing. Incorporation of crop residues, trash lines, hedges and live barriers are the most common soil and water conservation technologies. There has been little change in the proportion of households using these and other soil and water conservation technologies since 1990. There is above average use of fertilizer, pesticides and animal medicines in this zone, but below average use of herbicides and purchased fodder. Use of fertilizers, herbicides, and purchased fodder has increased significantly, however.

In bimodal low potential areas settlements and cultivated area are increasing, and grazing lands are decreasing. Mulching and tree planting on farmlands are the most common soil and

water conservation technologies being used in this area. Nearly 60% of households use mulching, probably because of the need to conserve soil moisture for banana production in this relatively dry region. Use of improved seeds is somewhat more common in this zone than elsewhere, while the use of purchased fodder, vaccines and animal medicines is below average. The use of purchased fodder has been decreasing since 1990, while use of other purchased inputs has become more common.

The largest increase in cultivated area and decline in fallow are observed in the bimodal medium agricultural potential zone. Smallholders may be expanding or shifting cultivated area to maintain production levels as land degradation, pests and other factors reduce yields. Incorporating crop residues and constructing trash lines are the most common soil and water conservation technologies in this area. Changes in the use of soil and water conservation technologies are not significant. Given declines in yields and changes in land use in this area, there may be opportunities to improve land management through the promotion of soil and water conservation technologies. Use of most inputs is close to average in this zone. Use of improved seed, purchased fodder and animal medicines has significantly increased since 1990.

Land use change has been significant in the bimodal high potential areas. Area under cultivation is increasing, grazing land is declining, wetlands are decreasing (probably due to drainage for cultivation or brick making), and there have been major increases in settlement area. Planting trees, mulching and the use of animal manure are the most common land management practices (used by about one-third of farmers). Surprisingly, use of all purchased inputs is average or below average in this region, despite relatively high access to markets and technical assistance programs in this region. However, there has been a major increase in the use of fertilizer in this region since 1990, and use of improved seeds has also increased significantly.

Land scarcity is extreme in the densely populated southwest highlands region. Fallowing for one year or more is no longer commonly practiced in any of the sample communities in this zone, and fallow strips are used by only 6 percent of households. In the late 1990s the average fallow was 0.3 years among households that use short-term fallow, decreasing from 0.8 years in the late 1980s. Since 1990, area under settlements and planted woodlots has increased, while all other land uses have remained constant or declined on average. Mulching, manuring, composting, trash lines and incorporation of crop residues are relatively common soil and water conservation practices practiced by at least one-fourth of farm households in the southwest highlands. The use of fallow strips has declined somewhat; while there has been little change of most other conservation practices. Purchased input use in the southwest highlands is close to the average for the country for most inputs. Use of purchased fodder, herbicides and fertilizer have increased significantly since 1990 in this zone.

Land is also very scarce in the eastern highlands, which are also densely populated. Fallowing is practiced by less than 10% of households, and the average fallow period for households using fallow has declined from 1.4 years in the late 1980's to 0.6 years in the late 1990's. As in the southwest highlands, settlements and planted woodlots are the only land uses that are increasing. A wide variety of soil and water conservation practices are used in the eastern highlands. Use of grass strips, contour plowing, incorporation of crop residues, manuring, tree planting, and soil bunds are all relatively common. Use of animal manure, incorporation of crop residues and planting grass strips have increased since 1990, while use of other practices has not changed significantly. The eastern highlands zone has the highest proportion of households using many purchased inputs, including fertilizer, herbicides, improved seed, fodder, animal vaccines and animal medicines. The use of fertilizer, pesticides, vaccines

and animal medicines has increased significantly in this zone since 1990. Proximity to the Kenya market is likely a main reason for relatively high and increasing use of purchased inputs in this zone.[15]

Access to markets and population density appear to have significant impacts on land use and many land management practices. In low market access and low population density areas there have been larger decreases in the proportion of land area under fallow, grazing areas, and forest/woodland; probably because more of such land uses were still available in these areas in the early 1990's. Settlement areas increased the most in low population density areas, likely for the same reason. Tree planting is more common in high market access and densely populated areas, probably because of better markets for tree products in such areas. Mulching, composting, and manuring are also more common in high market access and high population density areas. Use of these practices has also increased more in high access and densely populated areas since 1990. These results are consistent with the Boserup hypothesis that greater land scarcity and land values (whether population or market induced) promote greater investment in land conservation and improvement. However, incorporation of crop residues is more common in less densely populated areas, probably because use of annual crops and tillage is greater in these areas, which are generally drier and have lighter soils than more densely populated areas of Uganda. There appears to be little relationship between the proportion of households using most other soil and water conservation technologies and either market access or population density. Use of improved seeds and purchased fodder are significantly more common in more densely populated areas, and purchased fodder is also more common in areas of higher market access.

---

[15] The use of purchased inputs in the eastern highlands is relatively high compared to the rest of Uganda, but is still low by international standards.

The use of herbicides, purchased fodder and animal vaccines is increasing more rapidly in high market access and high population density regions of the country.

These results suggest that higher market access and higher population density are causing a general pattern of agricultural intensification involving decreased use of land for fallow, grazing area, forest or woodland; planting of trees and adoption of several soil and water conservation practices; and increased use of several purchased inputs. Interestingly, however, fertilizer use does not appear to be strongly affected by better access to markets or population pressure, except in the eastern highlands region as a result of access to the Kenya market. The limited impact of market access on fertilizer use ay be because of the dominance of the banana-coffee system in high market access areas of central Uganda, which has traditionally used little inorganic fertilizer.

POPULATION

There is no doubt that population is increasing rapidly throughout much of Uganda. Recall data on the number of households in LC1s in 1990 and 1999 from the community survey indicate an average annual rate of growth of 4.9% (Table A21). This growth rate seems very high and should be validated with secondary data. The highest rates of growth are observed in the unimodal rainfall areas and the bimodal high potential areas, while the bimodal medium potential areas have the lowest growth rate. There has been greater population growth in low population density areas. People may be migrating to these areas in response to small farm sizes and land degradation in other areas. This may explain why extensive land uses such as fallow, grazing and forest/woodland are declining more rapidly in less densely populated areas.

PRESENCE OF PROGRAMS AND ORGANIZATIONS

Since the late 1980's there has been a remarkable increase in the number of programs and organizations operating in communities in Uganda, including various government programs, non-government organizations from outside local communities (NGOs), community-based organizations (CBOs), and foreign, religious, and private for-profit organizations (Table A22). Government programs are more common in the bimodal high potential zone and southwest highlands. These organizations generally deal with issues such as water supply, natural resource management, health and educational services. They are relatively equally common in low vs. high market access areas, and low vs. high population density areas. NGOs are most common in the bimodal high and bimodal low potential zones, and are much more common in high market access and high population density areas. Whether NGOs are actively seeking out higher potential and higher access areas to implement their programs is an interesting question worth further study. CBOs are most common in the southwest highlands, one of the poorest regions of the country.

Programs and organizations that deal with agriculture and veterinary services and the environment (i.e. those that are likely to address the proximate causes of land degradation) are most common in the bimodal high potential zone (Table A23). Land degradation is a serious problem in this area. However, land degradation is also a serious problem in other areas such as the southwest highlands, which have fewer programs or organizations with a main focus on the environment. Programs and organizations that deal with income generation, poverty eradication and social development are most common in the unimodal and southwest highland areas, some of the poorest areas of the country.

DEVELOPMENT OF INFRASTRUCTURE AND SERVICES

Between 1990 and 1999 there was a considerable increase in the use of services, particularly of private transportation (Tables A24 and A25). In the bimodal high agricultural potential zone, the use of minibus transport became more common, while public bus transport became less common. The use of public motorbike transport (locally known as "boda boda") increased throughout Uganda. There were also increases in the use of other private services such as grain mills and input supply dealers, with the changes in input supply dealers taking place mainly in low market access, low population density areas. Both primary and secondary private school development was significant in the bimodal low and bimodal high agricultural potential regions, and in the unimodal areas the use of health clinic services has improved significantly. There has been a general trend toward privatization of services over the past 10 years, though government involvement has increased in some areas, especially primary education.

Interestingly, although there has been a marked increase in use of infrastructure and services, particularly in the areas of transportation and health, there has been little change in distance to infrastructure and services (Table A26). Of note are small improvements in the distance to tarmac roads in the bimodal low, medium and high zones, though there was no change in distances in the southwest and eastern highlands. There were surprisingly small changes in distance to the nearest trading center given increases in the importance of trading as a livelihood strategy. Distance to nearest grain mill improved throughout the country – especially in the southwest highlands (decreasing from an average of 10.4 miles in 1990 to 5.4 miles in 1999) – as a result of private investment in mills. There is no discernable change in the distance to fuelwood sources even though people perceived decreases in the availability of fuelwood for

cooking. Changes in distance to health services are minimal – suggesting that the general improvement in health is related to improvements in quality of health services rather than proximity of facilities.

EMERGING TRENDS IN DEVELOPMENT AND LAND MANAGEMENT

The general picture of development in Uganda between 1990 and 1999 is of significant improvement in many aspects of human welfare but persistent degradation of land and other resources. Food insecurity is still a major problem, especially in the less rainfall assured areas of the country. Land degradation is most serious in the densely populated highland regions. The average annual rate of population increase is very high and may be one of the main factors influencing land degradation throughout the country.

There have been a variety of changes in livelihood strategies. There have been increases in the production of storable annual crops such as maize, pulses and oilseeds, indicating a move towards crops with a shorter growing season. Cattle production has increased in several regions, and ownership of crossbred cattle has also increased, indicating the development of dairy production. Livelihood strategies are diversifying as trade and other non-farm employment become more important, particularly in high population density regions.

With respect to land management there have been increases in purchased input use and the 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 purchased inputs is still fairly limited (especially for fertilizer) and may not be substantially affecting average yields. In the high potential bimodal areas and eastern highlands, where rates of input use are among the highest in the country, soil fertility and other aspects of land degradation are perceived to be worsening. The proportion of households adopting new soil

and water conservation technologies is low, and suggests the need for programs and organizations to provide extension support to catalyze adoption of these technologies. At present, the involvement of such programs and organizations is limited, and in the case of NGO's, is biased towards higher potential areas in the Lake Victoria crescent.

4. DETERMINANTS AND IMPLICATIONS OF DEVELOPMENT PATHWAYS AND LAND MANAGEMENT

In this section, we investigate 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. First, we identify the dominant development pathways using factor analysis of the community survey data, and then investigate their determinants and implications using econometric analysis.

DEVELOPMENT PATHWAYS IN UGANDA

Using factor analysis of the primary occupations of men and changes in the top three occupations since 1990, we identify six dominant development pathways in the study region of Uganda (Table 1).[16] The first principal component factor is strongly associated with production of cereals or other storable annual crops, and with expansion of cereal production. We label this factor as representing a pathway of "increasing production of cereal crops." The second component is strongly associated with banana production and increasing importance of bananas and coffee ("increase of banana and coffee production" pathway). The third component is strongly associated with non-farm activities, and increasing importance of such activities

[16] As discussed in Section 3, the primary occupation of women is almost always household maintenance activities, except in the southwest highlands. Changes in most occupations for women are similar to those for men. Thus we focused on the occupations of men as a reasonable way of simplifying the classification problem.

("increase of non-farm activities"). The fourth component is strongly associated with production of horticultural crops, and with increasing importance of horticulture ("increase of horticulture"). The fifth component is strongly associated with production of cotton or tobacco, and with expansion of cotton production ("increase of cotton"). The sixth component is positively associated with coffee production and negatively associated with root crop production, but does not have any strong associations with changes in occupations ("stable coffee production").

Table 1--Identification of Development Pathways (Factor Analysis Results)[a]

	Rotated Factor Loadings					
Variable	1	2	3	4	5	6
Primary occupation						
- Cereals or other storable annuals	**0.823**	-0.158	-0.135	-0.016	-0.126	-0.132
- Horticultural crops	-0.097	-0.007	-0.078	**0.759**	-0.031	-0.107
- Bananas	-0.112	**0.692**	-0.107	-0.108	-0.109	-0.008
- Coffee	-0.300	-0.204	-0.044	-0.054	-0.098	**0.839**
- Cotton or tobacco	-0.141	-0.051	-0.026	-0.041	**0.824**	-0.064
- Root crops	-0.451	-0.280	-0.158	-0.119	-0.205	**-0.571**
- Cattle	-0.137	0.196	0.103	-0.102	0.068	-0.076
- Non-farm activities	-0.086	-0.104	**0.833**	0.158	-0.009	-0.029
Change in importance of top three occupations						
- Cereals	**0.761**	-0.058	0.056	-0.039	0.091	-0.152
- Other storable annuals	0.376	0.249	0.338	-0.086	-0.158	0.105
- Horticultural crops	0.053	-0.020	0.121	**0.807**	-0.007	0.078
- Bananas	-0.024	**0.771**	0.108	-0.028	0.028	-0.156
- Coffee	-0.197	**0.536**	-0.048	0.242	-0.036	-0.109
- Cotton	0.139	0.011	-0.013	0.009	**0.755**	0.034
- Root crops	0.092	-0.442	0.244	-0.062	-0.035	-0.291
- Livestock	0.270	0.148	-0.436	0.167	0.171	0.308
- Non-farm activities	0.088	0.190	**0.702**	-0.134	0.004	0.068

[a] Principal components factor method used. Factors rotated using varimax method. The six retained factors account for 56% of the variance, and represent factors with eigenvalues greater than 1.2

The first five development pathways represent a pattern of increasing specialization in an already important activity. Given the extent of market liberalization in Uganda during the

1990's, it is not surprising that increasing economic specialization based upon local comparative advantages took place.

Using econometric analysis, we investigate the factors associated with these different comparative advantages (Table 2).

Table 2. Determinants of Development Pathways (least squares regressions)[a]

Explanatory Variable	Increase of Cereals (Factor 1)	Increase of Bananas and Coffee (Factor 2)	Increase of Non-farm Activities (Factor 3)	Increase of Horticulture (Factor 4)	Increase of Cotton (Factor 5)	Stable Coffee Production (Factor 6)
Agro-Climatic Zones (cf. Unimodal)						
- Bimodal low	0.544*	0.578*	-0.837*	0.659	-0.201	0.556
- Bimodal medium	0.741***[R]	-0.089	0.110	0.316**	0.202	0.356
- Bimodal high	-0.106	0.528*	-0.577	0.011	-0.411	0.748**[R]
- Southwest highlands	-0.166	0.333	0.027	0.048	0.128	0.618
- Eastern highlands	0.780	0.460	-0.388	0.638	-0.375	1.057***
High market access	-0.044	0.081	0.129	-0.044	0.040	0.710***[R]
High population density (> 100/km^2)	0.468**[R]	0.022	0.420*	0.223*	0.279	0.276
Irrigation in village	0.082	0.066	-0.138	0.553**[R]	-0.263	0.323
Change in ln(number of households)	0.552	0.399	0.847*	-0.120	0.555	0.017
Change in distance to tarmac road (miles)	0.0069	0.0067	-0.0240***[R]	-0.0041	0.0034	-0.0034
Change in distance to rural market (miles)	-0.0359	-0.0658*	-0.0408**[R]	0.0015	-0.0287	0.0150
No. of government programs	0.182	-0.180	0.184	-0.019	0.114	-0.205*
No. of NGO programs	-0.117	-0.036	0.406***	-0.101	-0.080	0.064
No. of community-based organizations	0.414***[R]	0.119	0.126	-0.084	-0.175*	-0.280***
Intercept	-1.079***[R]	-0.456	-1.017***	-0.200	-0.181	0.972***[R]
R^2	0.274	0.186	0.310	0.157	0.102	0.324

[a] Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level in two-stage least squares regressions to predict change in ln(no. of households) and numbers of programs and organizations.

Increased importance of cereal production is most common in the bimodal medium rainfall agroclimatic zone and in higher population density areas. It is also associated with greater numbers of community-based organizations, most of which focus on income generation or poverty reduction. Promoting increased cereal production may be part of the activities of some of these organizations.

Increased banana and coffee production is more common in the bimodal high and bimodal low rainfall zones than in other agroclimatic zones, and more common where rural markets have developed (though these associations are only weakly statistically significant).

Increased non-farm activities are, not surprisingly, more common where roads and rural markets have developed. Non-governmental organization programs (NGO's) are also associated with increased non-farm activity. In many cases, such programs focus on reducing poverty through promoting income diversification, education and training. Non-farm development is also weakly associated with higher population density.

Increased horticultural production is not surprisingly associated with access to irrigation, and is more common in the bimodal medium rainfall zone than in several other zones. It is also weakly associated with higher population density, probably because of the high labor intensity involved in producing horticultural crops.

Increased cotton production is not strongly associated with any of the factors investigated. It is weakly negatively associated with the presence of community-based organizations (CBO's), though this result is not robust when using two-stage least squares to predict the number of organizations. Other more general factors, such as changes in cotton prices or marketing problems may be more important in determining development of cotton production than the localized factors that were investigated in this study.

The pathway of stable coffee production is most common in the bimodal high rainfall zone close to Lake Victoria and in the eastern highlands. In both of these zones coffee has long been a dominant economic activity, and this has not changed since 1990. Not surprisingly, coffee production is more common in higher market access areas. The presence of CBO's is negatively associated with stable coffee production, though this result is not robust. Perhaps such organizations focus their efforts more in poorer subsistence areas where coffee production is less common. That would explain why these results are not robust when using a two-stage estimation.

In general, we find that the factors hypothesized to determine the comparative advantage of different development pathways—including agricultural potential, market access, population density, development of infrastructure, and social capital (as measured by organizational presence)—are significantly associated with the development pathways; though different factors are important for different pathways. Agroclimatic conditions are particularly important for distinguishing areas of cereal expansion from perennials areas. Higher population density favors intensified production of cereals, horticulture and non-farm activities. Access to irrigation is critical for horticultural development, and improved access to roads and markets are critical for non-farm development. NGO programs appear to foster non-farm development, while CBO's promote cereal production.

CHANGES IN LIVESTOCK USE

Closely associated with changes in livelihood strategies may be changes in livestock ownership and use. Ownership of local cattle varieties is increasing more in areas where cereal production is increasing (Table 3), possibly because of complementarities between cattle and cereal production (e.g., use of oxen for draft power and grain straw as fodder, benefits of manure

in crop production). In addition, problems of pests and diseases affecting animals are often greater in more humid perennial crop areas than in dryer cereal growing areas. Consistent with this, we find declines (or less increase) in cattle ownership in areas where banana and coffee crops are increasing. Conversely, farmers may invest in cattle as a store of wealth in areas where coffee production is declining due to coffee wilt disease or other problems. Local cattle use is also declining where horticultural production is increasing, perhaps because cattle are less beneficial for (and may cause damage to) horticultural crops. Local cattle use is increasing more in communities having access to irrigation, perhaps due to greater availability of crop residues for feed.

Table 3. Determinants of Changes in Livestock Use (ordered probit regressions)[a]

Explanatory Variable	Local cattle	Crossbred Cattle	Goats	Sheep	Pigs	Chicken
Agro-Climatic Zones (cf. Unimodal)						
- Bimodal low	-0.143	2.003***[R]	-0.547	-0.508	-0.034	0.201
- Bimodal medium	0.370	0.739	-0.627	-0.268	0.008	0.297
- Bimodal high	-0.605	1.843***[R]	-0.965*	0.341	0.311	-0.112
- Southwest highlands	-0.434	-2.379**[R]	-1.835**	-0.059	-0.347	-1.057*
- Eastern highlands	-0.851	2.709***[R]	-0.844	-1.379**[R]	0.039	0.322
High market access	0.076	0.716	-0.015	-0.992***[R]	0.645**[R]	0.772***[R]
High population density (> 100/km^2)	-0.047	0.071	-0.041	-0.476	-0.078	-0.235
Irrigation in village	0.883**[R]	0.474	0.539**	-0.140	0.296	-0.520
Development Pathways						
- Increase of cereals	0.528***[R]	-0.018	0.164	-0.049	0.025	0.044
- Increase of banana and coffee	-0.215*[R]	-0.283	-0.103	-0.158	0.084	-0.136
- Increase of non-farm activities	0.186	0.447**[R]	-0.032	-0.071	-0.131	-0.052
- Increase of horticulture	-0.215**[R]	0.084	0.004	0.161	-0.078	0.116
- Increase of cotton	0.080	-0.000	0.003	0.145	-0.334***[R]	0.035
- Stable coffee production	-0.002	0.084	0.044	-0.050	0.149	-0.011
Change in ln(number of households)	0.364	0.447	-0.396	0.324	-0.207	-0.074
Change in dist. to tarmac road (miles)	-0.0036	0.0884***[R]	-0.006	0.0259	-0.0349***[R]	-0.0103
Change in dist. to rural market (miles)	0.0069	-0.0408	-0.091***	0.0674	0.0011	-0.0300
No. of government programs	-0.138	0.454**[R]	0.025	-0.319*[R]	-0.127	0.279**
No. of NGO programs	-0.161	0.l013	-0.193	0.157	0.254	0.124
No. of community-based organizations	-0.196	-0.027	0.060	-0.131	0.005	-0.042
Prob. > F	0.0003	0.0002	0.3360	0.2985	0.0023	0.2893

[a] Dependent variable takes values of –2 (major decrease), -1 (minor decrease), 0 (no change), +1 (minor increase), +2 (major increase). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln (no. of households) and numbers of programs and organizations.

Adoption of crossbred cattle is increasing, especially in the bimodal low and high rainfall zones and the eastern highlands, but not in the southwest highlands, probably as a result of increased dairy production in these zones. Use of crossbred cattle is also increasing in areas where non-farm activities are important, which, as we saw previously, are generally areas where market access is improving. However, controlling for development pathway, adoption of crossbred cattle has been greater where there has been less improvement in roads. This finding is surprising, since we would expect improved road access to favor dairy development. Government extension programs have favored dairy development, and may help to explain dairy development even in areas further from markets.

Sheep ownership is declining in the eastern highlands relative to other zones, in areas of higher market access, and where more government programs are operating. This may be due to displacement or replacement of sheep by crossbred cattle in such areas. Demand for sheep meat may be growing more slowly than demand for beef or milk as a result of lower income elasticity of demand.

Ownership of goats is declining in the southwest highlands, perhaps because of scarce fodder resources or efforts to limit damage to vegetation caused by goats. Increased goat ownership is more common where there is irrigation, and where rural markets are developing.

Ownership of pigs and chicken is increasing more (or declining less) in areas of higher market access. This is consistent with our hypothesis that opportunities for intensive production of such small animals are likely to be greater in areas close to urban markets. Consistent with this, ownership of pigs has also increased more commonly where road access has improved. Pigs have declined in cotton producing areas. Perhaps feed sources are scarce in these areas as a

result of an emphasis on cotton production. Government programs are positively associated with increased chicken production.

As with the development pathways, changes in ownership and use of different types of livestock are affected by different factors. Agroclimatic conditions and changes in market access strongly influence adoption of crossbred dairy cattle. Market access also favors intensive livestock such as pigs and poultry, but reduces extensive livestock activities such as sheep herding. Government programs have also apparently contributed to intensive livestock activities. The development pathways are associated with changes in livestock use, particularly of cattle.

CHANGES IN LAND USE

The most common use of land is for cultivation. Cultivated area has been expanding in all zones outside of the highlands. However, controlling for other determinants of change, increases in cultivated area are more common in the southwest highlands than in other zones (Table 4).

Table 4. Determinants of Changes in Land Use (ordered probit regressions)[a]

Explanatory Variable	Cultivated	Fallow	Grazing	Forest	Woodlots	Wetlands	Settle-ments
Agro-Climatic Zones (cf. Unimodal)							
- Bimodal low	0.152	0.257	0.285	0.222	0.195	1.299	0.309
- Bimodal medium	0.532	0.140	0.188	-0.496	-0.242	-0.029	0.115
- Bimodal high	0.364	0.501	-0.516	-0.161	-0.267	-0.246	1.058*
- Southwest highlands	1.251**[R]	0.881	-0.118	0.856	0.555	1.390*	0.502
- Eastern highlands	-0.180	0.432	0.097	-0.308	0.368	0.248	0.239
High market access	0.405	0.130	0.128	-0.144	-0.548**	-0.963**[R]	0.215
High population density (> 100/km^2)	0.012	-0.211	0.239	0.125	0.263	0.247	0.795**[R]
Irrigation in village	-1.475***[R]	0.632	0.169	0.948*	0.307	0.804*	0.121
Development Pathways							
- Increase of cereals	0.009	-0.032	-0.230*	-0.223	0.234*[R]	0.165	0.317**[R]
- Increase of banana and coffee	0.408***[R]	-0.108	-0.022	0.153	-0.110	-0.097	0.097
- Increase of non-farm activities	-0.111	-0.056	-0.034	-0.039	0.221*[R]	-0.171	0.122
- Increase of horticulture	0.144	-0.529*[R]	-0.471*[R]	0.069	-0.340**[R]	0.054	0.019
- Increase of cotton	0.067	0.013	-0.060	-0.130	0.091	0.313***[R]	-0.116*
- Stable coffee production	-0.143	0.271	0.202	0.118	0.474***[R]	-0.262**	-0.260*[R]
Change in ln(number of households)	-0.047	0.163	0.029	1.335**[R]	-0.645	0.315	1.500**
Change in dist. to tarmac road (miles)	-0.0401**[R]	-0.0219	-0.0367**[R]	0.0535***[R]	-0.0227***[R]	0.0363***[R]	-0.0142
Change in dist. to rural market (miles)	-0.0950	0.0933	0.0443	0.0352	0.0340	-0.0112	-0.0396
No. of government programs	0.233	-0.242	-0.025	-0.130	-0.088	-0.311	0.327*
No. of NGO programs	-0.247*	0.030	-0.094	-0.104	0.269**	0.144	-0.087
No. of community-based organizations	0.192	-0.171	0.147	-0.191	0.172	-0.404*	0.091
Prob. > F	0.0004	0.5430	0.4379	0.1286	0.0001	0.0132	0.0005

[a] Dependent variable takes values of –2 (major decrease), -1 (minor decrease), 0 (no change), +1 (minor increase), +2 (major increase). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln(no. of households) and numbers of programs and organizations.

Other factors that have a statistically significant influence on cultivated land use include the presence of irrigation (reduces expansion), banana and coffee expansion (increases expansion), and improved access to roads (increases expansion). Surprisingly, population growth is not significantly associated with increased use of land for cultivation.

Settlements are increasing everywhere. Not surprisingly, expansion of settlements is associated with higher population density and population growth. It is also associated with increased cereal production, but negatively associated with stable coffee production.

Fallow land is declining everywhere. We find few factors that lead to a statistically significant difference in this tendency. The one exception is expansion of horticultural production, which is (weakly) associated with decrease in fallow. The findings are similar for grazing land, which is also declining everywhere, but more so in horticultural communities. Interestingly, grazing land is declining less where road access is improving.

Natural forest area has been declining in all zones, and is no longer very common in any zone. Improvement in road access is strongly associated with reduced forest area while, surprisingly, population growth is associated with less deforestation. Place, Ssenteza and Otsuka (2001) found similar results for the effects of road access and population growth on deforestation in Uganda. The negative impact of road access on forest cover is consistent with findings from studies of deforestation in other parts of the world. The puzzling positive association between population growth and forest cover may be due to the fact that some areas where population growth is rapid, such as the bimodal low rainfall zone, are areas where there was relatively less natural forest to begin with, and so have less deforestation despite rapid population growth.

Planted woodlots are becoming more common, especially in areas of lower market access; in coffee, cereals and non-farm pathways; where NGO programs are operating; and

where road access has improved. They are less likely to be increasing in horticultural areas, perhaps because the value of land for crop production is higher in these areas.

Wetlands are declining, especially in areas of better market access, where road access has improved, or where coffee production is the development pathway. They are declining less in the cotton pathway. Irrigation is weakly associated with preservation of wetlands and forest, probably because it reduces pressure to expand cultivated area.

Overall, of the factors influencing changes in land use, improvement in access to roads appears to have the most effect, contributing to expansion in cultivated land, grazing area and woodlots, and to reductions in forests and wetlands. Road development may thus be helping to stimulate economic activity at the expense of conserving natural resources. Irrigation favors more intensive land use and therefore less expansion of cultivated area and greater preservation of forest and wetlands. The development pathways have differential associations with land use. Development of banana and coffee production is associated with expansion of cultivated area; while horticultural production is associated with declining fallow, grazing and woodlot area; and stable coffee production areas more commonly have increasing areas of woodlots but declining area of wetlands.

CHANGES IN LAND MANAGEMENT PRACTICES

Land management practices, such as fallowing; use of mulch, manure or compost; or investments in trees, soil bunds or other land improvements can also be affected by the factors determining comparative advantage and development pathways. The effects of these factors on changes in many land management practices were investigated, though in some cases, the results were not very statistically significant due to changes being fairly small for some practices (e.g.,

improved fallow, zero tillage, and contour plowing), or changes being similar everywhere (e.g., declines in use of fallow everywhere). Here, we focus only on land management practices for which the analysis had significant explanatory power.[17]

Adoption of land management practices differs across the agroclimatic zones of Uganda (Table 5). Several soil and water conservation practices are increasing more in the eastern highlands than in other areas; including composting, manuring and incorporating crop residues.

[17] That is, we report only results of regressions for land management practices for which the F test for all coefficients being equal to zero was rejected at the 10% level.

Table 5. Determinants of Changes in Land Management Practices (ordered probit regressions)[a]

Explanatory Variable	Fallow Strips	Planting Trees	Mulch	Compost	Manure	Plowing in Crop Residues	Soil Bunds
Agro-Climatic Zones (cf. Unimodal)							
- Bimodal low	1.360**	0.557	0.963*	0.818	0.124	0.060	0.078
- Bimodal medium	-0.293	-0.093	-0.135	0.153	-0.043	-0.443	-11.57***[R]
- Bimodal high	-0.112	0.848	0.067	1.225**	1.111***	0.544	-0.430
- Southwest highlands	-1.198	0.038	0.002	1.315*	0.537	-0.436	-13.71***
- Eastern highlands	0.259	1.348*	0.538	2.007**[R]	1.106***[R]	1.587**[R]	0.982
High market access	-0.616	1.073***[R]	0.087	0.909	0.478*	-0.466	-1.794*
High population density (> 100/km^2)	0.189	-0.224	0.253	0.163	0.009	-0.357	2.345**
Irrigation in village	0.799**	0.303	-0.673*	-0.685	-0.084	0.033	0.026
Development Pathways							
- Increase of cereals	0.234	0.166	0.100	0.152	0.180	-0.045	-0.132
- Increase of banana and coffee	-0.437**[R]	-0.007	0.268**[R]	0.474**[R]	0.249*	0.443***[R]	0.578**[R]
- Increase of non-farm activities	-0.023	-0.162	0.215*	0.207	0.062	0.374**[R]	-0.870**[R]
- Increase of horticulture	-0.022	-0.129	0.240	-0.075	-0.075	0.096	-1.203***
- Increase of cotton	0.240**	0.027	-0.108**[R]	-0.197	-0.167**[R]	-0.020	-1.903
- Stable coffee production	-0.463**[R]	0.213	0.023	0.062	0.254*[R]	0.132	-0.042
Change in ln(number of households)	-1.920**	0.282	-0.741	-0.230	0.367	0.349	-4.907***
Change in dist. to tarmac road (miles)	0.1038***[R]	0.0781*[R]	-0.0104	0.997***[R]	0.0161	0.0383*[R]	-0.0214
Change in dist. to rural market (miles)	0.0180	0.1715	-0.0723	0.094*	0.0869**	0.0424	-0.3374***
No. of government programs	-0.051	-0.021	0.331	0.172	0.059	-0.149	0.578*[R]
No. of NGO programs	0.213	0.137	0.017	0.259*	-0.124	0.067	0.401
No. of community-based organizations	-0.018	-0.163	-0.215	-0.260	-0.309*	0.166	0.487*
Prob. > F	0.0232	0.0005	0.0229	0.0000	0.0000	0.0004	0.0000

[a] Dependent variable takes values of –2 (major decrease), -1 (minor decrease), 0 (no change), +1 (minor increase), +2 (major increase). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.

*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.

[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln (no. of households) and numbers of programs and organizations.

Composting and manuring are also increasing in bimodal high potential areas more than in other zones. Use of fallow strips is generally declining, though not as much in the bimodal low potential areas as in other areas. Investment in soil bunds is occurring to a lesser extent (or not at all) in the bimodal medium rainfall zone and in the southwest highlands. In the latter case, farmers are reportedly destroying soil bunds to harvest the fertile soil that they contain (Olson 1995; Sserunkuuma et al. 2001).

There are significant differences across the development pathways in adoption of soil and water conservation practices. Many soil and water conservation practices—including mulching, composting, manuring, incorporating crop residues, and constructing soil bunds—are increasing more in areas of banana and coffee expansion than other development pathways. Manuring is also increasing more in areas of stable coffee production than other areas. Mulching and manuring are increasing less in the cotton pathway than other pathways. By contrast, use of fallow strips is declining more in banana and coffee producing areas and less in cotton areas. Fallow strips are apparently more suited to cotton production, while mulching and manuring are more suited to banana and coffee production. Incorporation of crop residues is becoming more common in non-farm development areas. Investment in soil bunds is lower in both non-farm and horticultural development pathways, perhaps because of higher labor opportunity costs in such areas.

Higher population density is associated with increased investment in soil bunds, consistent with the Boserupian hypothesis of population-induced land improvement (Tiffen et al. 1994; Pender 1998). However, more rapid population growth is associated with reduced investment in soil bunds, probably because increasing land scarcity increases the opportunity costs associated with the land that such bunds occupy. Thus the impacts of population growth on

a particular type of land improving investment depend upon the way it affects land and labor costs, as well as the labor and land intensity of the investment. Population growth is also associated with reduced use of fallow strips, consistent with the Boserupian hypothesis of population-induced intensification of land use.

Market access and changes in access to roads and markets have also influenced land management practices. Tree planting has increased more in areas with higher market access, probably because of greater marketability of tree products in such areas. However, improved road access is associated with less increase in tree planting (though this result is only weakly statistically significant). Increasing use of manure is weakly associated with higher market access. Improvements in road access are also associated with less use of fallow strips, compost or incorporation of crop residues. Increases in the value of land or labor resulting from improved access may account for these changes. Improved access to rural markets is associated with less use of manure, perhaps because of greater use of chemical fertilizer where access is improving. However, improved rural market access is associated with increased investment (or less decline in investment) in soil bunds.

The presence of irrigation is associated with less decline in use of fallow strips. Since irrigation enables more intensive use of cultivated land (as noted earlier), it may reduce pressure to abandon fallow practices on rainfed land.

The presence of programs and organizations has limited measurable impact on various land management practices. There are weak statistical associations between the presence of government programs or community-based organizations and investment in soil bunds, and between the presence of NGO programs and increase in composting. The weakness of these associations may be due to the crude measure of organizational activity (number of organizations

by type) used in the analysis. Further research on the impacts of programs and organizations, using more refined measures, is needed.

Overall, the different factors have diverse impacts on land management practices. The results support the hypothesis that development pathways have an important influence on land management, and support some (but not all) of our hypotheses about the impacts of population pressure and market access on land management practices. In general, the effects of a particular factor on land management appear to be very context-dependent, making generalizations difficult.

CHANGES IN PURCHASED INPUT USE

Use of purchased agricultural inputs such as fertilizers, improved seeds, pesticides and herbicides has generally increased in Uganda, though it remains low by international standards. We find few factors strongly associated with changes in use of fertilizer, pesticides, or herbicides (Table 6).

Table 6. Determinants of Changes in Purchased Input Use (ordered probit regressions)[a]

Explanatory Variable	Fertilizer	Improved Seeds	Pesticide	Herbicide
Agro-Climatic Zones (cf. Unimodal)				
- Bimodal low	0.101	1.116**	-0.680	-0.215
- Bimodal medium	0.058	1.066***[R]	-0.351	0.387
- Bimodal high	0.806	0.658*	-0.223	0.528
- Southwest highlands	-0.483	-0.088	-1.296**[R]	-0.281
- Eastern highlands	1.284**[R]	0.039	0.566	0.074
High market access	-0.091	-0.145	0.144	0.267
High population density (> 100/km^2)	-0.546	0.560*	0.082	-0.064
Irrigation in village	0.815*	0.342	-0.007	-0.677
Development Pathways				
- Increase of cereals	0.127	0.128	0.043	-0.145
- Increase of banana and coffee	-0.041	0.196	0.200	0.156
- Increase of non-farm activities	0.128	-0.137	-0.006	-0.073
- Increase of horticulture	-0.006	-0.281**[R]	0.073	0.242
- Increase of cotton	0.122	-0.478***[R]	-0.167	0.092
- Stable coffee production	0.126	-0.020	-0.082	0.209
Change in ln(number of households)	0.055	0.156	-0.194	0.145
Change in dist. to tarmac road (miles)	-0.0114	0.0185**[R]	-0.0174	-0.00195
Change in dist. to rural market (miles)	0.0757*	-0.0016	-0.0419	0.0537
No. of government programs	-0.557***[R]	0.390***	0.130	-0.085
No. of NGO programs	0.069	-0.244*	-0.240	0.082
No. of community-based organizations	0.021	-0.432**	0.127	-0.018
Prob. > F	0.0040	0.0054	0.3509	0.6627

[a] Dependent variable takes values of –2 (major decrease), -1 (minor decrease), 0 (no change), +1 (minor increase), +2 (major increase). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln(no. of households) and numbers of programs and organizations.

Fertilizer use has increased most in the eastern highlands, while pesticide use has declined in the southwest highlands. In the eastern highlands, farmers have greater access than other zones to fertilizer and other inputs from Kenya, and at lower costs. In the southwest, some NGO programs are promoting integrated pest management and other low input approaches, and are apparently achieving some success. Surprisingly, increased fertilizer use is less common where more government programs are operating. Some of these programs may be promoting alternatives to fertilizer (though we find no strong associations of government programs with fallowing, manure or compost use). Further research is needed to understand and explain this association.

Changes in use of improved seeds are associated with several factors. Increased use of improved seeds is more common in the bimodal low and medium rainfall zones than other zones, perhaps because some of the types of crops that are suited to these zones are ones for which successful improved varieties have been introduced in recent years. Mosaic-resistant cassava is one example. Increased use of improved seeds is less common in the horticultural and cotton development pathways, perhaps because these areas were already using improved seeds and/or because there have been fewer successful new varieties of these types of crops. Surprisingly, use of improved seeds has increased less where road access has improved. Government programs are associated with increased use of improved seeds, while CBO's and NGO's are (weakly) associated with less use. The negative effect of CBO's and NGO's is puzzling, as is the negative effect of increased road access; further research is needed to validate and explain these results.

CHANGES IN YIELDS

Despite increases in use of purchased inputs and several soil and water conservation practices, survey respondents reported declining yields of all crops in all zones of the country.

The most commonly cited reasons for declining yields are increased incidence of pests and diseases, declining soil fertility and changes in weather. Although these reported trends may be overly pessimistic, and need to be verified by other data sources, it is useful to try to understand factors leading to differences in these reported trends, since there are significant differences across communities.

There are substantial differences in yield trends for some crops across agroclimatic zones, especially for millet, cassava, and sweet potatoes (Table 7).

Table 7. Determinants of Perceived Changes in Crop Yields (ordered probit regressions)[a]

Explanatory Variable	Maize	Millet	Beans	Ground-nuts	Cassava	Sweet Potatoes	Bananas
Agro-Climatic Zones (cf. Unimodal)							
- Bimodal low	-0.110	-1.145	0.036	-0.680	-1.799***[R]	-0.969**	-1.070**
- Bimodal medium	0.269	-2.185***	-0.617	-0.584	-1.325***	-0.003	-1.070***
- Bimodal high	-0.139	-1.513**	-0.779*	-0.930*	-1.339***[R]	-1.032**	-0.477
- Southwest highlands	-0.994*	-2.542***	-1.134*	-1.171	-1.004	-1.157**	-0.583
- Eastern highlands	-0.444	-3.707***[R]	0.482	-1.852*[R]	-2.423***[R]	-2.430**[R]	-0.339
High market access	-0.211	0.413	0.330	-0.180	0.595*	-0.578	-0.033
High population density (> 100/km^2)	0.511*	-0.585	-0.106	0.406	0.646**[R]	0.279	-0.966**[R]
Irrigation in village	0.109	0.552	-0.043	-0.019	-0.797*[R]	-0.467	0.098
Development Pathways							
- Increase of cereals	-0.289**	-0.354	-0.083	-0.064	0.173	-0.053	-0.032
- Increase of banana and coffee	-0.256	-0.342	-0.040	-0.164	-0.040	0.129	0.328*[R]
- Increase of non-farm activities	-0.042	-0.074	0.101	0.086	-0.124	-0.025	0.150
- Increase of horticulture	0.015	0.159	0.045	-0.135	0.035	0.031	0.094
- Increase of cotton	-0.032	0.218	0.263*[R]	0.078	-0.042	0.002	0.260*
- Stable coffee production	-0.030	-0.319	-0.115	-0.303**[R]	-0.100	-0.081	-0.176
Change in ln(number of households)	1.151**[R]	-1.107	0.130	0.640	0.054	0.686	-0.387
Change in dist. to tarmac road (miles)	-0.0045	-0.340***[R]	-0.0037	0.0597***[R]	-0.0328**[R]	0.0377***[R]	-0.0239**[R]
Change in dist. to rural market (miles)	-0.0576	0.0479	0.0724	0.0263	0.0103	0.0874*[R]	0.1356**[R]
No. of government programs	0.129	-0.942***	-0.050	-0.041	0.307**[R]	0.246*	-0.639***
No. of NGO programs	-0.178	-0.486**[R]	-0.033	-0.047	-0.142	-0.197	0.210
No. of community-based organizations	0.180	-0.007	-0.273	-0.298	-0.106	-0.117	0.117
Prob. > F	0.0946	0.0006	0.0622	0.0823	0.0207	0.0008	0.0155

[a] Dependent variable takes values of –2 (major decrease), -1 (minor decrease), 0 (no change), +1 (minor increase), +2 (major increase).
Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln(no. of households) and numbers of programs and organizations.

Yields of these crops (and apparently others, though the statistical significance is low) have declined more in the bimodal rainfall zones and in the highlands than in the unimodal rainfall zone. This suggests that changes in rainfall patterns and/or pests and diseases (which were cited by many respondents in bimodal areas in the characterization studies of Sserunkuuma et al. (2001) and Bashaasha (2001)) are at least partly responsible for declining yields in the bimodal rainfall areas. Yield declines for several crops have been worst in the eastern highlands. Yield declines for bananas have been worst in the bimodal medium and bimodal low rainfall areas, controlling for other factors. Moisture stress for bananas may be particularly severe in these areas, which are not the most suitable for banana production (especially the bimodal low rainfall region).

There are a few differences in yield trends across the development pathways. Maize yields have declined more in the cereals expansion pathway, possibly as a result of expanding production onto less suitable lands and/or depletion of soil fertility. Banana yields have declined less in the banana-coffee expansion pathway, probably as a result of greater land and pest management effort in these areas (Gold et al. 1999). Bean yields have declined less in the cotton pathway, while groundnut yields have declined most in areas of stable coffee production.

Population growth is associated with smaller decline of maize yields, probably as a result of intensified maize production where population is growing rapidly. The decline in cassava yields is less common in more densely populated areas, again perhaps because of greater intensity of management. By contrast, declining banana yields are more common in more densely populated areas. This suggests that farmers are shifting effort from bananas to cassava in densely populated areas, perhaps because of the pest problems and soil infertility affecting

banana production, while mosaic resistant cassava is more resistant to disease than traditional cassava and more tolerant of low soil fertility than bananas.

Improvement in access to roads is associated with smaller decline in yields of millet, cassava and bananas, but with greater decline in yields of groundnuts and sweet potatoes. A positive association between road access and agricultural production (at least for some crops) is consistent with the findings of Deininger and Okidi (2001) based on a production function estimation using household data from Uganda. Improved access to rural markets is associated with greater decline in yields of sweet potatoes and bananas. It is difficult to give a simple explanation for why road and market access would contribute to yield declines in some cases and stem yield declines in others. It may be that by promoting increased effort for some crops, road and market development reduce farmers' effort for other crops.

Programs and organizations also have mixed associations with yield trends. Yields of cassava and sweet potatoes are less likely to decrease where government programs are operating, while yields of millet and bananas are more likely to decline. Yields of millet are also more likely to decline where NGO programs worked. These impacts may reflect the emphasis of the programs. If extension programs offer better technologies for some crops than for others, farmers may devote more effort to managing the crops using improved technologies, leading to better yields for those at the expense of other crops. For example, introduction of mosaic resistant cassava may have led farmers to manage cassava more intensively and bananas and millet less intensively, with differential impacts on yields.

The impacts of different factors on yield trends can be complex and sometimes unexpected, and measuring yield trends with confidence is difficult. Further research using household and plot level data is needed to clarify and explain these impacts.

CHANGES IN NATURAL RESOURCE CONDITIONS

One reason cited by many survey respondents for declining yields is land degradation; especially soil fertility depletion. As discussed in Section 4, many indicators of perceived changes in land and other resource conditions suggest a general pattern of natural resource degradation in Uganda. Here we investigate the factors that may explain differences across communities in such changes.

Few factors are associated with perceived changes in soil conditions, especially in soil fertility (Table 8).

Table 8. Determinants of Perceived Changes in Resource Conditions (ordered probit regressions)[a]

Explanatory Variable	Soil Fertility	Soil Moisture	Soil Erosion	Availability of Grazing Land	Quality of Grazing Land
Agro-Climatic Zones (cf. Unimodal)					
- Bimodal low	-0.750	-1.118**	-0.022	-0.072	-0.054
- Bimodal medium	0.024	-0.809**[R]	-0.236	0.336	-0.113
- Bimodal high	-0.704	-1.893***[R]	-1.037**	-0.780*	-0.769*
- Southwest highlands	0.183	-1.518**	-0.239	0.135	-0.094
- Eastern highlands	-0.532	-0.344	-1.193*[R]	-0.328	0.121
High market access	-0.478	-0.312	0.051	0.031	0.098
High population density (> 100/km^2)	-0.387	-0.462	-0.364	0.108	-0.144
Irrigation in village	0.225	0.121	0.145	0.075	0.646*[R]
Development Pathways					
- Increase of cereals	-0.223	-0.304**	-0.193	-0.281*	-0.243*
- Increase of banana and coffee	0.102	0.315*[R]	0.152	-0.173	0.068
- Increase of non-farm activities	-0.242	0.133	-0.414**[R]	-0.098	-0.213
- Increase of horticulture	0.073	-0.052	-0.035	-0.047	-0.226
- Increase of cotton	0.264	0.161	0.031	0.018	0.070
- Stable coffee production	-0.167	-0.011	0.042	-0.104	0.047
Change in ln(number of households)	-1.101	-0.294	0.109	0.794	0.640
Change in dist. to tarmac road (miles)	-0.0219**[R]	0.0053	0.0041	0.0024	-0.0209**[R]
Change in dist. to rural market (miles)	0.0231	0.0145	-0.0317	0.0001	0.1532**[R]
No. of government programs	-0.091	-0.196	-0.275	-0.0761	-0.256
No. of NGO programs	0.219	-0.194	0.279*	0.135	0.164
No. of community-based organizations	-0.117	0.192	0.190	0.272	0.360**
Prob. > F	0.0007	0.0099	0.1321	0.3269	0.0117

[a] Dependent variable takes values of –2 (major deterioration), -1 (minor deterioration), 0 (no change), +1 (minor improvement), +2 (major improvement). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.

*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.

[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln(no. of households) and numbers of programs and organizations.

Table 8 (Continued). Determinants of Perceived Changes in Resource Conditions (ordered probit regressions)[a]

Explanatory Variable	Availability of forest	Quality of Forest	Availability of Natural Water Sources	Quality of Natural Water Sources	Diversity of Wild Plants Available	Diversity of Wild Animals Available
Agro-Climatic Zones (cf. Unimodal)						
- Bimodal low	0.413	0.593	-0.221	0.331	0.531	0.502
- Bimodal medium	-0.414	0.071	-0.718	0.589	0.485	-0.083
- Bimodal high	0.838*	0.860	-0.182	1.377**	-1.240**[R]	-0.599
- Southwest highlands	0.593	1.790***[R]	0.366	1.081	1.282*	1.615**[R]
- Eastern highlands	-0.366	0.465	0.358	0.743	-7.537***[R]	-1.222
High market access	-0.298	-0.079	0.330	0.378	0.271	0.150
High population density (> 100/km^2)	0.120	-0.673*	0.355	-0.364	-0.757**[R]	-0.709*
Irrigation in village	0.292	1.025**	-0.117	-0.060	-0.180	0.368
Development Pathways						
- Increase of cereals	-0.430***[R]	-0.145	0.149	-0.001	-0.150	-0.078
- Increase of banana and coffee	0.168	0.285**[R]	0.377**[R]	-0.039	-0.076	0.136
- Increase of non-farm activities	0.085	0.204	0.322**[R]	0.510***[R]	-0.360**[R]	-0.233
- Increase of horticulture	0.081	0.184	0.015	-0.239	-0.305**[R]	-0.340**[R]
- Increase of cotton	-0.116	-0.081	0.025	0.062	0.168	0.165**[R]
- Stable coffee production	0.270*[R]	0.118	-0.301*	-0.040	-0.033	0.019
Change in ln(number of households)	0.866	0.736	0.275	-0.119	0.386	-0.088
Change in dist. to tarmac road (miles)	0.0322**[R]	0.0307	-0.0152	-0.0144**[R]	-0.0243**[R]	-0.0329***[R]
Change in dist. to rural market (miles)	0.0427	0.1169*	0.0540	0.1312**[R]	-0.0095	0.0620
No. of government programs	-0.064	-0.299	0.138	0.071	-0.077	-0.211
No. of NGO programs	0.071	0.290*[R]	-0.193	-0.007	0.109	-0.107
No. of community-based organizations	-0.117	-0.078	-0.214	-0.135	0.020	0.137
Prob. > F	0.2479	0.0547	0.1799	0.0005	0.0000	0.0001

[a] Dependent variable takes values of –2 (major deterioration), -1 (minor deterioration), 0 (no change), +1 (minor improvement), +2 (major improvement). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln(no. of households) and numbers of programs and organizations.

This is probably because major declines in soil fertility were cited in most communities, suggesting that the dominant causes are more general ones, such as a generally poorly developed extension system and input markets, rather than factors that vary greatly across communities. The only factor found to significantly affect changes in soil fertility is improved access to roads, which is associated with improvement (or less decline) in soil fertility. This supports the idea that soil fertility decline is due to poor development of markets or extension, both of which depend upon such infrastructure development.

Perceived changes in soil moisture are, not surprisingly, different in different agroclimatic zones. In general, soil moisture is declining more in bimodal than in unimodal rainfall areas. This is consistent with the finding above that yields are declining more in bimodal areas, and suggests that climate changes in the bimodal areas may be an important cause of declining yields. Soil moisture is also declining more in the cereal expansion pathway, perhaps as a result of tillage practices for cereals. Soil moisture is declining less in the banana-coffee expansion pathway than other pathways, probably due to greater adoption of soil and water conservation practices in the banana-coffee expansion pathway.

Increasing problems of soil erosion are most common in the bimodal high rainfall zone and eastern highlands. Expanded annual crop production on steep slopes may be the reason in both cases. Erosion is worsening more in the non-farm development pathway than other pathways. This may be due to less adoption of conservation investments such as soil bunds in this pathway, as we observed earlier.

There is a tendency for the availability and quality of grazing land to decline more in the bimodal high rainfall region and in the cereal expansion pathway, though these results are only weakly statistically significant. The quality of grazing land is less likely to decline in irrigated

communities, where road access has improved, or where CBO's are operating. These results suggest that intensification of cash crop production or development of non-farm activities, which are likely stimulated by these factors, can reduce pressure on grazing lands. On the other hand, development of rural markets is associated with a worsening of grazing land conditions.

Changes in the availability or quality of forests and woodlands differ due to several factors. Forest quality is being preserved more in the southwest highlands than in other zones. This may be due to remoteness, insecurity or greater efforts to preserve forests in some of these areas. Forest availability is declining more in the cereals expansion pathway and less in the stable coffee production pathway than other pathways. Quality of forest is declining least in the banana-coffee expansion pathway. Better conditions of forests in perennial crop production areas may be because of greater availability of tree products on farms in these areas, reducing pressure on forests. Forest availability is declining more where road access has improved, consistent with the finding concerning forest area discussed earlier. NGO programs appear to contribute to preservation of forest quality, likely due to an emphasis of many programs on resource and environmental conservation.

Changes in availability or quality of natural water sources also differ across different agro-climatic zones, development pathways, and market access conditions. Water quality has improved most in the bimodal high rainfall zone. Both natural water availability and quality are more likely to improve in the non-farm development pathway than most other pathways, while water availability is also improving more (or declining less) in the banana-coffee expansion pathway. In the case of the non-farm development pathway, development of non-farm activities may be reducing pressure on water resources for agriculture. In the banana-coffee expansion pathway, greater adoption of soil and water conservation practices, plus the shading effects of

these perennial crops, may be the main reasons for less negative impact on water availability. Increased access to roads is associated with improved water quality, while improved access to rural markets is associated with worsening water quality.

Changes in biodiversity, as perceived by community members as changes in diversity of wild plant and animal types, are associated with similar factors. The diversity of wild plants and animals is declining less in the southwest highlands than in other zones, consistent with the finding noted above that forest quality is better preserved in this zone. The diversity of wild plants is declining most in the eastern highlands and bimodal high rainfall areas. Plant and animal diversity is declining more in more densely populated areas, as one would expect. Horticultural development is associated with greater decline in plant and animal diversity. Plant diversity is also declining more in non-farm development areas, while animal diversity is declining less in cotton areas. In general, biodiversity appears to be declining more in more intensive farming systems. However, diversity of both plants and animals is surprisingly declining less in areas where road access is improving. Perhaps improved access reduces the need to collect wild plant species or hunt animals for food or other purposes.

In general, changes in natural resource conditions are affected by agro-climatic conditions, population pressure, changes in road and market access, and programs and organizations in complex ways. Improved road access has apparently had a beneficial impact on several resource conditions, including soil fertility, grazing land and water quality, and plant and animal biodiversity; but it has also contributed to deforestation. Irrigation appears to reduce pressure on grazing lands and forests. Population pressure is associated with declining forest quality and biodiversity. Several resource conditions are worsening more in the cereals expansion pathway than in other pathways, while several are improving more in the banana-

coffee expansion pathway, probably as a result of greater soil and water conservation efforts in the latter case. NGO's and CBO's have had a positive impact on some resource conditions. Other factors have more mixed or limited associations with changing resource conditions.

CHANGES IN HUMAN WELFARE

As noted earlier, many indicators of perceived changes in human welfare show improvement in Uganda, despite widespread perception of declining yields and worsening resource conditions. As with other outcomes, these changes vary across communities as a result of differences in agro-climatic conditions, market access, development pathways, and other factors.

There are mixed patterns of changes in different welfare indicators in different agroclimatic zones, controlling for other factors (Table 9).

Table 9. Determinants of Perceived Changes in Welfare Conditions (ordered probit regressions)[a]

Explanatory Variable	Prop. of Houses with Mud Floor	Prop. of Houses with Metal Roof	Average Farm Size	Prop. of Households With Adequate Food	Food Availability	Nutrition of Children
Agro-Climatic Zones (cf. Unimodal)						
- Bimodal low	-0.139	1.191**	-2.096**[R]	-1.080**	-1.575***[R]	-0.505
- Bimodal medium	-0.002	0.849*	0.153	0.167	-0.243	0.001
- Bimodal high	-0.097	0.726	-2.356***[R]	0.096	-0.818*[R]	-0.467
- Southwest highlands	-1.682**	1.844**	-0.881	-0.594	-1.960**[R]	-2.131***[R]
- Eastern highlands	-0.491	0.412	0.071	-0.698	-0.868	-0.201
High market access	-0.103	0.385	0.332	0.254	-0.111	-0.050
High population density (> 100/km^2)	0.194	1.082***[R]	-1.006**	-0.502	-0.454	-0.163
Irrigation in village	-0.355	-0.804**	-0.457	0.827**[R]	-0.593	-0.688*[R]
Development Pathways						
- Increase of cereals	0.018	0.077	-0.077	0.044	0.077	0.314**[R]
- Increase of banana and coffee	0.407**[R]	0.109	0.644**[R]	-0.004	0.628**[R]	0.414***[R]
- Increase of non-farm activities	-0.045	-0.065	-0.323	-0.178	-0.017	0.007
- Increase of horticulture	0.226	0.177	-0.370	-0.207	0.054	-0.027
- Increase of cotton	-0.027	-0.141	0.017	0.030	0.006	0.142
- Stable coffee production	0.214	0.129	0.215	-0.041	0.100	-0.020
Change in ln(number of households)	0.026	1.376**	-1.396**	1.501***[R]	0.529	-0.585
Change in dist. to tarmac road (miles)	-0.0327***[R]	-1.134***[R]	-0.0493***[R]	-0.0319***[R]	-0.0321***[R]	0.0038
Change in dist. to rural market (miles)	-0.0572	-0.302	-0.0395	0.0590	0.073	0.0353
No. of government programs	0.235	0.016	-0.223	0.252	-0.068	0.030
No. of NGO programs	0.024	-0.061	-0.192	-0.068	0.044	0.329**[R]
No. of community-based organizations	0.360**	-0.194	-0.499*	0.166	-0.030	0.449**[R]
Prob. > F	0.0002	0.0000	0.0003	0.0027	0.0133	0.0303

[a] Dependent variable takes values of –2 (major deterioration), -1 (minor deterioration), 0 (no change), +1 (minor improvement), +2 (major improvement). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln(no. of households) and numbers of programs and organizations.

Table 9 (continued). Determinants of Perceived Changes in Welfare Conditions (ordered probit regressions)[a]

Explanatory Variable	Infant Mortality	Availability of Drinking Water	Quality of Drinking Water	Ownership of Consumer Durables	Ability to Cope with Drought	Availability of Energy Sources for Cooking/Heating
Agro-Climatic Zones (cf. Unimodal)						
- Bimodal low	0.570	-0.109	-0.732*[R]	1.095**	0.582	1.214**
- Bimodal medium	0.207	0.234	-0.270	0.764**[R]	0.247	0.901*[R]
- Bimodal high	0.922**[R]	0.765	0.530	0.815**[R]	-0.283	-0.590
- Southwest highlands	0.726	-0.022	0.269	-0.432	0.611	1.351**
- Eastern highlands	-0.448	0.309	1.264	1.500**	-0.358	-1.745**
High market access	-0.438	0.691**	0.941***	0.424	0.227	0.174
High population density (> 100/km^2)	-0.164	0.055	-0.209	0.324	0.231	-0.795**
Irrigation in village	0.937**	-0.095	-1.137***[R]	-0.892**	-0.416	0.698*
Development Pathways						
- Increase of cereals	0.284*[R]	-0.075	0.109	0.020	-0.194	-0.429***
- Increase of banana and coffee	-0.263	0.293**[R]	0.308**[R]	0.155	0.246	-0.024
- Increase of non-farm activities	-0.202	0.020	0.173	-0.016	0.184	0.056
- Increase of horticulture	0.010	-0.048	0.083	0.141	-0.118	0.196**
- Increase of cotton	0.067	-0.092	0.228*[R]	-0.137	-0.201**[R]	-0.009
- Stable coffee production	0.042	-0.199	-0.193	0.044	-0.062	-0.263**
Change in ln(number of households)	0.250	-0.0107	-1.231**[R]	-0.558	0.854	-0.560
Change in dist. to tarmac road (miles)	-0.0037	-0.0072	-0.0212***[R]	-1.223***[R]	-0.021*[R]	-0.0183*
Change in dist. to rural market (miles)	0.0229	0.0386	0.0518	-0.094	-0.004	-0.0265
No. of government programs	-0.097	0.234	0.475***	0.186	-0.036	0.092
No. of NGO programs	0.274*	0.175	0.228	-0.015	-0.219	-0.360***
No. of community-based organizations	0.002	0.070	-0.080	0.025	0.047	-0.252*
Prob. > F	0.1304	0.1216	0.0001	0.0000	0.0626	0.0000

[a] Dependent variable takes values of –2 (major deterioration), -1 (minor deterioration), 0 (no change), +1 (minor improvement), +2 (major improvement). Coefficients and standard errors adjusted for stratification and probability weights. Standard errors robust to heteroskedasticity.
*, **, *** mean statistically significant at the 10%, 5% and 1% level, respectively.
[R] means the coefficient is of the same sign and statistically significant at 10% level when predicted values used for change in ln (no. of households) and numbers of programs and organizations.

In the bimodal low rainfall zone, housing quality (as indicated by houses with a metal roof), ownership of consumer durables and availability of energy sources have improved more than in most other zones; while average farm size, the proportion of households with adequate food, food availability and drinking water quality have declined more than in most other zones. Housing quality, ownership of consumer durables and availability of energy sources have also improved in the bimodal medium potential zone compared to unimodal areas. In the bimodal high rainfall zone, infant mortality and ownership of durable goods have improved (relative to unimodal areas), while average farm size has declined more than in all other zones and food availability has also declined. In the southwest highlands, use of metal roofs has increased more than in other zones, but use of mud floors has declined the least. Food availability and child nutrition have declined the most in this zone, while availability of energy sources has declined less than in most other zones. In the eastern highlands, ownership of durable goods has improved the most, while availability of energy sources has declined the most.

The availability and quality of drinking water have improved more in high market access areas than in low market access areas, probably because of the lower costs of providing such services in high access areas. We find no statistically significant difference in other indicators of welfare changes between high and low access areas.

Road development is associated with improvement in many welfare indicators, including improvements in the proportion of households having adequate food, food availability, housing quality (increased use of metal roofs and reduced use of mud floors), farm size (less likely to decline), drinking water quality, ownership of consumer durables,

and availability of energy sources. Road development (and associated improvement in transportation and other services) appears to be a primary reason for improvements in many aspects of welfare in Uganda.

Population pressure (both high population density and population growth) is associated with declining farm size and reduced drinking water quality, but also with improvements in housing quality, as measured by increased use of metal roofs. Surprisingly, population growth is positively associated with improvement in the proportion of households having adequate food. One might hypothesize that this is due to reverse causality; i.e., improvements in food security may attract immigration into areas where this is occurring (or worsening food security may cause emigration from other areas). However, this finding is robust when replacing population growth with predicted population growth in the regression, suggesting that reverse causality is not the explanation. An alternative explanation, consistent with the theory of Boserup, is that more rapid population growth stimulates intensification of food crop production, perhaps at the expense of cash crops or other activities. The positive association between maize yields and population growth noted earlier is consistent with this explanation.

Irrigation is associated with improvements in several welfare indicators, including the proportion of households having adequate food, reduction in infant mortality, and availability of energy sources. On the other hand, it is also associated with less improvement in other indicators, including improvements in housing quality (use of metal roofs), child nutrition, and ownership of consumer durables. Perhaps irrigated

areas were already better off in terms of some of these indicators, and therefore show less improvement as a result.

There are significant differences in welfare outcomes among the development pathways. Many welfare indicators have improved more in the banana-coffee expansion pathway than in other pathways, including housing quality (less use of mud floors), average farm size (less decline), food availability, child nutrition, and availability and quality of drinking water. In the cereals expansion pathway, child nutrition has improved and infant mortality declined more than in most other pathways, but the availability of energy sources has also declined more, probably as a result of deforestation associated with this pathway. The horticultural development pathway is associated with greater availability of energy sources, while stable coffee production is associated with reduced energy availability. The cotton development pathway is associated with increased drinking water quality but reduced ability to cope with drought.

Programs and organizations also have impacts on welfare indicators. Government programs are strongly associated with improved drinking water quality, probably because some of these programs focus on developing water supplies. NGO programs are associated with improvements in child nutrition and reduced infant mortality, but also with reduced availability of energy sources for heating and cooking. The latter finding may be due to the emphasis of many NGO's on environmental protection, which often includes opposition to cutting trees or charcoal production. This is consistent with the finding of Nkonya et al. (2001) that such programs promote greater enforcement of community bylaws regulating natural resource management. CBO's are also associated

with improvements in child nutrition but reduced availability of energy sources. In addition, they are associated with improvements in housing quality, as indicated by reduced use of mud floors. These findings are consistent with the emphasis of most CBO's on poverty reduction.

In general, road development has the strongest and most consistently positive impact on a wide variety of indicators of improvement in human welfare. Welfare outcomes are also more favorable in some development pathways, particularly the banana-coffee expansion pathway. Other factors have more mixed effects, depending on which indicators are considered.

5. CONCLUSIONS AND IMPLICATIONS

The general pattern of agricultural development occurring in Uganda during the 1990's involved increasing specialization and commercialization of economic activities in different locations, based upon differences in comparative advantage. This development pattern has been associated with changes in land use and agricultural practices, including expansion of cultivated area, settlements and woodlots at the expense of fallow, forest and wetlands; increased ownership of cattle but declining ownership of other types of livestock; and increased adoption of purchased inputs (though still low by international standards) and some soil and water conservation practices. Despite adoption of inputs and some conservation practices, crop yields, food security, and natural resource conditions appear to have degraded throughout much of Uganda. Nevertheless, many aspects of human welfare have improved, stimulated by

improvements in roads and access to services, various government and non-government programs, and other factors.

Six dominant development pathways emerged, almost all of which involve increasing specialization in already dominant activities. These include expansion of cereals production, expansion of banana and 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" development 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 causal factor associated with this development pathway is increased access to rural markets, suggesting that continued development of rural markets will be an important component of achieving such a "win-win-win" development strategy. Other strategies will be needed for less-favored areas not as suited for this development pathway.

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 wetland availability) and human welfare indicators. In areas where natural forests or wetlands are important, there may be trade-

offs 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 to expand cultivated area at the expense of forest, wetlands and fallow strips, contributes to adoption of fertilizer, 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 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, improvements in child nutrition and reduction in infant mortality. However such programs also are associated with some negative outcomes, such as declining yields of some crops (millet and bananas) and declining availability of energy sources. It may be that by promoting development of some crops such programs cause farmers to devote less effort to other crops, leading to some trade-offs in impacts on productivity. The environmental focus of many programs and organizations may be reducing availability of energy sources, reflecting a trade-off between environmental and welfare objectives.

Population growth had limited impacts on most indicators of livelihood strategies, land use, land management, or resource and welfare outcomes. There is some evidence that population growth contributed to agricultural intensification (e.g., the associations of population growth with reduced use of fallow strips and greater maize yields and food availability), consistent with Boserup's theory. However, population growth also appears to have reduced investment in soil bunds, probably because land scarcity reduces the ability of farmers to afford conservation structures that reduce cultivated area. This contradicts the predictions of Boserup's followers (e.g., Tiffen, et al. 1994) that population growth stimulates investment in land improvement, but is similar to findings from Ethiopia (Pender, et al. 2001). Impacts of population growth on resource conditions were generally insignificant, while associations with welfare indicators were mixed. Population growth is associated with improvement in housing quality, but also with declining farm sizes and worsening drinking water quality. In general, the impacts of population growth were not as negative as Malthusian pessimists often argue, nor as positive as Boserupian optimists argue.

It should be emphasized that these results are based upon rough qualitative measures of impacts as well as fairly crude measures of some 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 for the changes and impacts reported here.

REFERENCES

Agricultural Policy Secretariat. 2000. Characterization of policies and institutions affecting land management in Uganda.

Angelsen, A. 1999. Agricultural expansion and deforestation: Modelling the impact of population, market forces and property rights. *Journal of Development Economics* 58(1): 185-218.

Bagoora, F.D.K. 1988. Soil erosion and mass wasting risk in the highland areas of Uganda. *Mountain Research and Development* 8(2/3): 173-182.

Bashaasha, B. 2001. The evolution and characteristics of farming systems in Uganda. Makerere University. Mimeo.

Bekunda, M.A. and J.K. Lorup, 1994. Quantitative assessment of the impact of soil erosion on the water resources in Uganda. In Proceedings of the 14th Conference of the Soil Science Society of East Africa, ed. Kwakaikara, M.C., S. Mateete, A. Bekunda and T.S. Tenywa. November 21-25, 1994, Mbarara, Uganda.

Boserup, E. 1965. *The conditions of agricultural growth.* New York: Aldine Publishing Company.

Deininger, K. and J. Okidi. 2001. Rural households: Incomes, productivity and nonfarm enterprises. In *Uganda's Recovery: The Role of Farms, Firms, and Government*. Washington, D.C., The World Bank.

Food and Agriculture Organization of the United Nations (FAO). 1999. Uganda Soil Fertility Initiative: Draft Concept Paper. Investment Centre Division, FAO/World Bank Cooperative Programme, Rome. Mimeo.

Food and Agriculture Organization of the United Nations (FAO). 1989. FAO/UNESCO Soil Map of the World. Revised Legend. World Soil Resource. Report No. 60. FAO, Rome. Reprinted as technical paper 20, ISRC, Wageningen, 138 pp.

Gold, C.S., E.B. Karamura, A. Kiggundu, F. Bagamba, and A.M.K. Abera. 1999. Geographic shifts in the highland cooking banana (Musa spp., group AAA-EA) production in Uganda. *International Journal of Sustainable Development and World Ecology* 6(1): 45-59.

Herweg, K. 1992. Major constraints to effective soil conservation—experiences in Ethiopia. 7th ISCO Conference Proceedings. September 27-30, Sydney, Australia.

Jagger, P. 2001. Evolving roles of programs and organizations: Promoting sustainable land management in Uganda. International Food Policy Research Institute, Environment and Production Technology Division, Washington, D.C. Mimeo.

LaFrance, J. T. 1992. Do increased commodity prices lead to more or less soil degradation? *Australian Journal of Agricultural Economics* 36(1): 57-82.

Magunda, M.K. and M.M. Tenywa. 1999. Soil and Water Conservation, Kawanda Agricultural Research Institute and Makerere University Staff Report, Uganda.

McIntire, J., D. Bourzat, and P. Pingali. 1992. *Crop-livestock interaction in Sub-Saharan Africa*. Washington, DC: World Bank

Mukherjee, C., H. White and M. Wuyts, 1998. *Econometrics and data analysis for developing countries.* London: Routledge.

National Environment Management Authority (NEMA), 1998. State of the Environment Report for Uganda, 1998: 20-24. Kampala, Uganda.

Nkonya, E., R. Babigumira and R. Walusimbi. 2001. Soil conservation by-laws: Perceptions and enforcement among communities in Uganda. Environment and Production Technology Division, International Food Policy Research Institute, Washington, D.C. Mimeo.

Olson, J.M. 1995. Natural resource management by farmers in Kabale District, Uganda. Nairobi: International Centre for Research in Agroforestry. Mimeo.

Pagiola, S. 1996. Price policy and returns to soil conservation in semi-arid Kenya. *Environmental and Resource Economics* 8:251-271.

Pender, J. 1999. *Rural population growth, agricultural change and natural resource management in developing countries: A review of hypotheses and some evidence from Honduras.* Environment and Production Technology Division Discussion Paper No. 48, Washington, DC: International Food Policy Research Institute.

Pender, J. 1998. Population growth, agricultural intensification, induced innovation and natural resource sustainability: An application of neoclassical growth theory. *Agricultural Economics* 19: 99-112.

Pender, J., B. Gebremedhin, S. Benin and S. Ehui. 2001. Strategies for sustainable agricultural development in the Ethiopian highlands. *American Journal of Agricultural Economics*, December.

Pender, J. and J. Kerr. 1998. Determinants of farmers' indigenous soil and water conservation investments in India's semi-arid tropics. *Agricultural Economics* 19: 113-125.

Pender, J., S. J. Scherr, and G. Durón. 2000. Pathways of development in the hillsides of Honduras: Causes and implications for agricultural production, poverty, and sustainable resource use. In *Tradeoffs or synergies? Agricultural intensification, economic development and the environment*, ed. D.R. Lee and C. B. Barrett. Wallingford, UK: CAB International.

Place, F., J. Ssenteza, and K. Otsuka. 2001. Customary and private land management in Uganda. In *Land Tenure and Natural Resource Management: A Comparative Study of Agrarian Communities in Asia and Africa*. International Food Policy Research Institute, Johns Hopkins University Press.

Ruecker, G. 2001. Stratification and resource mapping methodology for community based analysis of soil degradation in Uganda. In *Policies for improved land management in Uganda,* ed. P. Jagger and J. Pender. Summary of papers and proceedings of a workshop held at Hotel Africana, Kampala, Uganda, 25 and 27 June 2001. Environment and Production Technology Division Workshop Summary Paper No. 10, Washington, D.C.: International Food Policy Research Institute.

Scherr, S. and P. Hazell. 1994. *Sustainable agricultural development strategies in fragile lands.* Environment and Production Technology Division Discussion Paper No. 1, Washington, DC: International Food Policy Research Institute.

Sserunkuuma, D., J. Pender, and E. Nkonya. 2001. Land management in Uganda: Characterization of problems and hypotheses about causes and strategies for improvement. International Food Policy Research Institute, Environment and Production Technology Division, Washington, D.C. Mimeo.

Stoorvogel, J. J., and E. M. A. Smaling. 1990. *Assessment of soil nutrient depletion in sub-Saharan Africa: 1983-2000*. Report 28. Wageningen, The Netherlands: Winand Staring Centre for Integrated Land, Soil and Water Research.

Tenywa, M.M., M.I. Isabirye, R. Lal, A.Lufafa, and P. Achan. 1999. Cultural practices and production constraints in smallholder banana-based cropping systems of Uganda's Lake Victoria Basin, *African Crop Science Journal*, 7(4): 541-550.

Tiffen, M., M. Mortimore, and F. Gichuki. 1994. *More people – less erosion: Environmental recovery in Kenya.* London, UK: Wylie and Sons.

Wood, S., K. Sebastian, F. Nachtergaele, D. Nielsen, and A. Dai. 1999. *Spatial aspects of the design and targeting of agricultural development strategies.* Environment and Production Technology Division Discussion Paper 44. Washington, DC: International Food Policy Research Institute.

Wortmann, C.S. and C.K. Kaizzi. 1998. Nutrient balances and expected effects of alternative practices in farming systems of Uganda. *Agriculture, Ecoysystems and Environment* 71(1-3): 115-130.

Zake, J.Y.K. and M. Magunda, 1999. Soil Conservation in the Highlands of Uganda, In *Strategies for poverty alleviation and sustainable resource management in the fragile lands of Sub-Saharan Africa*, ed. McCulloch, A.K., S. Babu, and P. Hazell. Proceedings of the International Conference held from 25 – 29 May, 1998 in Entebbe, Uganda. International Food Policy Research Institute (IFPRI) and National Agricultural Research Organization (NARO) and European Commission (EC).

Zake, J.Y.K., M.K. Magunda, and C. Nkwiine. 1997. Integrated soil management for sustainable agriculture and food security: The Uganda Case. Paper presented to Workshop on Integrated Soil Management for Sustainable Agriculture and Food Security in Southern and East Africa, Harare Zimbabwe, December 8-12.

APPENDIX TABLES

Table A1--Human Welfare Indicators, % of households/people in 1999[A]

Welfare Indicator	AVERAGE	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Households without adequate food throughout the year	60.5	66.4	71.8	48.7	52.5	95.1	60.3	56.5	62.1	60.1	60.6
Households with adults eating < two meals per day on average	49.5	62.2	66.5	39.5	47	58.3	40.1	48.6	49.8	51.6	48.3
Households with children eating < two meals per day on average	35.3	58.9	46.7	24.4	33	48.9	23.1	31.4	36.9	38.6	33.6
Houses with mud floor	89.5	95.3	86.4	91.1	82.2	97	99.3	93.8	87.7	91.3	88.5
Houses with walls of mud and wattle	64.5	59.7	76.8	59.6	54.6	92.1	93.1	70.1	62.1	64.4	64.5
Houses with walls of grass	1.8	0	1.9	0.1	0.9	9.7	4.2	0.6	2.3	0.6	2.5
Houses with metal roof	61.1	21.7	78.7	45.8	83	80.4	37.5	33.6	72.6	39.1	72.7
Adults able to read and write	65.4	70.6	64.8	64.1	64.9	67.4	54.2	62.1	66.8	65.1	65.6
Children of primary school age in school	92	97.7	92.3	93.6	87.5	92.2	95.6	93.5	91.3	92.7	91.6
Children of secondary school age in school	41.5	32.3	45.5	39.8	51.7	27.7	41.9	37.9	43	38.2	43.2

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A2 – Human Welfare Indicators, Change in % of Households/People Since 1990, rank[A,B]

Welfare Indicator	AVERAGE	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Hhds without adequate food throughout the year	0.73	0.27	0.17	0.69	0.55	1.31	1.7	0.69	0.75	0.35	0.93
Hhds with adults eating < two meals per day	0.57	0.21	1.07	0.52	0.58	0.7	1.09	0.55	0.58	0.24	0.75
Hhds with children eating < two meals per day	0.31	0.07	0.88	0.33	0.26	0.18	0.84	0.14	0.38	0.01	0.46
Houses with dirt floor	-0.35	-0.19	-0.54	-0.32	-0.53	-0.04	-0.25	-0.29	-0.37	-0.26	-0.39
Houses with walls of mud and wattle	-0.84	-0.63	-0.59	-0.62	-1.46	-0.26	-0.36	-0.63	-0.92	-0.6	-0.96
Houses with walls of grass	-0.42	-0.15	-1.33	-0.54	-0.32	-0.17	-0.41	-0.39	-0.42	-0.52	-0.36
Houses with metal roof	1.46	0.65	1.72	1.36	1.66	1.87	1.5	1.1	1.6	1	1.69
Adults able to read and write	0.82	0.5	0.83	0.69	0.9	1.17	1.11	0.75	0.84	0.71	0.87
Children of primary school age in school	1.87	2	1.86	1.94	1.75	1.87	2	1.85	1.88	1.92	1.85
Children of secondary school age in school	0.62	-0.27	0.97	0.81	0.79	0.52	0.55	0.59	0.64	0.55	0.66

A, Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A3--Perceptions of Change In Welfare of Households in Village since 1990, mean rank[A,B]

Welfare Item	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Average farm size	-1.58	-1.41	-1.92	-1.23	-1.95	-1.48	-1.55	-1.41	-1.65	-1.28	-1.74
Availability of adequate food	-1.16	-0.53	-1.38	-0.96	-1.33	-1.65	-1.50	-0.87	-1.28	-0.77	-1.36
Availability of drinking water	0.21	-0.09	-0.08	-0.16	0.82	0.13	-0.31	-0.33	0.43	-0.11	0.37
Quality of drinking water	0.58	0.4	-0.22	0.22	1.08	0.83	0.66	0.1	0.78	0.28	0.74
Nutrition of children	0.07	-0.1	0.61	0.44	-0.04	-0.69	0.11	0.12	0.04	0.27	-0.04
Infant mortality	0.83	0.57	1.05	0.74	1.06	0.65	0.55	0.96	0.78	0.92	0.78
Child mortality	0.78	0.22	1.04	0.68	1.07	0.74	0.55	0.73	0.8	0.8	0.77
Maternal mortality	0.62	0.56	1.33	0.51	0.75	0.31	0.23	0.34	0.73	0.5	0.68
Availability of educational services	1.18	1.59	1.31	1.16	1.12	1.08	0.5	1.2	1.18	1.57	1.14
Quality of educational services	-0.22	0.03	-0.06	-0.22	-0.64	0.26	0.45	-0.15	-0.25	-0.08	-0.29
Average level of hhd. durable goods	1.42	0.68	1.75	1.55	1.75	0.87	1.8	1.21	1.52	1.17	1.56
General health of people	0.39	0.32	0.3	0.83	0.75	-1.48	1.04	0.66	0.28	0.54	0.31
Availability of health services	1.13	1.02	1.07	1.13	1.31	0.91	0.8	0.98	1.19	1	1.2
Quality of health services	0.93	0.66	0.91	1.01	1	0.83	1.05	0.9	0.94	0.81	0.99
Ability to cope with drought	-0.29	-0.29	0.1	-0.31	-0.58	0.39	-0.86	-0.39	-0.25	-0.56	-0.3
Avail of energy for heat and cooking	-1.28	-1.3	-0.97	-0.88	-1.77	-1.04	-1.95	-1.13	-1.35	-0.99	-1.44
Avail of energy for light	0.85	1.38	0.61	0.78	0.88	0.39	1.36	1.03	0.78	0.96	0.79
Access to transportation	1.45	1.4	1.43	1.2	1.73	1.39	1.61	1.35	1.5	1.32	1.52
Avail of consumer goods	1.5	1.44	1.51	1.4	1.74	1.17	1.5	1.45	1.52	1.49	1.5

A. Means and errors are corrected for sampling stratification and sampling weights.

B. Values represent the average of rank data where 0=no significant change, +1=minor improvement, +2=major improvement, -1=minor deterioration, -2=major deterioration.

Table A4--Perceptions of Change in Resource Conditions in Village since 1990, mean rank[A,B]

Natural Resource Item	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Abandoned farmland	0.1	0	0.01	-0.04	0.33	0.09	-0.09	0.04	0.13	0.05	0.13
Avail. of crop land	-1.47	-1.31	-0.86	-1.19	-1.81	-1.83	-1.39	-1.41	-1.5	-1.35	-1.53
Soil fertility	-1.61	-1.3	-1.79	-1.39	-1.87	-1.65	-1.8	-1.28	-1.74	-1.37	-1.73
Soil moisture holding capacity	-1.14	-0.26	-1.18	-0.99	-1.67	-1.22	-0.7	-0.78	-1.3	-0.72	-1.36
Soil erosion	-0.98	-0.54	-0.19	-0.99	-1.41	-0.61	-1.7	-0.9	-1.01	-0.58	-1.19
Availability of grazing land	-1.07	-0.85	-0.98	-0.87	-1.52	-0.65	-1.41	-0.99	-1.11	-0.89	-1.17
Quality of grazing land	-0.51	-0.15	0.1	-0.56	-1	0	-0.3	-0.55	-0.5	-0.34	-0.6
Availability of forest/woodland	-0.74	-0.39	-0.09	-1.03	-0.94	-0.35	-0.5	-0.79	-0.72	-0.7	-0.76
Quality of forest/woodland	-0.48	-0.62	-0.02	-0.88	-0.35	0	-0.36	-0.68	-0.4	-0.5	-0.47
Avail. of natural water sources	-0.24	-0.12	-0.21	-0.49	-0.18	0	0	-0.35	-0.19	-0.38	-0.17
Quality of natural water sources	0.04	-0.32	-0.42	-0.06	0.39	0.17	-0.45	-0.23	0.16	-0.14	0.14
Diversity of wild plant types	-1.29	-1.1	-0.75	-1.08	-1.91	-0.57	-2	-1.08	-1.37	-0.79	-1.55
Diversity of wild animal types	-1.31	-1.26	-0.79	-1.4	-1.79	-1.13	-1.91	-1.25	-1.34	-1.02	-1.47

A. Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor improvement, +2=major improvement, -1=minor deterioration, -2=major deterioration.

Table A5--Primary Activities for Men in 1999, percent of villages[A]

Primary Activities of Men	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	30.1	20.6	7.6	36.3	30.4	34.9	40.8	27.1	31.4	23.5	33.6
Other storable annual crop production	3.9	0	35.5	4.2	0	0	0	1.7	4.7	3	4.3
Horticultural crop production	1	0	7	0	0	0	4.6	1.7	0	1.5	0
Banana production	13.8	0	25	2.8	14.1	43.4	29.6	21	14.5	12.2	14.6
Coffee production	19.2	7.3	10.5	12.7	38.1	4.3	25	5.1	25.1	4.3	27.1
Cotton production	6.6	17.7	0	9.9	0	8.7	0	8.5	5.8	9.6	5.1
Root crop production	16.8	47.1	0	22.3	10.6	0	0	39.1	7.5	37.1	6.2
Keeping cattle	1.6	0	14.5	0	1.8	0	0	1.7	1.6	4.7	0
Trading	2.6	7.3	0	0	5	0	0	0	3.7	0	4
Brewing beer	2.2	0	0	7.1	0	0	0	3	1.8	0	3.3
Charcoal making	1	0	0	0	0	8.7	0	0	1.6	0	1.7
Production of tobacco	1	0	0	1	0	0	0	0	2	4.1	0

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A6--Secondary Activities for Men in 1999, percent of villages[A]

Secondary Activities of Men	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	17.7	29.4	27.9	23.7	11.9	4.3	0	35	10.6	28.9	11.9
Other storable annual crop production	18	32.5	7.6	14.5	7	47.8	0	11.9	20.6	17	18.6
Horticultural crop production	4.4	0	0	8.5	5	0	4.6	0	6.2	0	6.6
Banana production	9.8	7.3	22.1	8.5	11.9	0	25	3.7	12.2	6.3	11.5
Coffee production	10.8	0	0	0	24.2	17.4	25	6.5	12.6	0	16.5
Cotton production	2.6	19	0	0	0	0	0	5.5	1.4	4.7	1.5
Root crop production	12.2	11.7	0	21.6	7.1	13.1	0	20.5	8.8	14.9	10.9
Keeping cattle	9.3	0	14.5	8.8	6.1	17.4	45.4	11.7	8.3	13.2	7.3
Keeping other livestock	1	0	0	0	1.8	0	0	0	1	1.7	0
Trading	5.5	0	7	5.7	7.1	0	0	2.2	6.9	5.1	5.8
Brewing beer	3.2	0	0	8.8	0	0	0	1.7	3.8	5.6	2
Brick making	3.3	0	0	0	10	0	0	0	4.6	0	5
Fishing	0	0	0	0	1	0	0	1	0	1	0
Stone crusher	2.2	0	0	0	6.8	0	0	0	3.1	1.7	2.5

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A7--Tertiary Activities for Men in 1999, percent of villages[A]

Tertiary Activities of Men	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	12.3	35.4	7	15.6	4	0	29.6	25.2	7	20.7	8
Other storable annual crop production	13.4	11.8	10.5	19.1	3.1	21.7	45.4	27.4	7.6	23.1	8.3
Horticultural crop production	1.9	0	0	4.2		0	20.4	2	1.8	0	2.9
Banana production	4.6	7.3	21	0	0	13	0	3.1	5.2	2.6	5.6
Coffee production	1.7	0	14.5	0	0.1	0	0	3.9	1	3	1
Cotton production	4.7	17.7	0	7.5	0.2	0	0	13.3	1	11.2	1.3
Root crop production	16.9	6	7.6	13	0	43.5	0	6	21.4	10.7	20.1
Keeping cattle	14.9	14.6	17.5	28.9	18	8.7	0	9.5	17.2	9.6	17.7
Keeping other livestock	5.4	0	0	7.1	5	0	0	0	7.7	2.5	6.9
Non-farm salary employment	1	0	7.6	0	10.1	0	0	0	1	1.6	0
Farm employment outside village	1	7.3	0	0	0	0	4.6	0	1.4	0	1.5
Trading	10.7	0	14.5	4.6	0	8.7	0	7.7	11.9	13.2	9.4
Crafts	1.6	0	0	0	5	0	0	0	2.3	0	2.5
Brewing beer	4.9	0	0	0	15.1	0	0	0	6.9	0	7.4
Brick making	2.2	0	0	0	5	4.3	0	1.9	2.3	1.6	2.5
Sugar cane production	3.3	0	0	0	10.1	0	0	0	4.6	0	5

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A8--Change in Importance of Three Most Important Activities for Men Since 1990, mean rank[A,B]

Activities of Men	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	0.64	-0.07	1.06	1.03	0.31	0.66	0.87	0.71	0.53	0.55	0.64
Other storable annual crop production	0.65	0.66	0.78	0.51	0.5	0.87	0.45	0.14	0.92	0.41	0.83
Horticultural crop production	1.02	N/A	2	1.67	-1	-1	1.38	2	0.84	2	0.95
Banana production	0.37	0	0.33	-0.88	0.94	0.46	0	0.11	0.43	0.37	0.37
Coffee production	0.26	0	0.28	-0.67	0.54	-0.4	0	0.58	0.2	-0.24	0.3
Cotton production	0.09	0	N/A	0.23	N/A	0	N/A	0.15	0	-0.16	0.51
Root crop production	0.59	0.18	0	0.86	0.31	0.92	N/A	0.65	0.54	0.47	0.69
Keeping cattle	0.74	-1	0.54	1.21	0.86	0	1.34	0.73	0.75	0.75	0.74
Trading	0.75	2	-0.38	0.11	0.95	2	0	-0.48	0.96	0.34	0.94

A. Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A9--Primary Activities for Women in 1999, percent of villages[A]

Primary Activities of Women	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	10.7	13.3	0	13	1	34.9	0	5.9	12.7	7.5	12.5
Other storable annual crop production	4.3	0	10.5	4.2	0	17.4	0	0	6.1	0	6.6
Banana production	1.7	0	0	0	0	13	0	1.9	1.6	5	0
Cotton production	1.1	0	0	0	0	8.7	0	0	1.6	0	1.7
Root crop production	2.2	0	0	0	5	4.3	0	1.9	2.3	1.6	2.5
Household maintenance activities	79.9	86.7	89.5	82.7	93.9	21.7	100	90.2	75.6	85.9	76.7

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A10--Secondary Activities for Women in 1999, percent of villages[A]

Secondary Activities of Women	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	29.2	61.7	32	24.5	16	34.8	40.7	42.3	23.8	35.4	26
Other storable annual crop production	14.6	6	36.1	8.8	13.9	26	20.4	8.1	17.3	14.6	14.6
Horticultural crop production	3.4	0	7	4.2	5	0	0	1.7	4.1	1.5	4.5
Banana production	10.5	7.3	18	11.3	13.1	0	18.5	3.8	13.5	5.1	13.4
Coffee production	1.1	0	0	0	0	8.7	0	0	1.6	0	1.7
Cotton production	1	0	0	0	0	0	20.4	2	0	0	1
Root crop production	31.8	17.7	0	38.2	50.9	8.8	0	32.9	31.3	31.9	31.7
Keeping other livestock	1	0	7	0	0	0	0	1.7	0	1.4	0
Household maintenance activities	8.2	7	0	13	1	21.7	0	7.9	8.3	10	7.2

A...Means and errors are corrected for sampling stratification and sampling weights.

Table A11--Tertiary Activities for Women in 1999, percent of villages[A]

Tertiary Activities of Women	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	12.8	11.8	0	22	6.8	17.3	0	24.9	7.8	23.7	7.1
Other storable annual crop production	35	42.7	32	40.9	38.3	8.7	25	39	33.3	41.1	31.8
Horticultural crop production	1	0	0	0	0	0	25	2	0	0	1.1
Banana production	3.5	0	24.4	0	2	8.7	0	5.6	2.7	2.9	3.9
Coffee production	1.3	0	0	4.2	0	0	0	0	1.8	0	2
Cotton production	2.4	17.7	0	0	0	0	0	5.5	1.2	7.1	0
Root crop production	17.4	7.3	7.6	28.7	8.9	26.1	25	13.4	19.1	11.9	20.3
Keeping cattle	1.1	0	7.6	0	0	0	20.4	2	1	3.3	0
Keeping other livestock	6.8	14.6	0	0	14.9	0	0	3.4	8.2	2.7	9
Trading	2.8	0	7.6	0	6.8	0	0	0	3.9	3.3	2.5
Crafts	6.4	0	21	0	15.1	0	0	0	9	0	9.7
Brewing beer	3.2	0	0	4.2	2	8.7	4.6	2.2	3.6	0	4.9
Household maintenance activities	6.4	6	0	0	5	30.4	0	1.9	8.3	4	7.7

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A12 – Change in Importance of Three Most Important Activities for Women Since 1990, mean rank[A,B]

Activites of Women	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cereal crop production	0.77	0.34	0.42	0.83	1.1	0.9	1.5	0.54	0.93	0.6	0.9
Other storable annual crop production	0.73	0	1.09	0.74	1.02	0.58	0	0.37	0.86	0.33	0.96
Horticultural crop production	1.07	N/A	2	2	0	N/A	1.19	1.46	0.93	2	0.95
Banana production	0.22	0	0.66	-1.25	0.99	0.4	-0.12	0.85	0.02	0.41	0.14
Coffee production	-0.86	N/A	N/A	-2	N/A	0	0	0	-1.06	N/A	-0.86
Cotton production	0	0	N/A	N/A	N/A	0	N/A	0	0	0	0
Root crop production	0.62	0	1	0.81	0.49	0.88	0	0.98	0.49	0.71	0.59
Keeping cattle	0.57	N/A	-1	N/A	N/A	N/A	2	2	-1	0.57	N/A
Keeping other livestock	-0.03	-1.5	0	N/A	2	N/A	N/A	1.1	-0.32	1.05	-0.29
Trading	2	0	2	N/A	2	N/A	N/A	N/A	2	2	1.99
Household maintenance activities	0.47	-0.07	0.12	0.62	0.45	1.06	0.77	0.55	0.45	0.4	0.52

A. Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A13--Trend of Change in Yield Since 1990 or Year When Began Growing Variety, mean rank [A,B]

Crop	AVG	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Bean	-0.96	-0.43	-0.73	-0.85	-1.13	-1.39	-0.52	-0.96	-0.97	-0.88	-1
Groundnut	-1.11	-0.39	-1.39	-1.05	-1.32	-1.54	-1.69	-0.91	-1.21	-1	-1.18
Maize	-0.62	-0.52	-0.76	-0.44	-0.6	-1.09	-0.84	-0.55	-0.65	-0.62	-0.62
Millet	-0.68	-0.16	-0.44	-0.59	-0.93	-1.13	-1.62	-0.53	-0.78	-0.54	-0.8
Sorghum	-0.56	-0.2	-0.21	-0.23	-0.76	-1.3	-1	-0.31	-0.66	-0.39	-0.66
Cassava	-0.81	-0.29	-1.3	-0.86	-0.81	-0.89	-1.67	-0.95	-0.75	-0.93	-0.74
Sweet Potato	-0.74	-0.28	-0.99	-0.43	-0.95	-1.22	-1.38	-0.46	-0.86	-0.53	-0.86
Banana	-1.33	-1.07	-1.23	-1.57	-1.35	-1.03	-1.21	-1.35	-1.33	-0.13	-0.41
Tomato	-0.58	-0.37	-0.54	-0.32	-1.02	-0.29	-0.14	-0.1	-0.72	-0.29	-0.7
Cabbage	-0.96	-0.43	-0.73	-0.85	-1.13	-1.39	-1.52	-0.96	-0.97	-0.88	-1

A. Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A14--Change in Proportion of Households Owning Livestock Since 1990, mean rank[A,B]

Livestock type	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cattle (local)	0.33	0.55	0.33	1.04	-0.31	0.09	-0.05	0.49	0.26	0.47	0.26
Cattle (crossbred)	0.23	0.07	0.3	0.09	0.5	0	0.45	0.07	0.3	0.11	0.3
Goats (local)	-0.16	0.61	-0.15	0.15	-0.4	-1.13	0.07	0.15	-0.28	0.1	-0.29
Pigs (local)	-0.15	-0.66	0.19	-0.45	0.43	-0.48	-0.44	-0.86	0.14	-0.62	0.09
Pigs (exotic)	0.03	0	0	0	0.1	0	0	0	0.05	0	0.05
Chicken (local)	-0.31	-0.29	-0.06	-0.08	-0.22	-1.21	-0.45	-0.51	-0.23	-0.28	-0.33
Sheep (local)	-0.29	0.04	-0.42	-0.22	-0.3	-0.61	-0.59	0.11	-0.45	0	-0.44
Rabbit (local)	-0.01	0.15	-0.06	0.03	-0.04	-0.22	0.2	0.05	-0.04	0.02	-0.03
Duck (local)	0.02	-0.03	0		0.06	0	0	0.12	-0.03	-0.02	0.02
Turkey (local)	0.05	0.12	0	0.05	0.07	0	0	0.13	0.02	0.09	0.03

A. Means and errors are corrected for sampling stratification and sampling weights.

B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A15 –Change in Proportion of Land Area Under Various Uses Since 1990, mean rank[A,B]

Land Use	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Cultivated land	0.66	0.33	0.97	1.04	0.83	-0.35	-0.05	0.79	0.6	0.85	0.55
Fallow	-1.23	-1.41	-1.25	-1.39	-1.08	-1.04	-1.2	-1.43	-1.15	-1.36	-1.17
Grazing area	-0.93	-0.94	-0.61	-0.86	-1.16	-0.69	-0.91	-1.04	-0.88	-1.01	-0.89
Forest/woodland	-0.63	-0.39	-0.34	-1.01	-0.58	-0.35	-0.41	-0.75	-0.58	-0.66	-0.62
Planted woodlots	0.27	0.15	0.36	0.17	0.22	0.7	0.45	0.18	0.31	-0.09	0.37
Wetland	-0.37	-0.19	0	-0.3	-0.71	-0.17	0	-0.09	-0.49	-0.22	-0.45
Settle ments	1.37	1.07	1.47	1.09	1.66	1.57	1.34	1.12	1.47	1.03	0.54
Wasteland	0.01	0	0.18	0	0	0	0	0	0.02	0.02	0.01

A. Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A16 – Percentage of Households Using Soil and Water Conservation Technologies in 1999[A]

SWC Technology	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Fallowing	14.8	38.3	18.1	21.5	4.2	0	8.15	24.6	10.7	31.5	6
Fallow strips	5	0	19.9	8.5	0.4	6.2	0	6.5	4.4	11.3	1.7
Planting trees (on farmland)	19.3	10.2	32.6	11.1	31.5	11.4	29.3	6.9	24.5	10.8	23.8
Mulching	27.5	5.6	58.7	13.7	33.7	53.9	13.6	10.7	34.8	17.3	32.9
Composting	9.1	0.2	10.2	0.4	14.2	24.6	14.3	2.5	11.9	3.8	11.9
Animal manure	21	11.5	18.9	7.1	31.5	36	35.2	6.7	27	8.4	27.6
Crop residue	30.2	83.1	10	29.6	13	25.4	49.2	44.4	24.3	44	23
Grass strips	7.3	16.9	1.1	4.6	2	8.4	57.5	7.2	7.3	3.4	7.7
Hedges or other live barriers	5.9	20.2	3.4	2.3	5.9	1.7	0	4.6	6.4	5.5	6
Trash lines	21.5	49.2	0	26.1	9.4	26.5	8.4	22.1	21.3	30.7	16.7
Ridges/tied ridges	3.8	4.4	7.8	1.7	6.5	0	0	1.2	4.9	1	5.3
Infiltration ditches	6.4	11	16.1	2.2	4.7	8.4	15.6	5.4	6.9	4.9	7.2
Zero tillage	4.5	18.9	0	2.2	3.8	0	0	8.1	3	8.3	2.5
Contour planting	9.7	0.6	0	15.7	11.1	0	40.8	13.5	8.1	8.6	10.2
Contour plowing	6.2	6	0	9.3	4	0	40.8	9.8	4.7	9.4	4.5
Soil bunds	6.3	3.7	8.1	0.7	9.9	8.7	21.6	5	6.8	2.2	8.4

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A17--Change in Proportion of Households Using Soil and Water Conservation Technologies Since 1990, mean rank[A,B]

SWC Technology	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Fallowing	-0.69	-0.85	-0.57	-0.97	-0.67	-0.17	-0.2	-1.03	-0.56	-0.79	-0.64
Fallow strips	-0.16	0	-0.23	-0.02	-0.21	-0.48	0	0	-0.22	-0.11	-0.18
Improved fallow	0	0	0	0	0	0	0	0	0	0	0
Alley cropping	0	0	0	0	0	0	0	0	0	0	0
Planting trees (on farmland)	0.42	0.22	0.58	0.2	0.75	0.17	0.7	0.11	0.55	0.21	0.53
Mulching	0.25	0.07	0.69	0.09	0.39	0.17	0.45	0.15	0.29	0.11	0.32
Composting	0.3	0.07	0.3	0.05	0.56	0.44	0.41	0.06	0.39	0.12	0.39
Animal manure	0.47	0.15	0.31	0.18	0.91	0.39	0.91	0.14	0.61	0.18	0.63
Crop residue	0.13	0.07	0.23	0.02	0.18	0.09	0.81	0.15	0.12	0.1	0.14
Grass strips	0.13	0.07	0	0.12	0.1	0.17	0.61	0.11	0.14	0.12	0.13
Hedges or other live barriers	0.07	0.21	0.19	0	0.06	0	0	0.01	0.09	0.03	0.09
Trash lines	0.13	0	0	0.11	0.18	0.26	0.2	0.05	0.17	0.12	0.14
Ridges/tied ridges	0.13	0.15	0.19	0.09	0.21	0	0	0.02	0.17	0.02	0.19
Infiltration ditches	0.16	0.22	0.35	0.05	0.18	0.17	0.2	0.11	0.18	0.12	0.18
Zero tillage	-0.06	-0.47	0	-0.18	0.18	0	0	-0.29	0.03	-0.26	0.04
Contour planting	0.09	0	0	0.07	0.21	0	0	0.07	0.1	0.08	0.09
Contour plowing	0.08	0	0	0.1	0.16	0	0	0.1	0.07	0.08	0.08
Soil bunds	0.18	0.07	0.19	0	0.43	0	0.41	0.12	0.2	0.04	0.25

A. Means and errors are corrected for sampling stratification and sampling weights.

B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A18 – Percentage of Households Using Agricultural Inputs in 1999[A]

Input	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Fertilizers	8.7	11.0	9.6	8.2	7.4	9.3	11.3	11.0	8.0	8.2	9.0
Pesticides	43.2	56.0	46.7	39.5	39.9	50.1	46.4	48.1	41.6	38.1	45.4
Herbicides	8.1	3.8	3.8	4.6	5.1	7.8	27.6	12.7	6.7	4.8	9.6
Improved seeds	61.6	57.9	72.6	70.2	46.7	53.1	76.3	64.9	60.5	47.7	67.8
Purchased feed/fodder	10.5	1.4	4.5	10.1	0.4	9.3	41.3	20.6	7.3	1.6	14.5
Animal vaccines	54.5	52.5	35.2	56.3	50.2	48.4	81.4	58.8	53.5	51.0	56.5
Animal medicines	57.3	93.6	33.9	54.7	56.3	55.8	75.1	68.1	53.9	55.3	58.2
Traditional pesticides	3.6	40.1	0	1.7	0	34.8	0	26.1	0.7	0.1	9.9
Traditional medicines	6.8	40.1	0	1.7	0.1	34.8	0	26.1	0.7	0.1	9.9

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A19 –Change in Proportion of Households Using Agricultural Inputs Since 1990, mean rank[A,B]

Input	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern Highlands	Low	High	Low	High
Fertilizers	0.72	0.74	0.79	0.48	1.90	1.09	0.25	0.67	0.74	1.60	0.56
Pesticides	0.44	0.14	0.74	0.53	0.54	0.20	0.25	0.14	0.56	0.55	0.41
Herbicides	0.65	2.0	1.00	0.32	0.76	1.23	0.80	0.41	0.75	0.76	0.63
Improved seeds	1.00	0.11	1.00	1.11	0.98	0.36	1.57	0.70	1.10	0.96	1.03
Purchased feed/fodder	1.29	0.82	-0.50	1.12	0.38	1.73	1.8	1.89	1.01	-0.01	1.45
Animal vaccines	0.42	0.05	0.18	0.60	0.13	0.28	1.0	0.63	0.36	0.19	0.54
Animal medicines	0.74	0	0.53	0.89	0.82	-0.04	1.25	0.45	0.83	0.86	0.69
Traditional pesticides	-0.29	-1.99	N/A	0	-0.68	0.66	0	-0.41	-0.24	-0.68	-0.160
Traditional medicines	-0.20	0	N/A	-1	0	0.10	N/A	0.08	-0.75	0	-0.22

A. Means and errors are corrected for sampling stratification and sampling weights.
B. Values represent the average of rank data where 0=no significant change, +1=minor increase, +2=major increase, -1=minor decrease, -2=major decrease.

Table A20--Average Fallow Period, Late 1980s and Late 1990s, years [A]

Fallow Period	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Late 1980s	2.19	3.3	1.74	2.82	1.87	0.8	1.41	2.77	1.96	2.97	1.79
Late 1990s	0.72	1.12	0.88	1.05	0.39	0.28	0.61	1.03	0.59	1.35	0.39

A Means and errors are corrected for sampling stratification and sampling weights.

Table A21 – Average Number of Households per LC1 and Growth Rate, 1990 to 1999

Households and Growth Rate	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	Southwest highlands	Eastern highlands	Low	High	Low	High
Households in LC1, 1990	108	95	72	99	152	67	60	84	118	81	122
Households in LC1, 1999	160	148	129	128	236	92	93	122	175	124	178
Average Annual Growth (%)	4.91	5.54	7.29	3.21	5.5	3.96	5.48	4.67	4.93	5.32	4.72

Table A22 – Number of Programs and Organizations per LC1 by Type

Type of Institution	AVERAGE	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	Southwest highlands	Eastern highlands	Low	High	Low	High
Program											
Government	0.64	0.74	0.36	0.39	1.10	1.17	0.30	0.58	0.66	0.60	0.66
Organization											
NGO	0.85	0.79	1.11	0.40	1.33	0.70	0.55	0.42	1.03	0.53	1.01
CBO	0.62	0.07	0.85	0.33	0.52	2.13	0	0.25	0.78	0.48	0.70
Foreign	0.08	0.07	003	0.07	0.04	0.09	0	0.07	0.08	0.13	0.05
Religious	0.06	0.23	0	0.03	0.07	0	0	0.16	0.02	0.11	0.04
Private	0.04	0.07	0	0.03	0.07	0	0	0.05	0.04	0.02	0.05

Table A23: Number of Programs and Organizations per LC1 by Main Focus[A] (n=85)

Main Focus of Program / Organization	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimoda l high	Southwest highlands	Eastern highlands	Low	High	Low	High
Ag. and vet. extension	0.34	0.37	0.28	0.28	0.46	0.14	0	0.17	0.41	0.29	0.36
Environment	0.21	0	0.34	0	0.45	0	0.5	0.04	0.29	0.03	0.31
Water	0.41	0.37	0.08	0.54	0.53	0.14	0.5	0.39	0.42	0.37	0.43
Credit	0.11	0.08	0.07	0	0.19	0.1	0	0.03	0.14	0.09	0.11
Education	0.31	0.42	0.54	0.28	0.24	0.33	0	0.39	0.28	0.35	0.29
Health	0.17	0.08	0.19	0.23	0.18	0.19	0	0.17	0.17	0.11	0.21
Income gen.	0.22	0	0.66	0.37	0.05	0.48	0	0.15	0.25	0.29	0.19
Poverty eradication	0.29	0.31	0.11	0.15	0.42	0.29	0	0.06	0.39	0.14	0.37
Social development	0.33	0.47	0.16	0.37	0.23	0.52	0.09	0.43	0.29	0.5	0.24
Women's empowerment/ emancipation	0.11	0.17	0.08	0	0.18	0	0.5	0.03	0.15	0.06	0.14

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A24 – Percentage of Villages Using Infrastructure and Services in 1999[A]

INFRASTRUCTURE OR SERVICE	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Tarmac road	98	100	100	95	100	96	100	93	100	94	100
All weather murram road	90	100	79	90	86	100	50	88	90	94	87
Seasonal road	83	85	86	93	66	96	95	96	78	98	80
Bus service	68	93	68	79	34	100	41	83	62	84	60
Minibus service	100	100	100	100	100	100	95	100	100	100	100
Pickup truck service	94	88	100	95	91	100	100	88	97	90	97
Motorcycle service	80	44	93	75	98	91	25	56	90	68	87
Trading center	100	100	100	100	100	100	100	100	100	100	100
Rural market	99	100	93	100	100	100	100	100	99	98	100
Input supply dealer	97	100	100	96	96	100	100	96	98	98	97
Grain mill	99	100	86	100	100	100	100	98	99	97	100
Coffee processing plant	53	15	68	38	91	35	25	30	63	28	26
Other agricultural processing plant	16	19	7	29	7	9	5	24	12	22	12
Primary school public	99	100	100	97	100	100	100	97	100	100	99
Primary school private	31	15	50	20	47	26	25	27	33	29	32
Secondary school public	91	88	100	95	82	100	95	86	93	90	91
Secondary school private	80	76	93	78	88	70	55	79	81	76	82
District Farm Institute	13	0	0	7	32	0	0	0	18	4	17
Community center	31	27	18	37	37	13	25	29	31	33	29
Health clinic	92	100	93	95	90	83	86	90	93	91	93
Dispensary	86	100	93	96	73	78	70	91	84	93	82
Health Center	70	94	73	64	58	91	50	83	65	77	66
Primary irrigation water source	16	13	0	13	24	9	30	4	20	6	20
Major fuelwood source	100	100	100	100	100	100	100	100	100	100	100

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A25–Percentage Change in Villages Using Infrastructure and Services between 1990 and 1999[A]

INFRASTRUCTURE OR SERVICE	AVG.	AGRICULTURAL POTENTIAL						MARKET ACCESS		POPULATION DENSITY	
		Unimodal	Bimodal low	Bimodal medium	Bimodal high	SW highlands	Eastern highlands	Low	High	Low	High
Tarmac road	5	0	7	8	5	0	0	1	6	1	6
All weather murram road	0	0	0	-4	2	0	0	2	-2	0	-1
Seasonal road	0	0	1	0	0	0	0	0	0	9	0
Bus service	1	24	-7	4	-13	4	0	20	-7	14	-6
Minibus service	31	66	21	30	13	48	29	48	24	44	25
Pickup truck service	10	0	14	15	11	9	0	11	11	10	11
Motorcycle service	67	19	78	54	80	5	25	41	78	38	83
Trading center	8	12	7	7	11	0	0	11	6	7	8
Rural market	1	0	0	4	0	0	0	0	2	0	2
Input supply dealer	8	29	10	0	3	7	5	16	5	14	5
Grain mill	6	12	1	4	8	0	5	6	5	7	15
Coffee processing plant	10	0	18	3	24	5	0	11	10	-1	-24
Other agricultural processing plant	4	6	-68	4	5	0	0	6	3	6	2
Primary school public	0	0	0	0	2	0	0	0	1	2	0
Primary school private	1	-4	3	8	-5	13	25	5	2	8	0
Secondary school public	4	0	0	4	7	0	4	0	5	1	4
Secondary school private	45	61	43	43	41	53	30	45	46	36	49
District Farm Institute	3	0	0	6	5	0	0	0	4	2	2
Community center	2	-13	-7	11	2	0	-5	2	1	5	-1
Health clinic	23	53	7	24	16	18	0	34	18	31	16
Dispensary	7	6	25	-1	-1	13	0	9	4	17	1
Health Center	9	0	12	4	22	0	5	0	14	2	13
Primary irrigation water source	4	0	0	0	10	0	0	-1	4	0	4
Major fuelwood source	0	0	0	0	0	0	0	0	0	0	0

A. Means and errors are corrected for sampling stratification and sampling weights.

Table A26 – Average Distance to Various Infrastructure and Services (if used) in 990 and 1999, miles[A]

INFRASTRUCTURE OR SERVICE	AVERAGE 1990	AVERAGE 1999
Tarmac road	17.8	16.6
All weather murram road	2.1	1.9
Seasonal road	0.3	0.3
Bus service	5.5	5.8
Minibus service	3.7	3.4
Pickup truck service	4.4	4.1
Motorcycle service	5.6	1.9
Trading center	2.0	1.7
Rural market	3.7	3.3
Input supply dealer	9.2	6.4
Grain mill	6.4	4.3
Coffee processing plant	9.5	8.7
Other agricultural processing plant	5.3	4
Primary school public	1.3	1.2
Primary school private	2.0	3.6
Secondary school public	6.4	5.4
Secondary school private	8.5	5.5
Agricultural college	102.9	N/A
District Farm Institute	13.6	26.3
Community center	3.8	3.7
Health clinic	3.3	2.5
Dispensary	4.5	4.3
Health Center	10	7.7
Primary irrigation water source	0.4	0.4
Major fuelwood source	0.5	0.5

A. Means and errors are corrected for sampling stratification and sampling weights.

LIST OF EPTD DISCUSSION PAPERS

01 *Sustainable Agricultural Development Strategies in Fragile Lands*, by Sara J. Scherr and Peter B.R. Hazell, June 1994.

02 *Confronting the Environmental Consequences of the Green Revolution in Asia*, by Prabhu L. Pingali and Mark W. Rosegrant, August 1994.

03 *Infrastructure and Technology Constraints to Agricultural Development in the Humid and Subhumid Tropics of Africa*, by Dunstan S.C. Spencer, August 1994.

04 *Water Markets in Pakistan: Participation and Productivity*, by Ruth Meinzen-Dick and Martha Sullins, September 1994.

05 *The Impact of Technical Change in Agriculture on Human Fertility: District-level Evidence From India*, by Stephen A. Vosti, Julie Witcover, and Michael Lipton, October 1994.

06 *Reforming Water Allocation Policy Through Markets in Tradable Water Rights: Lessons from Chile, Mexico, and California*, by Mark W. Rosegrant and Renato Gazri S, October 1994.

07 *Total Factor Productivity and Sources of Long-Term Growth in Indian Agriculture*, by Mark W. Rosegrant and Robert E. Evenson, April 1995.

08 *Farm-Nonfarm Growth Linkages in Zambia*, by Peter B.R. Hazell and Behjat Hoijati, April 1995.

09 *Livestock and Deforestation in Central America in the 1980s and 1990s: A Policy Perspective*, by David Kaimowitz (Interamerican Institute for Cooperation on Agriculture), June 1995.

10 *Effects of the Structural Adjustment Program on Agricultural Production and Resource Use in Egypt*, by Peter B.R. Hazell, Nicostrato Perez, Gamal Siam, and Ibrahim Soliman, August 1995.

11 *Local Organizations for Natural Resource Management: Lessons from Theoretical and Empirical Literature*, by Lise Nordvig Rasmussen and Ruth Meinzen-Dick, August 1995.

12 *Quality-Equivalent and Cost-Adjusted Measurement of International Competitiveness in Japanese Rice Markets*, by Shoichi Ito, Mark W. Rosegrant, and Mercedita C. Agcaoili-Sombilla, August 1995.

13 *Role of Inputs, Institutions, and Technical Innovations in Stimulating Growth in Chinese Agriculture*, by Shenggen Fan and Philip G. Pardey, September 1995.

14 *Investments in African Agricultural Research*, by Philip G. Pardey, Johannes Roseboom, and Nienke Beintema, October 1995.

15 *Role of Terms of Trade in Indian Agricultural Growth: A National and State Level Analysis*, by Peter B.R. Hazell, V.N. Misra, and Behjat Hoijati, December 1995.

16 *Policies and Markets for Non-Timber Tree Products*, by Peter A. Dewees and Sara J. Scherr, March 1996.

17 *Determinants of Farmers' Indigenous Soil and Water Conservation Investments in India's Semi-Arid Tropics*, by John Pender and John Kerr, August 1996.

18 *Summary of a Productive Partnership: The Benefits from U.S. Participation in the CGIAR*, by Philip G. Pardey, Julian M. Alston, Jason E. Christian, and Shenggen Fan, October 1996.

19 *Crop Genetic Resource Policy: Towards a Research Agenda*, by Brian D. Wright, October 1996.

20 *Sustainable Development of Rainfed Agriculture in India*, by John M. Kerr, November 1996.

21 *Impact of Market and Population Pressure on Production, Incomes and Natural Resources in the Dryland Savannas of West Africa: Bioeconomic Modeling at the Village Level*, by Bruno Barbier, November 1996.

22 *Why Do Projections on China's Future Food Supply and Demand Differ*? by Shenggen Fan and Mercedita Agcaoili-Sombilla, March 1997.

23 *Agroecological Aspects of Evaluating Agricultural R&D*, by Stanley Wood and Philip G. Pardey, March 1997.

*24 **Population Pressure, Land Tenure, and Tree Resource Management in Uganda,* by Frank Place and Keijiro Otsuka, March 1997.

25 *Should India Invest More in Less-favored Areas?* by Shenggen Fan and Peter Hazell, April 1997.

26 *Population Pressure and the Microeconomy of Land Management in Hills and Mountains of Developing Countries,* by Scott R. Templeton and Sara J. Scherr, April 1997.

27 *Population Land Tenure and Natural Resource Management: The Case of Customary Land Area in Malawi,* by Frank Place and Keijiro Otsuka, April 1997.

28 *Water Resources Development in Africa: A Review and Synthesis of Issues, Potentials, and Strategies for the Future,* by Mark W. Rosegrant and Nicostrato D. Perez, September 1997.

29 Financing Agricultural R&D in Rich Countries: What's Happening and Why? by Julian M. Alston, Philip G. Pardey, and Vincent H. Smith, September 1997.

30 *How Fast Have China's Agricultural Production and Productivity Really Been Growing?* by Shenggen Fan, September 1997.

31 *Does Land Tenure Insecurity Discourage Tree Planting? Evolution of Customary Land Tenure and Agroforestry management in Sumatra,* by Keijiro Otsuka, S. Suyanto, and Thomas P. Tomich, December 1997.

32 *Natural Resource Management in the Hillsides of Honduras: Bioeconomic Modeling at the Micro-Watershed Level,* by Bruno Barbier and Gilles Bergeron, January 1998.

33 Government Spending, Growth, and Poverty: An Analysis of Interlinkages in Rural India, by Shenggen Fan, Peter Hazell, and Sukhadeo Thorat, March 1998. Revised December 1998.

34 Coalitions and the Organization of Multiple-Stakeholder Action: A Case Study of Agricultural Research and Extension in Rajasthan, India, by Ruth Alsop, April 1998.

35 *Dynamics in the Creation and Depreciation of Knowledge and the Returns to Research*, by Julian Alston, Barbara Craig, and Philip Pardey, July, 1998.

36 *Educating Agricultural Researchers: A Review of the Role of African Universities*, by Nienke M. Beintema, Philip G. Pardey, and Johannes Roseboom, August 1998.

37 *The Changing Organizational Basis of African Agricultural Research*, by Johannes Roseboom, Philip G. Pardey, and Nienke M. Beintema, November 1998.

38 *Research Returns Redux: A Meta-Analysis of the Returns to Agricultural R&D*, by Julian M. Alston, Michele C. Marra, Philip G. Pardey, and T.J. Wyatt, November 1998.

39 *Technological Change, Technical and Allocative Efficiency in Chinese Agriculture: The Case of Rice Production in Jiangsu*, by Shenggen Fan, January 1999.

40 *The Substance of Interaction: Design and Policy Implications of NGO-Government Projects in India*, by Ruth Alsop with Ved Arya, January 1999.

41 *Strategies for Sustainable Agricultural Development in the East African Highlands*, by John Pender, Frank Place, and Simeon Ehui, April 1999.

42 *Cost Aspects of African Agricultural Research*, by Philip G. Pardey, Johannes Roseboom, Nienke M. Beintema, and Connie Chan-Kang, April 1999.

43 *Are Returns to Public Investment Lower in Less-favored Rural Areas? An Empirical Analysis of India*, by Shenggen Fan and Peter Hazell, May 1999.

44 *Spatial Aspects of the Design and Targeting of Agricultural Development Strategies*, by Stanley Wood, Kate Sebastian, Freddy Nachtergaele, Daniel Nielsen, and Aiguo Dai, May 1999.

45 *Pathways of Development in the Hillsides of Honduras: Causes and Implications for Agricultural Production, Poverty, and Sustainable Resource Use*, by John Pender, Sara J. Scherr, and Guadalupe Durón, May 1999.

46 *Determinants of Land Use Change: Evidence from a Community Study in Honduras*, by Gilles Bergeron and John Pender, July 1999.

47 *Impact on Food Security and Rural Development of Reallocating Water from Agriculture*, by Mark W. Rosegrant and Claudia Ringler, August 1999.

48 *Rural Population Growth, Agricultural Change and Natural Resource Management in Developing Countries: A Review of Hypotheses and Some Evidence from Honduras,* by John Pender, August 1999.

49 *Organizational Development and Natural Resource Management: Evidence from Central Honduras*, by John Pender and Sara J. Scherr, November 1999.

50 *Estimating Crop-Specific Production Technologies in Chinese Agriculture: A Generalized Maximum Entropy Approach,* by Xiaobo Zhang and Shenggen Fan, September 1999.

51 *Dynamic Implications of Patenting for Crop Genetic Resources,* by Bonwoo Koo and Brian D. Wright, October 1999.

52 *Costing the Ex Situ Conservation of Genetic Resources: Maize and Wheat at CIMMYT*, by Philip G. Pardey, Bonwoo Koo, Brian D. Wright, M. Eric van Dusen, Bent Skovmand, and Suketoshi Taba, October 1999.

53 Past and Future Sources of Growth for China, by Shenggen Fan, Xiaobo Zhang, and Sherman Robinson, October 1999.

54 The Timing of Evaluation of Genebank Accessions and the Effects of Biotechnology, by Bonwoo Koo and Brian D. Wright, October 1999.

55 *New Approaches to Crop Yield Insurance in Developing Countries,* by Jerry Skees, Peter Hazell, and Mario Miranda, November 1999.

56 *Impact of Agricultural Research on Poverty Alleviation: Conceptual Framework with Illustrations from the Literature,* by John Kerr and Shashi Kolavalli, December 1999.

57 Could Futures Markets Help Growers Better Manage Coffee Price Risks in Costa Rica? by Peter Hazell, January 2000.

58 *Industrialization, Urbanization, and Land Use in China,* by Xiaobo Zhang, Tim Mount, and Richard Boisvert, January 2000.

59 *Water Rights and Multiple Water Uses: Framework and Application to Kirindi Oya Irrigation System, Sri Lanka,* by Ruth Meinzen-Dick and Margaretha Bakker, March 2000.

60 *Community natural Resource Management: The Case of Woodlots in Northern Ethiopia,* by Berhanu Gebremedhin, John Pender and Girmay Tesfaye, April 2000.

61 *What Affects Organization and Collective Action for Managing Resources? Evidence from Canal Irrigation Systems in India,* by Ruth Meinzen-Dick, K.V. Raju, and Ashok Gulati, June 2000.

62 *The Effects of the U.S. Plant Variety Protection Act on Wheat Genetic Improvement*, by Julian M. Alston and Raymond J. Venner, May 2000.

63 *Integrated Economic-Hydrologic Water Modeling at the Basin Scale: The Maipo River Basin,* by M. W. Rosegrant, C. Ringler, D.C. McKinney, X. Cai, A. Keller, and G. Donoso, May 2000.

64 *Irrigation and Water Resources in Latin America and he Caribbean: Challenges and Strategies,* by Claudia Ringler, Mark W. Rosegrant, and Michael S. Paisner, June 2000.

65 *The Role of Trees for Sustainable Management of Less-favored Lands: The Case of Eucalyptus in Ethiopia,* by Pamela Jagger & John Pender, June 2000.

66 *Growth and Poverty in Rural China: The Role of Public Investments,* by Shenggen Fan, Linxiu Zhang, and Xiaobo Zhang, June 2000.

67 *Small-Scale Farms in the Western Brazilian Amazon: Can They Benefit from Carbon Trade?* by Chantal Carpentier, Steve Vosti, and Julie Witcover, September 2000.

68 *An Evaluation of Dryland Watershed Development Projects in India,* by John Kerr, Ganesh Pangare, Vasudha Lokur Pangare, and P.J. George, October 2000.

69 *Consumption Effects of Genetic Modification: What If Consumers Are Right?* by Konstantinos Giannakas and Murray Fulton, November 2000.

70 *South-North Trade, Intellectual Property Jurisdictions, and Freedom to Operate in Agricultural Research on Staple Crops,* by Eran Binenbaum, Carol

Nottenburg, Philip G. Pardey, Brian D. Wright, and Patricia Zambrano, December 2000.

71 *Public Investment and Regional Inequality in Rural China,* by Xiaobo Zhang and Shenggen Fan, December 2000.

72 *Does Efficient Water Management Matter? Physical and Economic Efficiency of Water Use in the River Basin,* by Ximing Cai, Claudia Ringler, and Mark W. Rosegrant, March 2001.

73 *Monitoring Systems for Managing Natural Resources: Economics, Indicators and Environmental Externalities in a Costa Rican Watershed,* by Peter Hazell, Ujjayant Chakravorty, John Dixon, and Rafael Celis, March 2001.

74 *Does Guanxi Matter to Nonfarm Employment?* by Xiaobo Zhang and Guo Li, June 2001.

75 *The Effect of Environmental Variability on Livestock and Land-Use Management: The Borana Plateau, Southern Ethiopia,* by Nancy McCarthy, Abdul Kamara, and Michael Kirk, July 2001.

76 *Market Imperfections and Land Productivity in the Ethiopian Highlands*, Stein Holden, Bekele Shiferaw, and John Pender, August 2001.

77 *Strategies for Sustainable Agricultural Development in the Ethiopian Highlands*, John Pender, Berhanu Gebremedhin, Samuel Benin, and Simeon Ehui, August 2001.

78 *Managing Droughts in the Low-Rainfall Areas of the Middle East and North Africa: Policy Issues*, Peter Hazell, Peter Oram, Nabil Chaherli, September 2001.

79 *Accessing Other People's Technology: Do Non-Profit Agencies Need It? How To Obtain It*, by Carol Nottenburg, Philip G. Pardey, and Brian D. Wright, September 2001.

80 *The Economics of Intellectual Property Rights Under Imperfect Enforcement: Developing Countries, Biotechnology, and the TRIPS Agreement*, by Konstantinos Giannakas, September 2001.

81 *Land Lease Markets and Agricultural Efficiency: Theory and Evidence from Ethiopia,* by John Pender and Marcel Fafchamps, October 2001.

82 *The Demand for Crop Genetic Resources: International Use of the U.S. National Plant Germplasm System*, by M. Smale, K. Day-Rubenstein, A. Zohrabian, and T. Hodgkin, October 2001.

83 *How Agricultural Research Affects Urban Poverty in Developing Countries: The Case of China*, by Shenggen Fan, Cheng Fang, and Xiaobo Zhang, October 2001.

84 *How Productive Is Infrastructure? New Approach and Evidence From Rural India*, by Xiaobo Zhang and Shenggen Fan, October 2001.

ASSESSMENT OF STRATEGIC LAND USE OPTIONS FOR UGANDA

Phase I Draft Completion Report

APPENDIX C

Potential Economic Benefits of Increased Agricultural Productivity in Uganda

Stanley Wood and Liang You

Environment and Production Technology Division

Submitted to USAID/Uganda

The International Food Policy Research Institute
2033 K Street, N.W. Washington, D.C. 20006

August 2001

Potential Economic Benefits of Increased Agricultural Productivity in Uganda

Stanley Wood and Liang You

Introduction

Pender et al (Appendix B) identify a range of potential development pathways for rural Ugandan households and communities. Their research involves extensive survey and analysis designed to identify successful livelihood strategies and the conditions that enable them. The general typology of enabling conditions is expressed by the interplay of three variables: agricultural potential, population density, and market integration. Applying this typology in a spatial context allows geographic domains to be delineated within which one or more promising development pathways – such as intensification of coffee or cereal production – appear to be feasible. However, we must look beyond feasibility to the actual incentives that each livelihood strategy offers rural households. Key amongst the factors influencing the relative attractiveness of livelihood options is profitability, both in the short term and over longer periods during which increasing numbers of households adopt the same strategy. As adoption levels increase, aggregate supply conditions will change and bring the potential for lower market prices. The consequence of changing prices depends on the net production or consumption status of households.

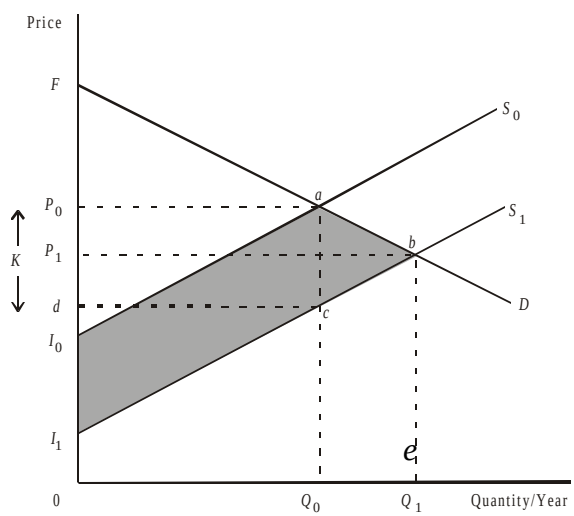
In this preliminary assessment of the likely economic benefits of alternative livelihood strategies we make several simplifying assumptions. We assume that each strategy can be represented by one or more marketable commodities, and that the potential payoff to increased productivity of those commodities serves as an adequate measure of a strategy's attractiveness. Thus, we have collected sub-national (district level) production and market information for the major food and cash crops of Uganda, and made preliminary baseline assessments of the economic gains from enhancing the productivity of crop production in different locations. Potential benefits are assessed for producers as well as for consumers.

We begin with a brief introduction to the methodological basis for estimating the economic benefits of improved productivity, then describe the model scenarios developed for the Phase I "Baseline Assessments", and the results obtained. In the strategic land-use framework described in the main report we term these the "private" benefits, since they reflect only on the benefits accruing to (and costs incurred by) land users themselves. The broader "external" or "social" costs that the selected land use option might incur – such as increased sediment load in streams, loss of habitat and natural biodiversity, and degradation of forest through depletion of fuelwood supplies - must be considered, but are treated separately.

1 Representing productivity change in an economic framework

An economic approach to evaluating productivity change begins with the basic, commodity market model of research benefits depicted in Figure 1: S_0 represents the supply function before a research-induced technical change, and D_0 represents the demand function. The initial price and quantity are P_0 and Q_0. Suppose research generates yield increasing or input saving technologies. These effects can be expressed as a per unit reduction in production costs, K, that are modeled as a parallel shift down in the supply function to S_1. This research-induced supply shift leads to an increase in production and consumption to Q_1 (ÄQ = Q_1 - Q_0), and the market price falls to P_1 (by ÄP = P_0 - P_1). Consumers are better off because R&D enables them to consume more of the commodity at a lower price.

Figure 1: *The Basic Supply-and-Demand Model of Research Benefits*

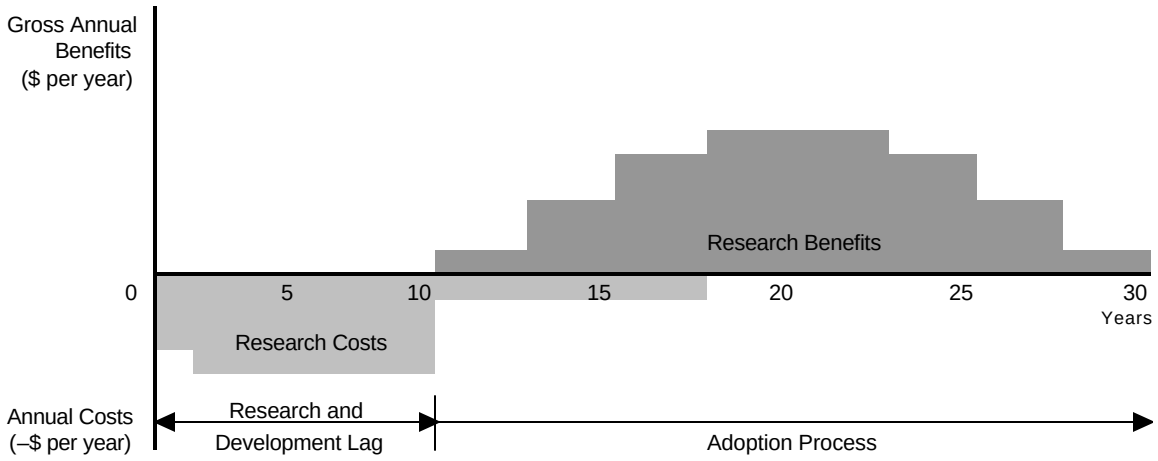


Although they receive a lower price per unit, producers who adopt the new technology are better off, too, because their unit costs have fallen by an amount, K per unit, that is more than the fall in price. The consumer surplus measure of the consumer benefit is equal to area P_0abP_1, i.e. rectangle P_0aeP_1 $(=Q_0 \times \Delta P)$ plus triangle abe. The producer surplus measure of the producer gain is equal to area P_1bcd in Figure 1, i.e. rectangle P_1ecd $(=Q_0 \times [K - \Delta P])$ plus triangle bce. Total benefits are obtained as the sum of producer and consumer benefits. As an approximation, the cost-saving per unit multiplied by the initial quantity, KHQ_0, is often used. Thus the size of the market, as indexed by the initial quantity Q_0, as well as the size of the improved productivity savings in the per unit cost of production, K, are critical factors in estimating the economic benefits from productivity change. Better estimates of K mean better estimates of the benefits from technical change, and a better basis on which to allocate scarce investment resources (into research and extension for example).

Figure 1 is the basic static model for research evaluation. However, evaluations of the economic effects of technical change involve procedures to account for the timing of streams of benefits and costs, since there may be lengthy lag times between the initial investment in technology research, the eventual adoption of research results, and the flow

of research benefits. Figure 2 represents schematically the timing of flows of benefits and costs from a successful investment in developing a new technology.[1] The vertical axis represents the *flow of benefits and costs* in a particular year and the horizontal axis represents years after the commencement of the R&D investment.

Figure 2: *Time Profiles of Research Costs and Benfits*



Initially, R&D projects involve expenditure without benefits so that, during the *research lag* period (say 3-10 years),only R&D costs (negative benefits) are considered. After the initial research lag there may be a further delay, a *development lag* of several years, involving field trials for testing, certification and approval of the new technology or new variety. Even when a commercial product is available, there are further lags before the maximum adoption of the new technology is achieved. The *adoption lag* may involve several years. Eventually, as shown in Figure 2, the annual flow of net benefits from the adoption of the new technology becomes positive (at least, for a profitable investment this is true). In most cases the flow of benefits will eventually decline as the new technology is progressively abandoned when it becomes obsolete (e.g., as newer and better technologies evolve) or depreciates (e.g., as pests evolve), or becomes uneconomic for some other reason. A complete evaluation of a particular research investment must therefore take account of the dynamic relationships between investments in research that lead (after some lags) to a stream of future benefits as shown in Figure 2.

2. The DREAM Approach

In their text on the principles and practices of research evaluation, Alston, Norton and Pardey (1995) presented a model – ***DREAM*** - for operationalizing the concepts outlined in the preceding section. The **DREAM** approach is based upon the economic surplus method, and was developed assuming the following conditions:

[1] Many new technologies are not successful in the sense that they are never developed for commercial use or adopted in the field. The figure refers to a new technology that is successful, and adopted.

- multiple regions
- producing a homogeneous product
- with linear supply and demand in each region
- with exogenous growth of supply and demand
- with a parallel (technology-induced) supply shift in one or more regions
- with consequent supply shifts in other regions (through the effects of trade and of technology transfer)
- with a range of market-distorting policies
- with a research lag followed by an adoption curve up to a maximum
- with an eventual decline in adoption

The model, is the conceptual basis for the *DREAM* computer program that has been developed by IFPRI and used for the Uganda productivity analysis. Figures 3 and 4 show *DREAM* data entry screens for scenario definition and for defining the adoption curve of new technology for a single region.

Figure 3: *The DREAM Scenario Definition Screen*

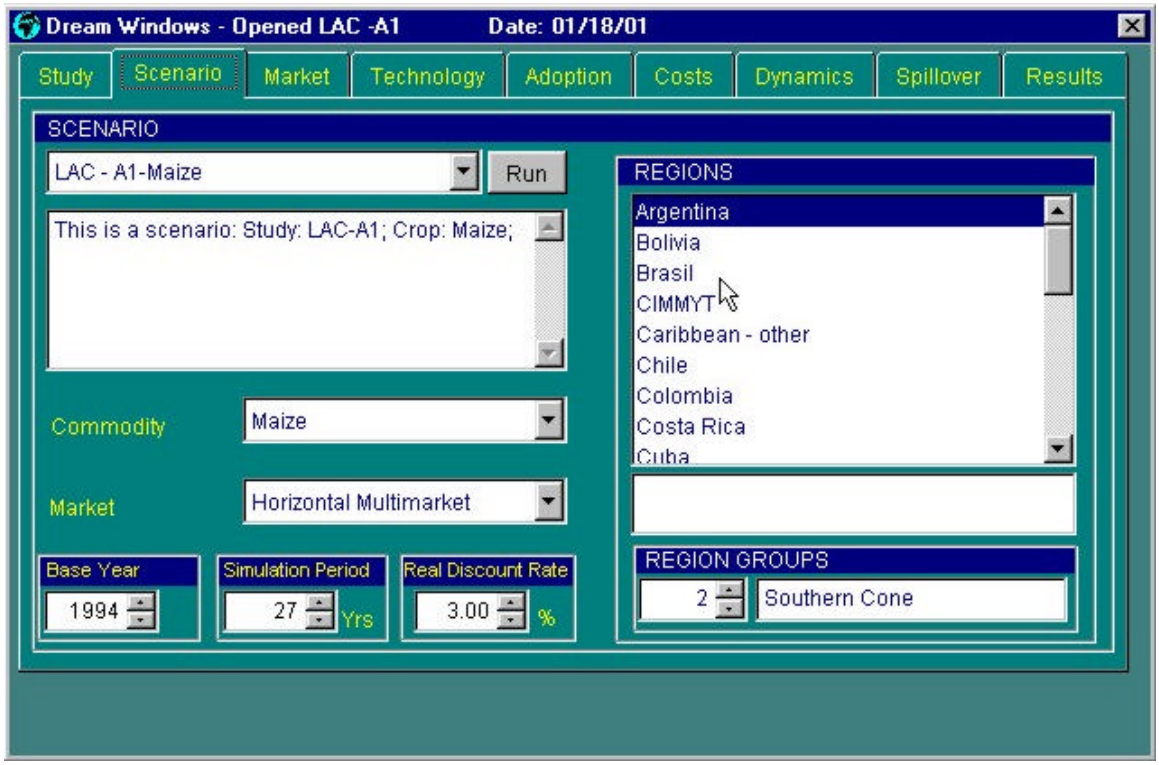
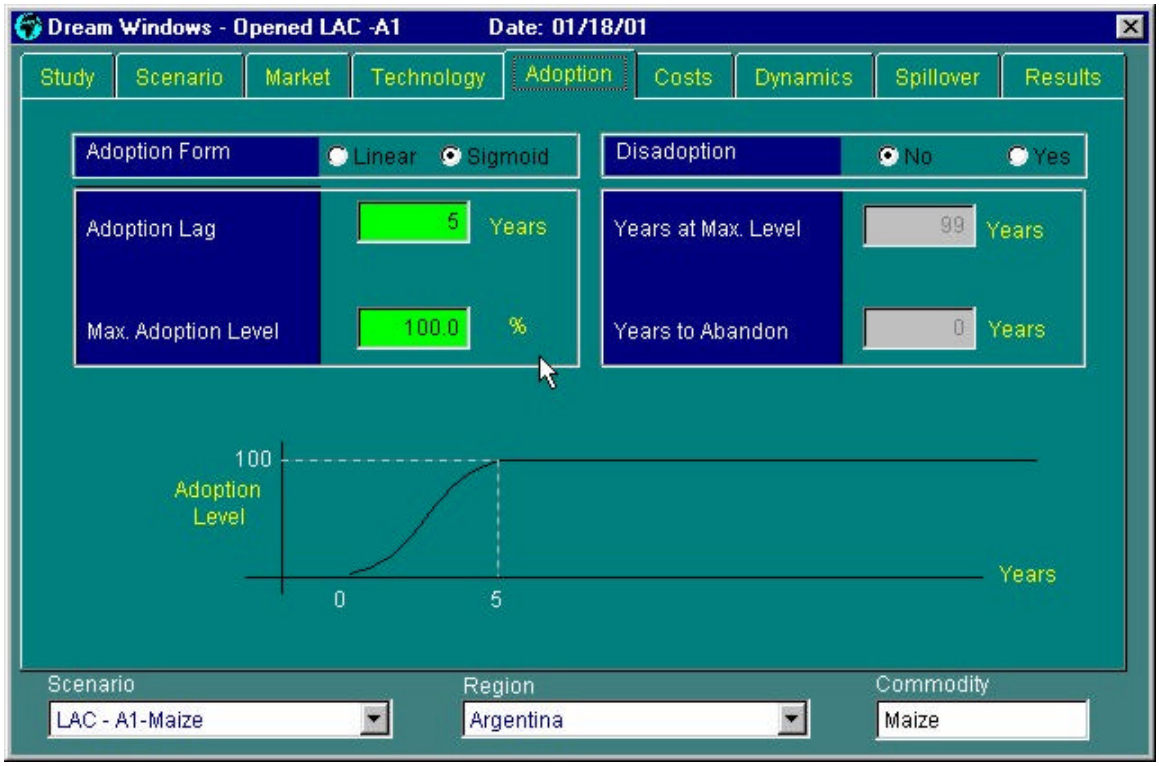


Figure 4: *The DREAM Adoption Screen*



DREAM provides estimates of changes in production, consumption, trade, food prices, and economic surplus for producers and consumers, as a consequence of changes in productivity (or price policies).

3. Phase I Baseline Assessments For Uganda

In Phase I we used *DREAM* to estimate the economic benefits that would be derived from productivity increases in 14 crops and 39 districts in Uganda.[2] The DREAM analysis takes the form of a simulation through time as the productivity enhancing measures are disseminated and adopted and their impacts felt over a larger area. The base period for the simulation was 1997, but the base period market values were the annual average values of production, consumption and prices from 1996 to 1998, so as to minimize the effects of short-term variability. Demand growth over the simulation period was estimated on the basis of projected population and income growth rates. The productivity change was set as one percent for all commodities so as to obtain comparable baseline benefit estimates. To enable the modeling of the Ugandan economy in the presence of international trade, two additional DREAM regions were defined: the rest of ASARECA, and the Rest of the World. Both regions were represented by their respective total production and consumption and estimated average border prices.

[2] The commodities included in the Phase I assessment were: coffee (arabica and robusta), cassava, millet, sweet potato, bean, maize, Irish potato, sorghum, groundnuts, cotton, cocoa, and cashew nuts. Notable omissions are: plantain, banana, beef, milk, and high-value vegetables. Data problems made it impossible to complete these commodities in the time frame of the phase I activities.

Table 1: *General Specification of Baseline DREAM Simulations for Uganda (Phase I)*

Model Parameters	**Value**	**Remarks**
Scenario Constants		
Base year	1997	1996-1998 average
Simulation period	24 years	1997 to 2020 (24 years)
Real discount rate	3%	Used to calculate Net Present Values
Market		
Initial price		Border prices (US$/ton)
Price transmission elasticity	0.8	Reflects transaction costs that lead to imperfect transmission of price changes
Supply		
Initial quantity		1996-98 average district production
Elasticity	1.0	
Exogenous growth		Equal to projected demand growth
Tax/Subsidy	0.	
Demand		
Initial quantity		1996-98 average national consumption
Elasticity	0.5	
Exogenous growth		Based on projected national population and income growth
Tax/Subsidy	0	
R&D parameters		
Probability of success	100%	
Gestation lag	5 years	Productivity change available after 5 years
Adoption profile		Maximum adoption after 5 years
Time to ceiling	5 years	Maximum adoption level
Ceiling level	100%	Sigmoidal. No disadoption
Functional form	Sigmoid	
Spillover(optional)		Technology spillover from innovating region to others
Spillover coefficient	0.5	
Spillover lag	3 years	Time lag for technology to spillover between regions
Supply shift		
Baseline productivity change	1%	

In order to convert benefit streams from the simulation to a single (1997) present value, a real discount rate of 3% was used. It was assumed that new technology would take 5 years to develop (that is be available in 2002) and take another 5 years for Ugandan farmers to adopt. Since district-level consumption data was not available, it was assumed that all districts have the same per capita consumption and so district consumption was assessed as proportional to share of national total. This (and other) assumptions can be refined in Phase II through access to the most recent Uganda household survey data. Table 1 summarises the generic conditions set for all commodity baseline simulation runs, and Table 2 shows the specific market parameters for maize. In the simulation, exogenous production growth is assumed to be equal to demand growth to maintain

constant real price throughout the simulation period (in the absence of the productivity change).

Table 2: ***Sample Market Data for DREAM Baseline Simulations: Maize***

		Quantities (1998)			Elasticity		Demand Growth Variables		
Region Groups	**DREAM Regions**	**Supply**	**Demand**	**Prices**	**Supply**	**Demand**	**Food/(Feed +Food)**	**Income Elasticity**	**Growth in GDP/capita**
		(tons)	(tons)	(US$/ton)					(%/pa)
	Arua	44,703	24,276	144.45	1.0	0.5	0.87	0.57	2.55
	Moyo	4,096	3,053	144.45	1.0	0.5	0.87	0.57	2.55
	Nebbi	19,396	12,404	144.45	1.0	0.5	0.87	0.57	2.55
	Gulu	36,545	13,345	144.45	1.0	0.5	0.87	0.57	2.55
Northern	Kitgum	37,579	14,153	144.45	1.0	0.5	0.87	0.57	2.55
	Apac	39,154	16,656	144.45	1.0	0.5	0.87	0.57	2.55
	Lira	51,540	18,875	144.45	1.0	0.5	0.87	0.57	2.55
	Kotido	5,080	7,324	144.45	1.0	0.5	0.87	0.57	2.55
	Moroto	11,946	7,709	144.45	1.0	0.5	0.87	0.57	2.55
	subtotal	250,040	117,797						
	Soroti	17,855	12,064	144.45	1.0	0.5	0.87	0.57	2.55
	Kumi	21,732	9,994	144.45	1.0	0.5	0.87	0.57	2.55
	Mbale	42,939	27,466	144.45	1.0	0.5	0.87	0.57	2.55
	Kapchorwa	43,905	4,429	144.45	1.0	0.5	0.87	0.57	2.55
Eastern	Kamuli	43,029	18,585	144.45	1.0	0.5	0.87	0.57	2.55
	Pallisa	24,257	13,652	144.45	1.0	0.5	0.87	0.57	2.55
	Tororo	32,858	15,181	144.45	1.0	0.5	0.87	0.57	2.55
	Jinja	15,270	11,595	144.45	1.0	0.5	0.87	0.57	2.55
	Iganga	58,923	26,434	144.45	1.0	0.5	0.87	0.57	2.55
	subtotal	300,768	139,399						
	Kiboga	3,803	5,227	144.45	1.0	0.5	0.87	0.57	2.55
	Luwero	9,799	14,346	144.45	1.0	0.5	0.87	0.57	2.55
	Mukono	6,883	32,217	144.45	1.0	0.5	0.87	0.57	2.55
Central	Mubende	8,869	18,269	144.45	1.0	0.5	0.87	0.57	2.55
	Mpigi	11,987	34,190	144.45	1.0	0.5	0.87	0.57	2.55
	Kampala		27,086	144.45	1.0	0.5	0.87	0.57	2.55
	Masaka	8,286	26,019	144.45	1.0	0.5	0.87	0.57	2.55
	Kalangala	758	569	144.45	1.0	0.5	0.87	0.57	2.55
	Rakai	16,325	13,767	144.45	1.0	0.5	0.87	0.57	2.55
	subtotal	66,710	171,689						
	Masindi	44,897	10,436	144.45	1.0	0.5	0.87	0.57	2.55
	Hoima	26,438	7,815	144.45	1.0	0.5	0.87	0.57	2.55
	Kabale	19,693	17,453	144.45	1.0	0.5	0.87	0.57	2.55
	Bundibugyo	1,559	4,855	144.45	1.0	0.5	0.87	0.57	2.55
	Kabarole	24,084	27,623	144.45	1.0	0.5	0.87	0.57	2.55
Western	Kasese	10,638	12,963	144.45	1.0	0.5	0.87	0.57	2.55
	Bushenyi	16,534	22,439	144.45	1.0	0.5	0.87	0.57	2.55
	Ntungamo		11,611	144.45	1.0	0.5	0.87	0.57	2.55
	Mbarara	26,516	30,085	144.45	1.0	0.5	0.87	0.57	2.55
	Rukungiri	7,757	15,854	144.45	1.0	0.5	0.87	0.57	2.55
	Kisoro	8,438	7,532	144.45	1.0	0.5	0.87	0.57	2.55
	Kibaale	3,581	7,897	144.45	1.0	0.5	0.87	0.57	2.55
	subtotal	190,135	176,563						
	Rest of ASARECA	9,143,922	9,538,395	144.45	1.0	0.5	0.95	0.53	-0.26
ROW	Rest of World	585,686,295	585,494,026	145.52	1.0	0.5	0.29	0.86	1.36
World	Total	595,637,869	595,637,869						

Table 3 shows the benefits to each district of a one percent increase in productivity for each of the 14 crops (although not all districts grow all crops). Since the district production is relatively small compared to total production, and this baseline assessment assumes transactions costs are relatively low, productivity change has relatively little effect on general price levels, so consumers benefit little from the new technology. The variation of total benefits across districts is predominantly attributable to relative shares of production and relative prices (i.e., relative values of production across districts). The largest present value of benefits from a single-shot one percent

productivity increase is for Robusta coffee in Mukono district 12,244,000 US$. This is due to the relatively higher levels of production (over 46,000 tons of Robusta) and price.

Table 3 *Benefits of a One Percent Increase in Productivity - Baseline Simulations* (thousand US$)*

Region	District	Maize	Millet	Sorghum	Rice	Cassava	Irish Potato	Sweet Potato	Beans	Groundnuts	Cotton	Arabica Coffe	Robusta Coffee	Cocoa	Cashew Nuts
	Arua	973	1,267	789	13	2,183	124	877	716	674	52	436	0	0	8
	Moyo	91	99	127	20	253	9	317	18	142	6	0	0	0	0
	Nebbi	449	645	306	0	1,677	131	490	267	383	0	908	0	0	5
	Gulu	860	1,893	966	155	2,015	0	1,408	988	634	17	0	0	0	1
Northern	Kitgum	893	2,021	918	2	2,139	4	1,461	931	1,063	127	0	0	0	1
	Apac	776	1,923	378	0	2,010	24	1,270	1,069	484	544	0	0	0	1
	Lira	1,096	1,785	946	21	1,806	293	761	1,063	384	722	0	0	0	1
	Kotido	106	132	706	0	15	0	17	25	115	1	0	0	0	1
	Moroto	344	93	627	0	24	0	57	70	24	0	0	0	0	0
	Subtotal	5,567	9,857	5,960	211	12,132	585	6,665	5,139	4,104	1,469	1,364	0	0	18
	Soroti	480	1,831	775	7	1,637	323	1,263	538	494	92	0	0	0	19
	Kumi	585	2,062	542	391	2,262	290	1,615	514	744	36	0	0	0	5
	Mbale	965	1,338	171	28	2,744	508	1,872	1,293	435	121	6,285	0	0	1
	Kapchorwa	945	421	3	11	50	249	280	1,545	39	0	2,586	0	0	0
Eastern	Kamuli	948	1,933	40	164	1,706	380	1,157	672	285	141	0	791	12	0
	Pallisa	530	639	169	1,028	1,052	89	1,221	190	201	534	0	0	0	5
	Tororo	743	1,559	446	1,171	851	302	521	961	529	458	0	0	0	3
	Jinja	372	179	0	33	326	254	975	555	18	0	0	1,164	25	0
	Iganga	1,225	2,014	246	171	2,528	221	1,430	437	348	99	0	1,739	25	0
	Subtotal	6,794	11,974	2,413	3,003	13,156	2,516	10,314	6,704	3,083	1,482	8,871	3,693	62	32
	Kiboga	77	25	6	0	582	62	464	86	39	2	0	2,414	0	0
	Luwero	245	91	13	0	353	450	155	316	152	14	0	4,735	7	0
	Mukono	157	181	58	0	1,322	63	997	480	79	0	0	12,247	134	0
	Mubende	175	37	11	0	47	90	252	125	56	0	0	3,513	0	0
Central	Mpigi	250	13	45	0	1,083	99	417	307	53	0	0	6,903	11	0
	Kampala	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Masaka	173	18	136	0	643	345	773	342	133	0	0	9,096	0	0
	Kalangala	13	0	2	0	226	4	144	5	4	0	0	206	0	0
	Rakai	308	29	103	0	339	122	821	501	106	0	0	2,258	0	0
	Subtotal	1,399	393	373	0	4,689	1,233	3,964	2,162	621	17	0	41,374	152	0
	Masindi	1,091	1,234	66	0	1,675	121	1,474	953	221	128	0	581	11	0
	Hoima	625	1,036	183	0	986	118	1,516	550	162	20	0	848	30	0
	Kabale	520	911	481	0	368	4,947	1,104	1,183	19	0	0	0	0	0
	Bundibugyo	41	2	4	75	240	132	48	144	23	0	315	313	205	0
	Kabarole	487	456	221	0	1,389	197	796	772	252	2	243	484	0	0
	Kasese	227	4	4	0	283	226	7	109	9	180	1,281	0	0	0
Western	Bushenyi	375	579	196	0	381	54	488	360	117	48	0	1,353	0	0
	Ntungamo	0	0	0	0	0	0	0	0	0	0	0	727	0	0
	Mbarara	562	989	513	0	968	239	867	830	363	0	0	0	0	0
	Rukungiri	194	251	141	0	110	393	611	188	105	0	0	597	0	0
	Kisoro	208	564	258	0	0	1,265	66	199	4	0	0	0	0	0
	Kibaale	66	29	18	99	204	78	154	127	111	10	0	665	6	0
	Subtotal	4,393	6,034	2,086	173	6,588	7,771	7,100	5,414	1,376	389	1,839	5,569	253	0
Uganda	Total	18,173	28,259	10,851	3,387	36,469	12,105	28,033	19,419	9,195	3,356	12,074	50,636	466	50

Table 4 ranks producer benefits in a more aggregated format, i.e four geographical regions: Northern, Eastern, Central, Western. For Uganda as a whole, the ranking is: Robusta coffee, cassava, millet, sweet potato, bean, maize, Irish potato, Arabic coffee, sorghum, groundnuts, seedcotton, cocoa bean, cashew nuts. However, the rank is different among different sub-regions as shown in the same table. For Northern and Eastern districts, cassava, millet and sweet potato are the top three crops, while Robusta coffee is the top crop for Central districts and Irish potato for Western districts. For Central districts, the benefits for the second ranking crops cassava is only 11% of that for top-ranked crop Robusta coffee while in other districts, the differences between ranked crops are small. Figure 1 draws the crop specific producer benefits by the four geographical regions in one figure. It shows that Northern and Eastern districts will benefit more from productivity advances in cereal (maize, millet, rice, sorghum) production than other districts. Western districts have larger benefits from productivity advances in sweet potato and Irish potato while the central districts will benefits from productivity advances in Robusta coffee.

Table 4: Commodity Benefit Rankings by Region

	Northern			Eastern			Central			Western			Uganda	
Rank	Crop	Relativity	Benefits (1000US$)	Crop	Relativity	Benefits (1000US$)	Crop	Relativity	Benefits (1000US$)	Crop	Relativity	Benefits (1000US$)	Crop	Relativity
1	Cassava	1.00	12,127	Cassava	1.00	13,149	Robusta Coffee	1.00	41,365	Irish potato	1.00	7,770	Robusta Coffee	1.00
2	Millet	0.81	9,854	Millet	0.91	11,970	Cassava	0.11	4,585	Sweet potato	0.91	7,097	Cassava	0.72
3	Sweet potato	0.55	6,654	Sweet potato	0.78	10,311	Sweet potato	0.10	3,962	Cassava	0.85	6,589	Millet	0.56
4	Sorghum	0.49	5,980	Arabic Coffee	0.67	8,871	bean	0.05	2,162	Millet	0.78	6,031	Sweet potato	0.55
5	Maize	0.46	5,587	Maize	0.52	6,794	Maize	0.03	1,399	Robusta Coffee	0.72	5,568	bean	0.38
6	bean	0.42	5,138	bean	0.51	6,702	Irish potato	0.03	1,233	bean	0.70	5,412	Maize	0.36
7	Groundnuts	0.34	4,104	Robusta Coffee	0.28	3,693	Groundnuts	0.02	621	Maize	0.57	4,393	Irish potato	0.24
8	Seedcotton	0.12	1,469	Groundnuts	0.24	3,093	Millet	0.01	393	Sorghum	0.27	2,085	Arabic Coffee	0.24
9	Arabic Coffee	0.11	1,364	Rice	0.23	3,003	Sorghum	0.01	373	Arabic Coffee	0.24	1,839	Sorghum	0.21
10	Irish potato	0.05	585	Irish potato	0.19	2,516	Cocoa bean	0.00	152	Groundnuts	0.18	1,376	Groundnuts	0.18
11	Rice	0.02	211	Sorghum	0.18	2,413	Seedcotton	0.00	17	Seedcotton	0.05	389	Rice	0.07
12	cashew nuts	0.00	18	Seedcotton	0.11	1,482	Rice	0.00	0	Cocoa bean	0.03	253	Seedcotton	0.07
13	Robusta Coffee	0	0	Cocoa bean	0.00	62	Arabic Coffee	0.00	0	Rice	0.02	173	Cocoa bean	0.01
14	Cocoa bean	0	0	cashew nuts	0.00	32	cashew nuts	0.00	0	cashew nuts	0.00	0	cashew nuts	0.00

The spatial distribution of potential economic benefits of land use options is visualized in Figures 8 and 9 of the main report, which show a measure of producer benefits for selected food and cash crops at the district level. The spatial extent of production is assumed to correspond to the agricultural extent derived from the 1km grid land cover database for Uganda. Cassava and maize have the highest benefits in northern and eastern Uganda. The benefits are generally higher for cassava than for maize (note that the two maps have different color codes). Coffee has high benefits in the Lake Victoria crescent, in particular in Central Region, along Lake Albert in the West (Masindi and Hoima districts), and in the southwestern highlands. Benefits for cotton are generally lower than for coffee. The highest benefits can be realized in Apac, Lira and Pallisa districts. One may also see a large cluster of districts of high to medium cotton benefits stretching across the country from Lake Albert along the Lake Kyoga Basin and down into the Eastern Region.

The maps are useful to get a better sense of the spatial patterns of potential benefits than is possible with tabulations. These maps can assist the planning process, e.g. by identifying clusters of areas of high economic potential with respect to a certain land use option that cut across regional boundaries. For example, potential producer benefits for coffee cluster along the Lake Victoria crescent, while maize benefits are much more evenly spread across the country. The coarse spatial resolution (district level) of the production data that is available for the DREAM simulations does not at this point allow us to relate benefits directly to the private land use options (strategy domains) outlined in Section 2 of the report. However, the model offers considerable scope for a more refined analysis in the more detailed planning process, especially if combined with field surveys in the areas of priority.

C. Plans for Phase II

In phase II we plan to develop a more refined DREAM model and add complementary models that can do a better job in:

1. Providing a consistent framework for balancing alternative production scenarios with demand (including trade) and market prices. This is necessary to ensure that land use plans are consistent with private profitability at the farm level and with

sector-wide goals for growth, food security, employment, exports and the like. The framework will also be used to analyze the impact of agricultural sector and trade policy reforms on agricultural production and prices, which can then be linked back in an iterative way to the spatial and community level analyses to explore the implications for development and land use pathways and their environmental and social outcomes.

2. Reflecting the within-district homogeneity in farming conditions - both biophysical and socioeconomic. This will be done by describing a range of "representative producer" conditions within districts, and will result in a richer and more reliable assessment of the likely impacts of productivity change at a higher level of spatial and socioeconomic resolution.
3. Reflecting the impediments to supply and demand growth and marketing (national, regional and international) that lead to short-term instability. This will be done by undertaking short-run and long-run analysis of productivity change.

In phase II we will also be able to use our household and community survey data to evaluate the local level impacts of alternative land uses on production, incomes, poverty, and livelihood strategies.

References

Alston, J., G. Norton, and P.G. Pardey. 1995. *"Science Under Scarcity: The Principles and Practice of Research Evaluation"*. CABI.

Wood, S., L. You and W. Baitx. 2000. *"DREAM Version 3"*. Software and Manual. IFPRI. Washignton. DC. Downloadable from http://www.ifpri.cgiar.org/

ASSESSMENT OF STRATEGIC LAND USE OPTIONS FOR UGANDA

Phase I Draft Completion Report

APPENDIX D

Market Feasibility of Land Use Options in Uganda

Mylène Kherallah and Peter Gruhn

Markets and Structural Studies Division

Submitted to USAID/Uganda

The International Food Policy Research Institute
2033 K Street, N.W. Washington, D.C. 20006

August 2001

Market Feasibility of Land Use Options in Uganda

1. Introduction

The objective of this report is two-pronged: 1) to assess the feasibility of the land use options suggested for Uganda in terms of the availability of marketing services that could facilitate the commercialization of agriculture and access of farmers to input markets; and 2) to identify the types of policy interventions and investments needed to improve the market conditions -- and therefore promote the feasibility -- of the land use options proposed. The importance of market services for the development of the agricultural sector, especially high-value cash crop production, cannot be overstated. Without access to competitive markets and availability of storage, transport, and communication infrastructure, farmers and traders cannot market their products effectively, and land use options that focus on the commercialization of crop production may not be feasible. On the other hand, intensification of food production which requires access to fertilizer and improved seed varieties may not be feasible if input markets are not functioning properly or if farmers do not have access to these markets.

While the general study uses "market access" (measured as the travel time from any location to the nearest three towns or cities, weighted by the population of the towns or cities) as one of the criteria for selecting the development pathways or land-use options, this criterion is not enough to determine the market feasibility of the options. To assess the options in terms of their market feasibility, we need to use empirical evidence on the availability and quality of marketing services in selected regions in Uganda. Characterizing regions in terms of market services adds a richer dimension to the process of identifying appropriate development and investment strategies in the selected regions.

This report focuses on 3 main characteristics of the market: market competition, volume of marketed products, and status of market infrastructure (storage, transport, credit, communication and market information services). More competitive markets

imply lower marketing costs, better prices for farmers and consumers, and more efficient market services. Higher volumes traded reduce market thinness, result in better coordination and more fluid market activities, and reduce unit marketing costs because of economies of scale. Transport, storage, and communication networks are essential for farmer and traders to conduct their marketing activities effectively. Access to credit institutions and market information services are also important, especially for large-scale traders -- such as wholesalers and importers/exporters – that typically require large working capital and timely information about external markets.

2. Research Methodology

The study uses the results of a survey of both input and output traders in Uganda conducted by IFPRI in 2000-2001. The output trader sample includes four types of commodity traders: coffee, cotton, cassava, and maize traders. These commodities were selected because of their importance in the agricultural economy of Uganda and their potential for further growth and expansion. Commodity traders are all wholesalers and are classified into: exporters, Kampala traders, main town traders, primary fixed location traders, and itinerant traders. For this study, itinerant traders were excluded. The sample is composed of 352 traders, of which 105 were itinerant traders. Therefore, the sample used for this study is composed of 247 traders. The districts covered are located in three of the four regions of the country (Central, East and North) and include:

Apac, Lira, Masindi in the North;

Busia, Iganda, Jinja, Kamuli, Mbale, Pallisa,Tororo in the East; and

Kampala, Luwero, Masaka, Mpigi, Mukono in the Centre.

The districts were chosen based mainly on production, marketing locations, and security considerations. The sample of traders was randomly drawn and should be

representative of the trader population in the regions covered. The survey was launched in September 2000 and completed in February/March 2001.

The input traders sample includes traders of fertilizer, seeds, agrochemicals, and agricultural tools and equipment. Based on information from various NGOs, there are about 500-600 seed, fertilizer and agro-chemical traders in Uganda. The total sample size in the IFPRI study includes 148 input traders located across the Northern, Central, Eastern and Western regions. The sample includes nearly all of the seed, fertilizer, and agro-chemical importers and wholesalers in the country, as well as a random sample of stockists (retailers) from the following districts:

Kampala, Mpigi, Luwero, Mukono in the Centre;

Mbarara, Kasese, Masaka, Rakai in the West;

Tororo, Busia, Iganga, Kamuli, Mbale in the East;

Lira, Apac, Masindi, Soroti in the North.

The Central region had the largest sample size (85 traders) because the majority of input traders are located in this region. For input traders outside of Kampala, the selection was based on two steps. In the first step, 17 representative districts were selected. In the second step, up to 10 stockists were randomly selected in each district. The selection of 17 districts was based partly on random sampling, partly on preserving regional balance, and partly on the number of input traders and security considerations in each region.

The output traders questionnaire covers a wide variety of topics. For the purpose of this study, however, we focus on the 3 main characteristics of the market: competition, volume traded, and infrastructure. These are measured as follows:

- market competition: measured by the number of purchasing and sales competitors in the markets where traders operate;

- volumes traded by commodity: measured as the total volume traded by the average trader;
- infrastructure:
    - transport: measured by extent of use of transport services, the distance transported for each product, the type of transport used, whether it is owned or rented, the types of problems traders face with transporters, and the types of restrictions traders face in the movement of their goods;
    - communication and access to information: measured by the extent of use and access to telephones, faxes, computers, email connections, radios, newspaper, and other media to access market information;
    - storage facilities: extent of use of storage facilities, type and capacity of storage facilities used, availability of sufficient storage facilities;
    - credit use: extent of credit use and ability to borrow, sources of credit, and average amounts borrowed.

From the input trader survey, we will primarily focus on the availability of various agricultural inputs by region. Therefore, we only report information on the average volume sold and prices of the main inputs traded in each region.

3. Results from the Output Traders Survey

3.1 Market Competition

In this section, we report the results on market competition. The results in Table 3.1 show that market competition, as measured by the average number of purchasing and selling competitors per trader, is more prevalent in the Central and Eastern regions than in the Northern region. The average number of purchasing competitors is about 90 to 100 for traders in the Central and Eastern regions, while it is only 24 for traders in the Northern region. This indicates that farmers in the North may have a smaller choice of traders to whom they can sell. In certain areas, especially remote ones, traders may be able to exert market power and purchase from farmers at lower prices than the market.

The districts with the highest level of purchase competition are Kampala in the Center, and Jinja and Mbale in the East. Tororo, Busia, and Iganga also have fairly competitive markets. The districts with the smallest number of purchasing traders are Masindi in the North and Mpigi in the Center.

On the sales side, the Eastern region shows the largest number of competing traders per district. Once again, the Northern region exhibits the lowest level of market competition among sales traders. However, the number of sales competitors in the North is more than twice the number of purchasing competitors. Therefore, there seems to be more market concentration in purchasing from farmers than selling to other traders or consumers in this area. In general, the districts with the highest level of competition among sales traders are also the ones with the highest level of competition among purchasing traders; i.e. Jinja, Kampala, Mbale, Iganga and Tororo. Lira in the North has a higher level of sales than purchasing competitors and shows the highest level of competition in the Northern region; Masindi, on the other hand, shows the smallest number of sales competitors.

These results suggest that areas with greater market competition are those close to the border with Kenya and in the capital city of Kampala. These areas tend to have higher population density, better access to major markets and trade routes, and more developed transport infrastructure. Therefore, they would be more suitable for intensification of commercialized agriculture (such as perishable cash-crop production). While the Northern region may be suitable for extensification of cash crop production, one limiting factor is low market competition.

3.2 Volumes Traded

Average volumes purchased and sold by commodity trader are calculated in Tables 3.2.1 and 3.2.2. The figures suggest that volumes traded are much larger for Kampala traders, especially for coffee and cotton. For food crops, volumes of maize purchased and sold are larger than for cassava. Cassava markets seem to be thin in the Northern region. Volumes traded seem to follow the production potential of the region.

For example, cassava markets are larger in the Eastern region where most cassava is grown; coffee trade is more active in the Central (and Western) regions where coffee is grown; and cotton is more commonly traded in the Eastern and Northern regions where it is more widely grown. Maize, on the other hand, is grown and traded through-out the country. In general, the districts with the largest volumes traded are Kampala, Mbale, Iganga, Jinja, and Tororo (the last three are on the trade route with Kenya). This is expected given their level of infrastructure development and population density.

Table 3.2.3 shows the average distances traveled to purchase and sales markets based on the fixed location of the trader. Kampala traders seem to purchase their commodities from longer distances than other regional traders. This is expected since Kampala is not a major production area and traders have to procure their goods from other agricultural regions. Kampala is also a major node through which many export and inter-regionally traded commodities flow. Similarly, Jinja, Tororo, Busia and Mbale are important centers where commodities are assembled and shipped by road and/or rail towards Kenya (Nairobi or Mombassa) for re-export to Europe, Asia, or other African countries. On the other hand, traders in the Northern region and small fixed location or main town traders through-out Uganda seem to purchase mainly from their local markets and sell in markets that are further away. The average distance to a sale market for Northern traders is about 90 kms, more than twice as far for traders in the Central region and 30 percent further then for traders in the Eastern region. Given that the Central and Eastern regions have large consumption markets and that coffee and cotton are usually shipped for export through collection centers such as Kampala, Jinja, Tororo, Busia and Mbale, these results are expected.

3.3 Infrastructure

The availability and quality of market infrastructure are analyzed by examining the output traders' response to questions regarding their use of transport, storage, communication, information, and credit services. The results are as follows.

Transport. Overall, over 80 percent of output traders in Uganda use some means of transport to transport their commodities either from their purchase markets, or to their sale markets, or both. The most common means of transport is hired transport (72 % of all traders). Only about 20 percent of traders own the transport vehicles used to move their commodities. About 17 percent of all traders do not use any means of transport -- either because the commodity is delivered to their place of sale, or customers may pick up from the trader location, or because the trader does not handle the transport of the commodity, rather the commodity is transferred directly from the primary seller to the final buyer or exporter. The break-down by region and districts shown in Table 3.3.1 suggests that the extent of non-use of transport is more common in the Northern region (22 percent of traders there did not use any transport), mainly because in Apac over one-third of the traders do not use any means of transport. In the Eastern region, traders in Busia have limited need for transport as they largely organize the collection of the various commodities and transfer it to trucks supplied by other traders or exporters for shipment to Kenya. Exporters typically transfer the commodity from the wholesalers/assemblers directly to export markets. Consequently, they rarely need to transport the commodity to the location of their business. In the rest of the districts, use of transport is common for the majority of the traders.

Traders were asked whether they faced transport restrictions (see results in Table 3.3.2). About one-quarter of the traders in the Eastern region reported that they did face transport restrictions, probably because of trading with Kenya where police and customs patrols are more frequent. The districts where traders reported most transport restrictions are Mbale and Iganga. For the other regions and districts, the percentage of traders that reported transport restrictions were less than 12%. Most restrictions were imposed by the police.

Almost one-third of the traders reported that they had problems with transport services. As shown in Table 3.3.4, these problems were most common in the Eastern followed by the Northern region. In the North, the most significant problems with transport are related to cheating on transport costs and bad road. For the other regions, the problems were evenly split between delivery problems, poor road infrastructure, theft

(more in the Eastern part) and cheating on transport costs (the latter is lowest in the Central region). It is noteworthy that Jinja had quite a few problems with theft and that Luwero in the Central region and Lira and Masindi in the Northern region had the most problems with poor road infrastructure. This calls for measure to curb theft in the Eastern region and improve road infrastructure in the North to promote agricultural trade.

Communication. In general, traders rely either on other traders or their regular customers to obtain information on prices in their sales markets. However, as shown in Table 3.4, it is quite clear that traders in the Northern region rely more on their customers, while traders in the Eastern and Central region rely more on other traders for price information. This may suggest that trader networks and social capital are more prevalent in the latter two regions. Traders in the Northern region have less access to information than their counterparts in the other regions and have to rely more on their customers to obtain timely market information.

In terms of use of tele-communication equipment, Tables 3.3.5 and 3.3.6 demonstrate that the Central region (especially Kampala) is the most advanced region in terms of use of mobile telephones, faxes, computers, and emails. Most traders have access to a telephone even if they do not use or own one, except in the Northern region where less than a quarter of the traders have access to a telephone. Apac seems to be the worst off in terms of use or access to a telephone. Use of computers and emails is still quite rare except for Kampala. Use of radio to obtain market price information is widespread in all regions, followed by newspapers.

Storage. Another important facility for traders is storage space. As shown in Table 3.3.7, most traders use storage facilities to store their products. However, between 20 and 25 percent of traders report that they do not have enough storage space. Storage space is particularly insufficient for traders in Kamuli and Lira. As expected, the largest storage capacities are found in the Center, especially Kampala, despite the fact that price of storage is expensive because of the high value of real estate in Kampala city. Storage capacities are generally large in the North where the collection of agricultural

commodities is less frequent, and in the main transport node centers in the East (Busia, Tororo, and Mbale).

Credit. Use of credit is limited to about 50 percent of the traders (see Table 3.3.8). However, between 55 percent and 100 percent of traders would be able to borrow additional funds if needed. Traders in Kampala, Kamuli, Mbale, Pallisa, Tororo and Lira seem more likely to use credit (over 60 percent), but in Kampala, only 55 percent of the traders reported that they could borrow additional funds if needed. Perhaps these traders are at the maximum limit of their borrowing capacity. None of the traders in Masindi use any credit and only 64 percent of traders could borrow additional funds if needed. This could imply that credit facilities in Masindi are lacking. Traders usually use credit to finance their purchases. Average interest rates are about 3 percent per month with the highest rates charge by commercial banks and other unspecified lenders (such as money-lenders). These rates do not vary much by region.

The results in Table 3.3.9 indicate that the use of formal and informal sources of credit varies significantly by district. For traders in Kampala, where formal credit institutions are more available, use of banks is more likely than in any other district. In Kampala, for example, more than 50 percent of traders use banks to obtain loans. For the Eastern region, other traders, family and friends, and other credit institutions are more important sources of credit than banks. In the North, other traders are the main source of credit for traders in the Lira district, but for traders in Apac, , other credit institutions (such as NGOs) are more important.

In Table 3.3.10, we asked the traders about the types of credit sources available to them if they wanted to borrow additional funds. This could reflect partially the availability of different sources of credit in each region and district. Additional borrowing seems to be more available from banks in the Eastern and Northern region. This could indicate that the low level of credit use in these regions is constrained by demand (mainly because of high interest rates) rather than supply of credit services. Despite the fact that Kampala has the largest supply of credit facilities and banks, traders there do not feel

they could borrow further from these institutions, most likely because of their credit limit and existing outstanding loans.

4. Results from the Input Traders Survey

Table 4.1 shows the distribution of the sampled input traders. All importers are located in Kampala. Kampala also holds the largest number and percentage of wholesalers and stockists (retailers). The Eastern region has the second largest number of traders (28 out of 148). Both the Northern and Western region have a very low percentage of wholesalers (between 5 and 7 percent of traders in that region).

In Table 4.2, we show the percentage of traders that trade each type of input. The figures indicate that in most cases, all traders market seeds, fertilizer and agro-chemicals. About 50 percent of the traders also trade in agricultural equipment. The traders with the largest range of products are those located in the Central and Eastern region, followed by the Western region. In the North, however, especially in Apac, the percentage of traders that market fertilizer and agro-chemicals is lower than in any other district. In terms of quantities traded, the figures in Table 4.3 indicate that Kampala traders trade the largest quantities of seeds and fertilizers. This is expected since all importers are located in Kampala and importers usually purchase and sell on a large-scale. In the Center, Masaka and Rakai traders also handle relatively large quantities of inputs. The Northern and Western regions show the smallest volumes of inputs traded per trader. This distribution indicates that in the Central and Eastern regions, inputs markets are less thin than in the Northern and Western regions. These findings suggest that any land-use options that focus on intensifying use of inputs in the latter two regions would have to involve complementary measures to further develop input markets in these two regions.

5. Mapping the Marketing Characteristics with the Land-Use Strategies

The objective of this section is to determine the market feasibility of the land-use strategies by comparing the potential extensification and intensification land-use strategies with some of the market survey variables described earlier. To do so, we compare GIS maps representing the land-use strategies with GIS maps representing market survey variables related to competition (number of purchase and sales competitors) and infrastructure (extent of use of transport, storage, communication, and credit infrastructure). Comparisons of the land use and marketing maps leads to the following findings:

Land Use Strategies

Map 5.1 summarizes various agriculture based land use strategies. As shown in Map 5.1, the primary areas for agricultural intensification are located in South-Western Uganda, and in a widening band of 50 to 100 km around Lake Victoria from the Tanzanian border to the Kenyan border, respectively (the Lake Victoria band). The primary areas for extensification, by contrast, are located in a band starting from the shore of Lake Albert and heading eastward to encompass the Lake Kyoga basin (the Lake Albert - Kyoga band). For the purposes of this study, we will concentrate on market and infrastructure related factors that could help promote the extensifictaion and intensification of annual and perennial cash crops in these areas.

Competition

Map 5.2 provides an indication of the number of trader competitors when purchasing and selling their various commodities. As shown in Map 5.2, the number of purchase and sale competitors in the Lake Albert - Kyoga band is low. Also, as previously mentioned, there appear to be less competition in purchasing from farmers than from selling to other traders and consumers in this band. Although competition tends to be higher along the Lake Victoria band, competition tends to become less vigorous as one moves away from the main commercial, and population centers of Kampala, Mukono, Jinja, Tororo, Busia, and Masaka. Therefore, a strategy of extensifying or intensifying cash crop production in these two bands may not be feasible if trader entry in

these areas remain limited, particularly in such districts as Masindi, northern Luwero, Apac, and Lira, and to a lesser extent in such central and eastern districts as Mpigi, and less accessible parts of Kamuli, Iganga, and Mbale.

Infrastructure

Transport. As one would expect most traders use some type of transportation in the buying and selling of their products. Trucks are the predominant type of transportation used by traders. Overall, 52 percent of traders use trucks to move their commodities. As shown in Map 5.3, truck transport is used least commonly in Masaka, and Mbale in central Uganda, in Kamuli, Pallisa, and Mbale in eastern Uganda, and away from the primary highway routes in the Lake Albert - Kyogu band. If goods move at all to markets in these more remote areas, traders are forced to use other less efficient forms of transport such as motorbikes, bicycles, wheelbarrows, or by walking. Map 5.4 further illustrates the areas where traders have difficulty transporting goods. Traders in the Lake Albert - Kyogu band chiefly site poor infrastructure as their principal transport related problem, while to the east and in Masaka, traders site delays in delivery caused by such factors as periodic road impassability and seasonal transport bottlenecks. Although restrictions on the transport of goods are low, the relatively high incidence of theft in these areas of eastern Uganda may in part explain the increased number of road inspections in these districts as police undertake efforts to deal with the theft problems. A strategy to promote cash cropping in the extensification and intensification bands, will need to include measures to enhance and improve the quality of the road, rail, and air freight networks. In addition, measures to improve the effectiveness and efficiency of the transport system through Kenya and Tanzania to sea ports, and to improve access to other regional markets would help to make Ugandan goods more competitive and help to get the products to market more quickly.

Communication. As described previously, only 29 percent of traders have a telephone. Although telephone infrastructure exists along the Lake Victoria belt, access to telephones is relatively limited or nonexistent in the intensification areas of Kamuli, Pallisa, and Mbale, and the Lake Albert - Kyogo agriculture extensification band (see Map 5.5). Telephone ownership is mainly limited to in and around the main population,

commercial, and transport centers and nodes, such as Kampala, Busia, Mbale, Tororo, Masaka, and Mukono. Despite the relatively low use of telephones and other communication means, the introduction of mobile phone communication infrastructure has played an important role in expanding telephone usage into new areas and in improving and extending access in already covered areas (see Map 5.5). Given the dominance of face to face communication, the low access and use of telephones, and the limited availability and use of other communication technologies, trader entry into cash crop extensification and intensification areas will be restrained without better access to local, domestic, regional, and export price and market information, and improvements in communication infrastructure.

Storage. Overall, about 90 percent of commodity traders use storage. However, with the exception of traders in Kampala and in a few areas of the Lake Albert - Kyoga band, most traders have very little storage capacity (see Map 5.6). Fortunately, over 81 percent have enough storage capacity for their current trading needs. Of those that could use more storage, over 90 percent have not acquired additional storage space because of the high cost of building new facilities. If extensification and intensification of agricultural production occurs in these regions as hoped, then demand by traders for access to additional storage facilities will quickly increase.

Credit. Only about 50 percent of commodity traders use credit, of which nearly all is used to purchase product from farmers and assemblers. As shown in Map 5.7, credit use tends to be higher in the northern districts of Apac and Lira, around Kampala, and in the eastern districts of Palisa, Kamuli, and Mbale. In these survey areas, the credit is mainly used to purchase coffee and maize (Kampala), and to purchase raw cotton for processing and maize (the other districts), of which most is slated for subsequent export sales to the East through Kenya. Most loans come from other traders, formal credit sources, and friends and family. In particular, about two-thirds of the bank loans, and nearly 50 percent of NGO loans went to cotton traders. If needed, most traders could borrow additional funds from family and friends and from formal sources such as banks and NGOs. Additional loans from banks are most readily available to traders in the Kampala area, and to cotton traders in northern and eastern Uganda. As many of the

NGOs activities are primarily focused on more remote areas such as in northern Uganda, traders tend to have better access to NGO based loans in these places. Analysis of the commodity trader data would suggest that, whereas traders around Kampala and a few other major markets and traders of export products such as cotton and maize have generally better access to credit, use and access to credit for trading activities is generally low. Use of collateral, particularly the traded product, is also low. For traders to expand and deepen their activities, additional measures will be needed to improve trader access to lending institutions throughout Uganda. A review of the performance of existing warehouse receipt systems should also be undertaken, and if successful, assistance may be warranted to facilitate and widen the availability and use of this type of system.

6. Conclusions

The availability of marketing services will play an important role in the development of agricultural potential in the Lake Albert - Kyoga extensification band and the Lake Victoria intensification band. A number of interventions and investments may be warranted to improve market conditions and therefore improve the feasibility of the land use development options proposed for these areas.

Competition between traders is generally low in the Lake Albert - Kyoga band and in remote areas of the Lake Victoria band. These areas are also underdeveloped in terms of agricultural commercialization, transport and communication infrastructure, and access to agricultural inputs. Given the relatively high level of competition in areas where markets and infrastructure are in place and the higher level of competition and commercialization outside of these areas where infrastructure improvements have recently been made, traders are likely to respond positively to marketing opportunities as more remote and underdeveloped areas open up with improvements in infrastructure.

The volumes traded and the storage capacities of traders in Uganda are generally small. Although storage capacity appears to be largely sufficient for current trading needs, a substantial increase in the volume traded could quickly overwhelm the existing

storage facilities currently available to traders. Given the cost of building additional storage space, the lack of storage in the near future could become a serious constraint to the accumulation and profitable trading of product over space and time.

Infrastructure in Uganda needs improvement. For commercial activities to expand in the Lake Albert - Kyoga extensification band and in the Lake Victoria intensification band, substantial improvements in transport and communication infrastructure will be necessary to better link remote areas to markets, particularly for export trade. Timely information on marketing opportunities needs to reach remote areas more effectively, and the cash crops produced in these areas need to be able to more quickly and efficiently reach local, domestic, regional and foreign markets, particularly for highly perishable fruits and vegetables.

Table 3.1 – Average number of purchase and sales competitor per trader

Region and District	Average number of purchase competitors	Average number of sales competitors
Central		
Kampala	149	109
Luwero	78	56
Masaka	47	56
Mpigi	18	57
Mukono	75	44
Av. Central region	98	77
Eastern		
Busia	80	50
Iganga	78	145
Jinja	235	193
Kamuli	50	31
Mbale	100	102
Pallisa	70	63
Tororo	90	130
Av. Eastern region	95	105
Northern		
Apac	20	36
Lira	33	119
Masindi	16	9
Av. Northern region	24	64

Table 3.2.1 – Average volume purchased by product trader (in metric tons)

Region and district	Maize	Cassava	Coffee	Cotton
Central				
Kampala	1673	243	203907	6504
Luwero	50		66	
Masaka	32.5	53.5	529	
Mpigi	180		192	
Mukono	35.5	119	113	
Av. Central region	**1134**	**192**	**47245**	**6504**
Eastern				
Busia	430			
Iganga	200	562	44	
Jinja	156	219	95	
Kamuli	20	84		217
Mbale	412	104	1062	333
Pallisa	60	90		149
Tororo	349	261		240
Av. Eastern region	**210**	**255**	**563**	**208**
Northern				
Apac	131	66		157
Lira	151	82		257.5
Masindi	174.5	70.3		
Av. Northern region	**156**	**72**		**199**

Table 3.2.2 – Total volume sold by the average product trader (in metric tons)

Region and District	Maize	Cassava	Coffee	Cotton
Central				
Kampala	1518.2	237.9	10596.8	6175
Luwero	47.5		65.3	
Masaka	27.5	50.3	473	
Mpigi	120		168	
Mukono	29	116	93	
Av. Central region	**1027**	**187**	**2470**	**6175**
Eastern				
Busia	421			
Iganga	194	543	35	
Jinja	168.5	203	92	
Kamuli	19	82		217
Mbale	387	102	443	333
Pallisa	60	88.5		168
Tororo	324	238		216
Av. Eastern region	**202**	**244**	**229.1**	**212**
Northern				
Apac	127	65		156
Lira	150	79		228
Masindi	174	62		
Av. Northern region	**155**	**69**		**186**

Table 3.2.3 – Average distance to purchase or sales market (in kilometers)

Region and district	Av. Distance to purchase market	Av. Distance to sale market
Central		
Kampala	215.4	50.4
Luwero	19.7	18
Masaka	39.3	63.7
Mpigi	13.2	22
Mukono	40.1	17
Av. Central region	**110**	**38.8**
Eastern		
Busia	373.6	1.2
Iganga	47.8	116.9
Jinja	89.7	104.8
Kamuli	25.1	34.7
Mbale	56.3	58.7
Pallisa	54.7	40.2
Tororo	55.8	28.5
Av. Eastern region	**58.1**	**60.1**
Northern		
Apac	20.6	84.5
Lira	20.6	90.6
Masindi	16.9	114.5
Av. Northern region	**20.0**	**91.7**

Table 3.3.1 - Use of Transport

Region and District	Did not use transport	Used own vehicles	Hired transport	Used both own and hired transport	Other	Total
Central						
Kampala	36.36	6.82	38.64	18.18	0	100
Luwero	0	28.57	57.14	14.29	0	100
Masaka	0	0	80	20	0	100
Mpigi	18.18	27.27	36.36	18.18	0	100
Mukono	0	10	75	15	0	100
Av. Central region	**18.56**	**10.31**	**53.61**	**17.53**	**0**	**100**
Eastern						
Busia	100	0	0	0	0	100
Iganga	0	6.25	87.5	6.25	0	100
Jinja	25	12.5	50	12.5	0	100
Kamuli	9.09	18.18	63.64	9.09	0	100
Mbale	15.79	10.53	63.16	10.53	0	100
Pallisa	12.5	6.25	62.5	6.25	6.25	100
Tororo	0	0	81.82	18.18	0	100
Av. Eastern region	**12.05**	**8.43**	**67.47**	**9.64**	**1.20**	**100**
Western						
Apac	35.48	3.23	54.84	3.23	3.23	100
Lira	12	8	64	8	8	100
Masindi	9.09	9.09	63.64	18.18	0	100
Av. Western region	**22.39**	**5.97**	**59.7**	**7.46**	**4.48**	**100**

Table 3.3.2 - Transport Restrictions

Region and district	Percentage of traders that reported transport restrictions
Central	
Kampala	11.4
Luwero	14.3
Masaka	6.7
Mpigi	9.1
Mukono	5
Av. Central region	**9.3**
Eastern	
Busia	0
Iganga	31.2
Jinja	25
Kamuli	18.2
Mbale	36.8
Pallisa	12.5
Tororo	18.2
Av. Eastern region	**24.1**
Northern	
Apac	9.7
Lira	12
Masindi	9.1
Av. Northern region	**10.4**

Table 3.3.3 - Main problems with transport

Region and district	Percentage of traders reporting transport problems	Percentage of traders reporting delivery problems	Percentage of traders reporting poor road infrastructure	Percentage of traders reporting problems with theft	Percentage of traders reporting problems with cheating on transport costs
Central					
Kampala	27.3	6.8	4.5	9.1	0
Luwero	42.9	0	28.6	14.3	0
Masaka	33.3	6.7	0	6.7	6.7
Mpigi	0	0	0	0	0
Mukono	15	5	10	0	0
Av. Central region	23.7	5.2	6.2	6.2	1
Eastern					
Busia	0	0	0	0	0
Iganga	50	12.5	12.5	12.5	12.5
Jinja	50	12.5	12.5	37.5	12.5
Kamuli	36.4	18.2	0	0	0
Mbale	31.6	10.5	15.8	5.3	15.8
Pallisa	37.5	0	0	18.8	6.2
Tororo	36.4	0	9.1	9.1	9.1
Av. Eastern region	38.6	8.4	8.4	12	9.6
Northern					
Apac	29	12.9	6.5	6.5	16.1
Lira	40	8	28	0	24
Masindi	27.3	9.1	18.2	0	18.2
Av. Northern region	32.8	10.4	16.4	3	19.4

Table 3.3.4 - Main source of information on the price of the day in the main sales market

Region and district	Percentage of traders reporting regular customers	Percentage of traders reporting other traders
Central		
Kampala	11.4	43.2
Luwero	28.6	57.1
Masaka	33.3	60
Mpigi	54.5	36.4
Mukono	35	60
Av. Central region	**25.8**	**49.5**
Eastern		
Busia	0	100
Iganga	18.8	43.8
Jinja	12.5	87.5
Kamuli	27.3	54.5
Mbale	36.8	42.1
Pallisa	31.2	50
Tororo	27.3	45.5
Av. Eastern region	**26.5**	**51.8**
Northern		
Apac	51.6	25.8
Lira	64	20
Masindi	54.5	36.4
Av. Northern region	**56.7**	**25.4**

Table 3.3.5 - Use of telecommunication tools

Region and district	Percentage of traders that use a telephone	% of traders that have a mobile phone	% of traders that use a ground line phone	% of traders that have access to a phone	% of traders that have a fax
Central					
Kampala	97.7	77.3	61.4	87.5	40.9
Luwero	71.4	14.3	14.3	66.7	0
Masaka	93.3	33.3	0	90	6.7
Mpigi	81.8	9.1	0	80	0
Mukono	95	20	5	93.3	0
Av. Central region	92.8	46.4	29.9	85.7	19.6
Eastern					
Busia	100	100	0	0	
Iganga	93.8	12.5	12.5	100	0
Jinja	100	12.5	0	100	0
Kamuli	72.7	0	0	72.7	0
Mbale	78.9	31.6	26.3	63.6	5.6
Pallisa	43.8	12.5	0	35.7	0
Tororo	63.6	18.2	27.3	57.1	0
Av. Eastern region	74.7	18.1	12	68.9	1.2
Northern					
Apac	12.9	0	0	13.8	0
Lira	32	8	4	26.1	8
Masindi	36.4	9.1	0	37.5	0
Av. Northern region	23.9	4.5	1.5	21.7	3

Table 3.3.6 - Use of computers, emails, and access to price information

Region and district	% of traders that have a computer	% of traders that have email	% of traders that have a radio	% of traders that have access to a radio for price information	% of traders that have access to a newspaper for price information
Central					
Kampala	43.2	45.5	95.5	88.6	93.2
Luwero	0	14.3	100	85.7	85.7
Masaka	0	0	100	86.7	80
Mpigi	0	0	100	100	81.8
Mukono	0	0	100	94.7	73.7
Av. Central region	**19.6**	**21.6**	**97.9**	**90.5**	**85.4**
Eastern					
Busia	0	0	100	50	50
Iganga	0	0	93.8	86.7	62.5
Jinja	0	0	100	85.7	87.5
Kamuli	0	0	100	90.9	72.7
Mbale	5.3	5.3	100	94.7	73.7
Pallisa	0	0	100	86.7	73.3
Tororo	9.1	9.1	100	90.9	100
Av. Eastern region	**2.4**	**2.4**	**98.8**	**88.8**	**75.6**
Northern					
Apac	0	0	100	93.5	71
Lira	8	8	100	92	80
Masindi	0	0	100	81.8	100
Av. Northern region	**3**	**3**	**100**	**91**	**79.1**

Table 3.3.7 - Use of Storage facilities

Region and district	% of traders that use storage facilities	% of traders that reported sufficient storage facilities	Average storage capacity per trader in mt	Average storage rental period in months	Average price of storage Ush/mt/month
Central					
Kampala	97.7	81	5741	8.2	2732.1
Luwero	100	100	13	8.2	1064.5
Masaka	93.3	85.7	17.3	8.7	390.8
Mpigi	100	90.9	6.3	9.3	879.6
Mukono	90	83.3	28.2	9.9	285.6
Av. Central region	**95.9**	**84.8**	**2880**	**8.7**	**1584.7**
Eastern					
Busia	100	100	350	12	24.3
Iganga	93.8	92.9	26.2	9.9	245.9
Jinja	100	100	58	9.8	272.9
Kamuli	90.9	60	5	12	1448.7
Mbale	89.5	82.4	78.1	8.5	6124.9
Pallisa	100	81.2	17	10.5	193.3
Tororo	100	72.7	73.2	6.2	471.1
Av. Eastern region	**95.2**	**82.1**	**65.7**	**8.6**	**1562.5**
Northern					
Apac	100	80.6	491.8	6	502.1
Lira	100	64	26	6.2	1116.5
Masindi	90.9	100	278.6	8.8	1784.1
Av. Northern region	**98.5**	**77.3**	**276.9**	**6.3**	**853.9**

Table 3.3.8 - Extent of use of credit and ability to borrow additional funds

Region and district	% of traders that use credit	% of traders who could borrow additional funds if needed
Central		
Kampala	58.5	55
Luwero	42.9	85.7
Masaka	40	57.1
Mpigi	27.3	72.7
Mukono	55	78.9
Av. Central region	**50**	**64.8**
Eastern		
Busia	50	100
Iganga	37.5	75
Jinja	37.5	75
Kamuli	63.6	90.9
Mbale	63.2	78.9
Pallisa	68.8	75
Tororo	45.5	81.8
Av. Eastern region	**54.2**	**79.5**
Northern		
Apac	51.6	100
Lira	66.7	96
Masindi	0	63.6
Av. Northern region	**48.5**	**92.5**

Table 3.3.9 - Source of credit loans

Region and District	Other Traders	Friends and relatives	Banks	Other credit institutions	Processors/ buyers/ customers	Other	Total
Central							
Kampala	0	13.04	56.52	21.74	8.7	0	100
Luwero	66.67	33.33	0	0	0	0	100
Masaka	12.5	37.5	12.5	25	0	12.5	100
Mpigi	33.33	33.33	33.33	0	0	0	100
Mukono	61.54	30.77	7.69	0	0	0	100
Av. Central region	**26.42**	**24.53**	**30.19**	**13.21**	**3.77**	**1.89**	**100**
Eastern							
Busia	0	0	0	0	0	100	100
Iganga	33.33	33.33	16.67	16.67	0	0	100
Jinja	0	33.33	0	66.67	0	0	100
Kamuli	50	37.5	0	12.5	0	0	100
Mbale	28.57	21.43	21.43	7.14	14.29	7.14	100
Pallisa	41.67	8.33	8.33	16.67	25	0	100
Tororo	0	60	0	40	0	0	100
Av. Eastern region	**30.61**	**26.53**	**10.2**	**18.37**	**10.2**	**4.08**	**100**
Northern							
Apac	25	5	20	45	5	0	100
Lira	67.65	2.94	11.76	14.71	2.94	0	100
Av. Northern region	**55.56**	**3.7**	**24.07**	**12.96**	**3.7**	**0**	**100**

Table 3.3.10 - Availability of credit sources for additional borrowing

Region and District	% of traders than can get it from Friends and family	from Money-lenders	from Informal savings & loan assoc.	from NGOs	from Banks	from Processors/ buyers/ customers
Central						
Kampala	9.1	2.3	4.5	13.6	20.5	0
Luwero	71.4	42.9	28.6	42.9	14.3	28.6
Masaka	26.7	13.3	0	6.7	20	6.7
Mpigi	45.5	9.1	9.1	18.2	36.4	0
Mukono	50	25	20	20	25	20
Av. Central region	**28.9**	**12.4**	**9.3**	**16.5**	**22.7**	**7.2**
Eastern						
Busia	0	0	0	0	100	0
Iganga	37.5	6.2	6.2	31.2	12.5	6.2
Jinja	12.5	12.5	25	12.5	12.5	0
Kamuli	27.3	0	0	18.2	45.5	9.1
Mbale	21.1	15.8	15.8	21.1	52.6	10.5
Pallisa	31.2	6.2	18.8	25	31.2	6.2
Tororo	18.2	9.1	18.2	9.1	63.6	0
Av. Eastern region	**25.3**	**8.4**	**13.3**	**20.5**	**38.6**	**6**
Northern						
Apac	38.7	16.1	16.1	61.3	45.2	3.2
Lira	44	16	16	44	56	12
Masindi	36.4	18.2	18.2	27.3	36.4	0
Av. Northern region	**40.3**	**16.4**	**16.4**	**49.3**	**47.8**	**6**

Table 4.1 – Distribution of Input Traders Sample (absolute numbers and % by type of trader (in parenthesis))

Region and District	Importer	Wholesaler	Stockist	Total
Central				
Kampala	10 (22%)	7 (16%)	28 (62%)	100%
Luwero	0	0	8 (100%)	100%
Masaka	0	4 (40%)	6 (60%)	100%
Mpigi	0	0	8 (100%)	100%
Mukono	0	0	10 (100%)	100%
Rakai	0	1 (25%)	3 (75%)	100%
Soroti	0	0	2 (100%)	100%
Tot. Central region	**10 (11%)**	**12 (14%)**	**65 (75%)**	**87 (100%)**
East				
Busia	0	0	4 (100%)	4 (100%)
Iganga	0	1 (12.5%)	7 (87.5%)	8 (100%)
Kamuli	0	0	4 (100%)	4 (100%)
Mbale	0	2 (25%)	6 (75%)	8 (100%)
Tororo	0	0	4 (100%)	4 (100%)
Tot. Eastern region	**0**	**3 (11%)**	**25 (89%)**	**28 (100%)**
North				
Apac		0	4 (100%)	4 (100%)
Lira		1 (20%)	4 (80%)	5 (100%)
Masindi		0	10 (100%)	10 (100%)
Tot. Northern region		**1 (5%)**	**18 (95%)**	**19 (100%)**
West				
Kasese		1 (25%)	3 (75%)	4 (100%)
Mbarara		0	10 (100%)	10 (100%)
Tot. Western region		**1 (7%)**	**13 (93%)**	**14 (100%)**

Table 4.2 – Percent of traders that trade in each input

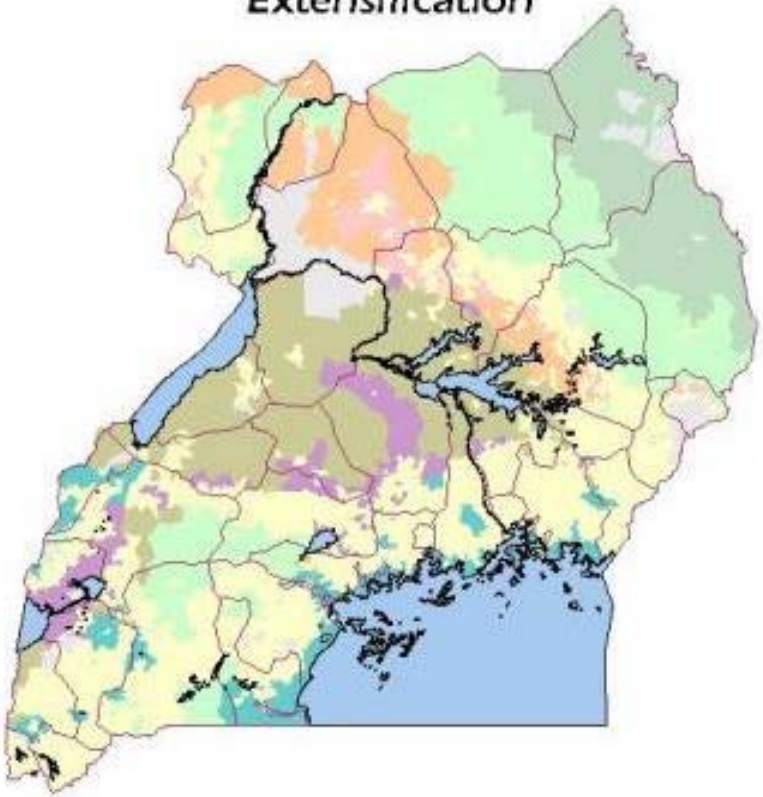
District and region	Seeds	Fertilizer	Agro-chemicals
Central			
Kampala	82.2	84.4	91.1
Luwero	100	100	100
Masaka	80	100	100
Mpigi	100	100	100
Mukono	100	100	100
Rakai	100	100	100
Soroti	100	100	100
Tot. Central region	**88.5**	**92**	**95.4**
East			
Busia	100	75	50
Iganga	100	100	100
Kamuli	100	75	75
Mbale	87.5	87.5	87.5
Tororo	100	50	75
Tot. Eastern region	**96.4**	**82.1**	**82.1**
Northern			
Apac	100	25	25
Lira	100	60	80
Masindi	100	40	90
Tot. Northern region	**100**	**42.1**	**73.7**
Western			
Kasese	100	75	100
Mbarara	100	30	100
Tot. Western region	**100**	**42.9**	**100**

Table 4.3 – Total volume of input traded per average trader (in kilograms)

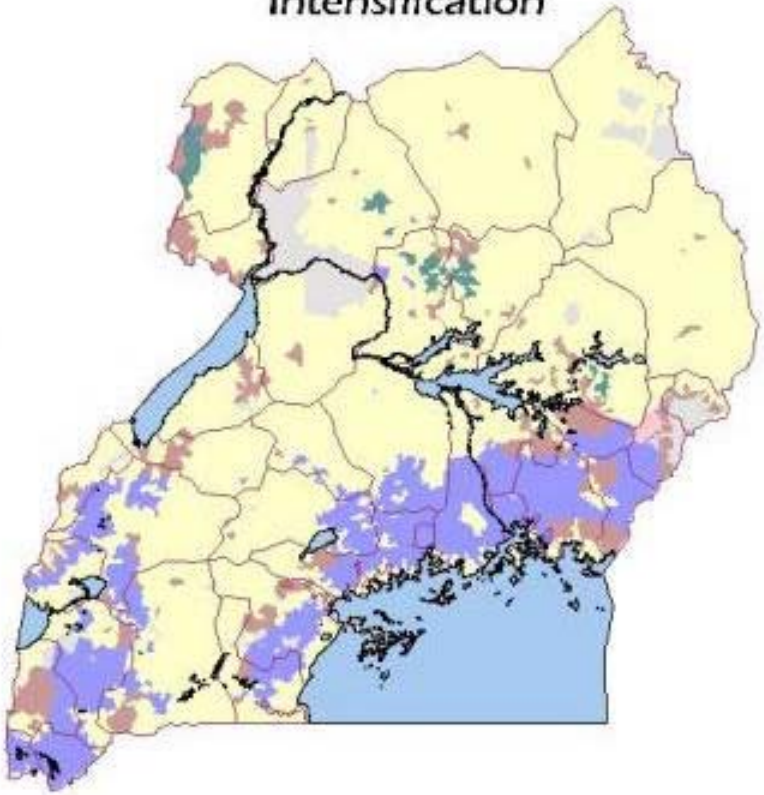
Region and District	Maize seeds	Bean seeds	Fertilizer
Central			
Kampala	58924	51708	238604
Luwero	3780	2466	8488
Masaka	35284	4183	54021
Mpigi	755	307	2325
Mukono	757	478	1875
Rakai	3902	160	14368
Soroti	190		
Tot. Central region	**32225**	**21843**	**122991**
Eastern			
Busia	2018	52	396
Iganga	7252	3427	10102
Kamuli	1210	50	52
Mbale	30419	40000	173873
Tororo	500	1895	
Tot. Eastern region	**14108**	**7205**	**56655**
Northern			
Apac	203	106	250
Lira	105	150	1207
Masindi	4005	1115	289
Tot. Northern region	**1882**	**401**	**677**
Western			
Kasese	1040	30	12571
Mbarara	1291	260	538
Tot. Western region	**1229**	**222**	**6554**

Map 5.1: Sample of Agriculture Based Potential Land Use Strategies

Extensification



Intensification



Potential Extensification Land Use Strategies	Suitable Areas
Expand Subsistence Crops	
Expand Annual Cash Crops	
Expand Perennial Cash Crops	
Expand Livestock Production	

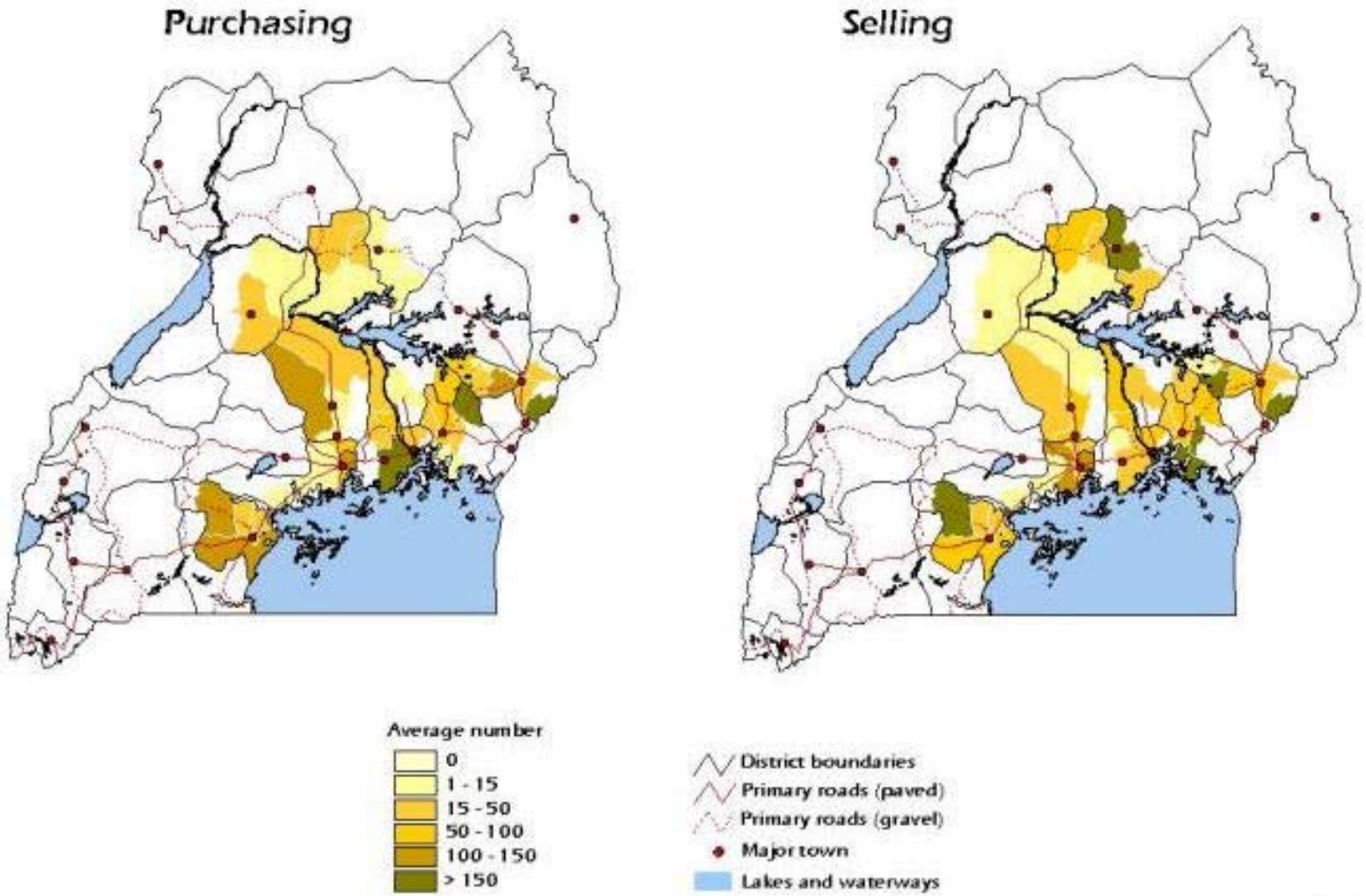
Potential Intensification Land Use Strategies	Suitable Areas
Intensify Subsistence Food Crops	
Intensify Annual Cash Crops	
Intensify Perennial Cash Crops	
Intensify Livestock Production (Dairy)	

District boundaries
Lakes and waterways
Insufficient data
No suitable strategy

Note: *The areas suitable for specific land use strategies were defined based on population density, market access and agricultural potential.*

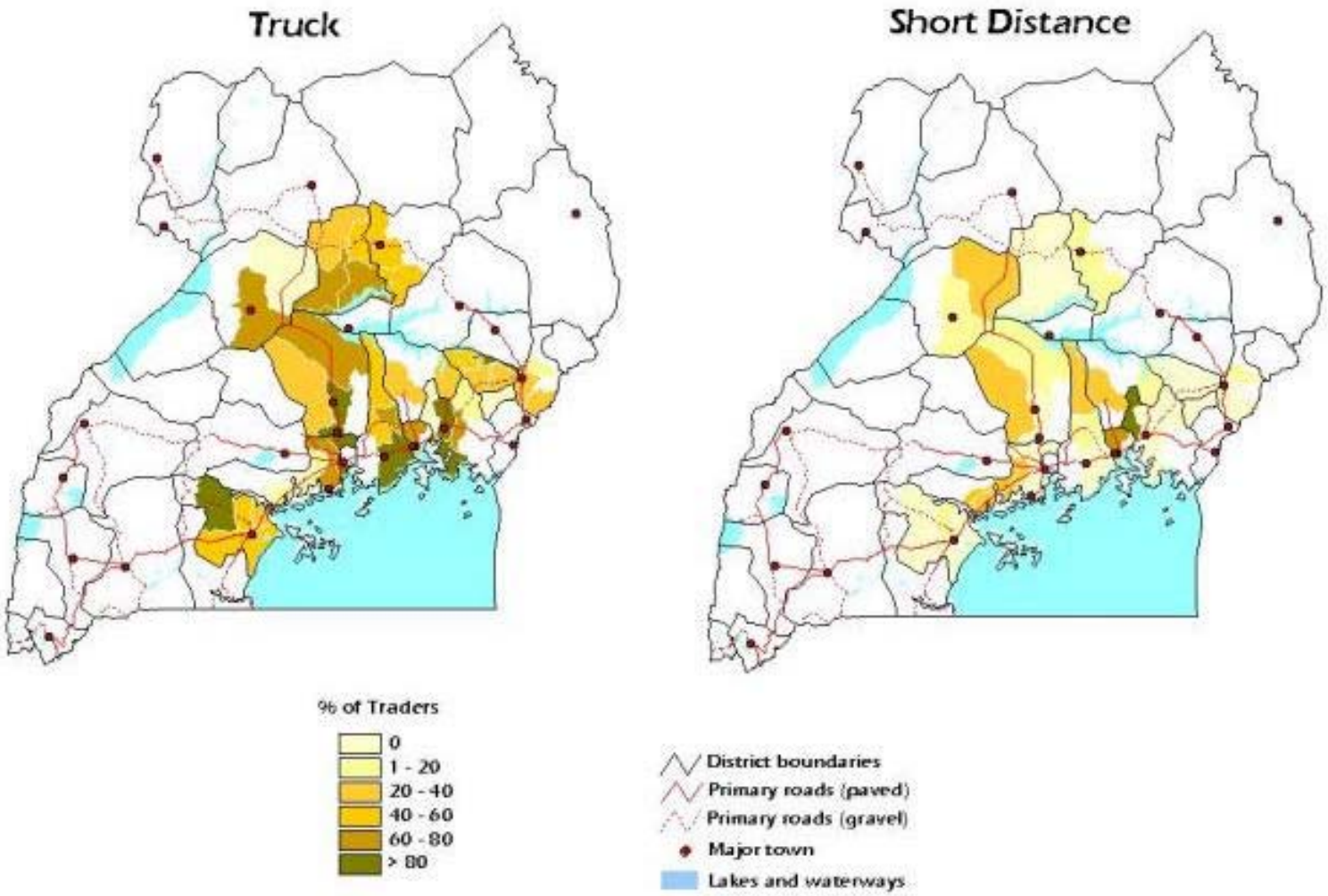
Source: Adapted from Sserunkuuma et al, 2001.

Map 5.2: Average number of competitors



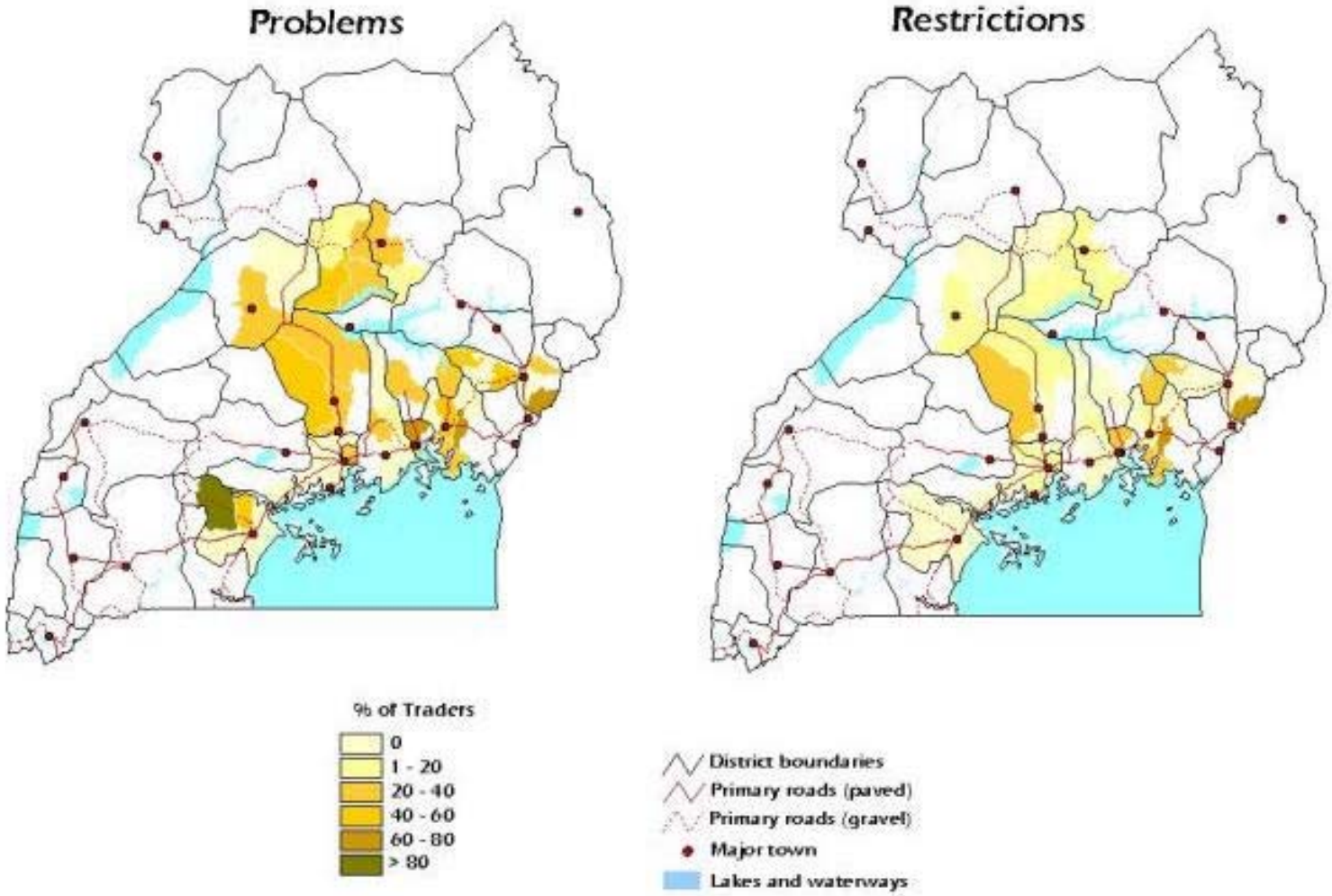
Source: IFPRI Trader survey, 2000

Map 5.3: Percentage of traders using various means of transport



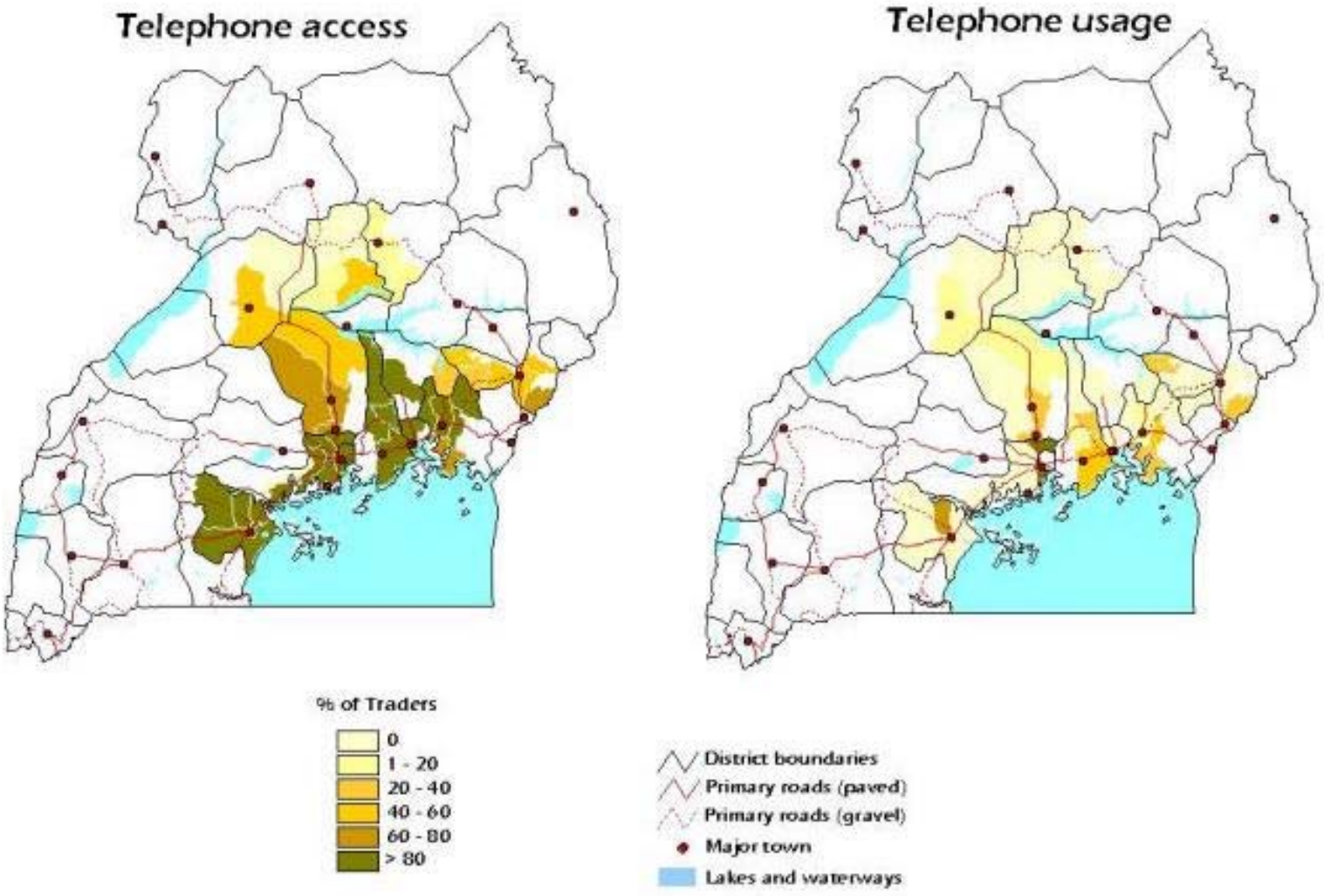
Source: IFPRI Trader survey, 2000

Map 5.4: Percentage of traders reporting transport problems and restrictions



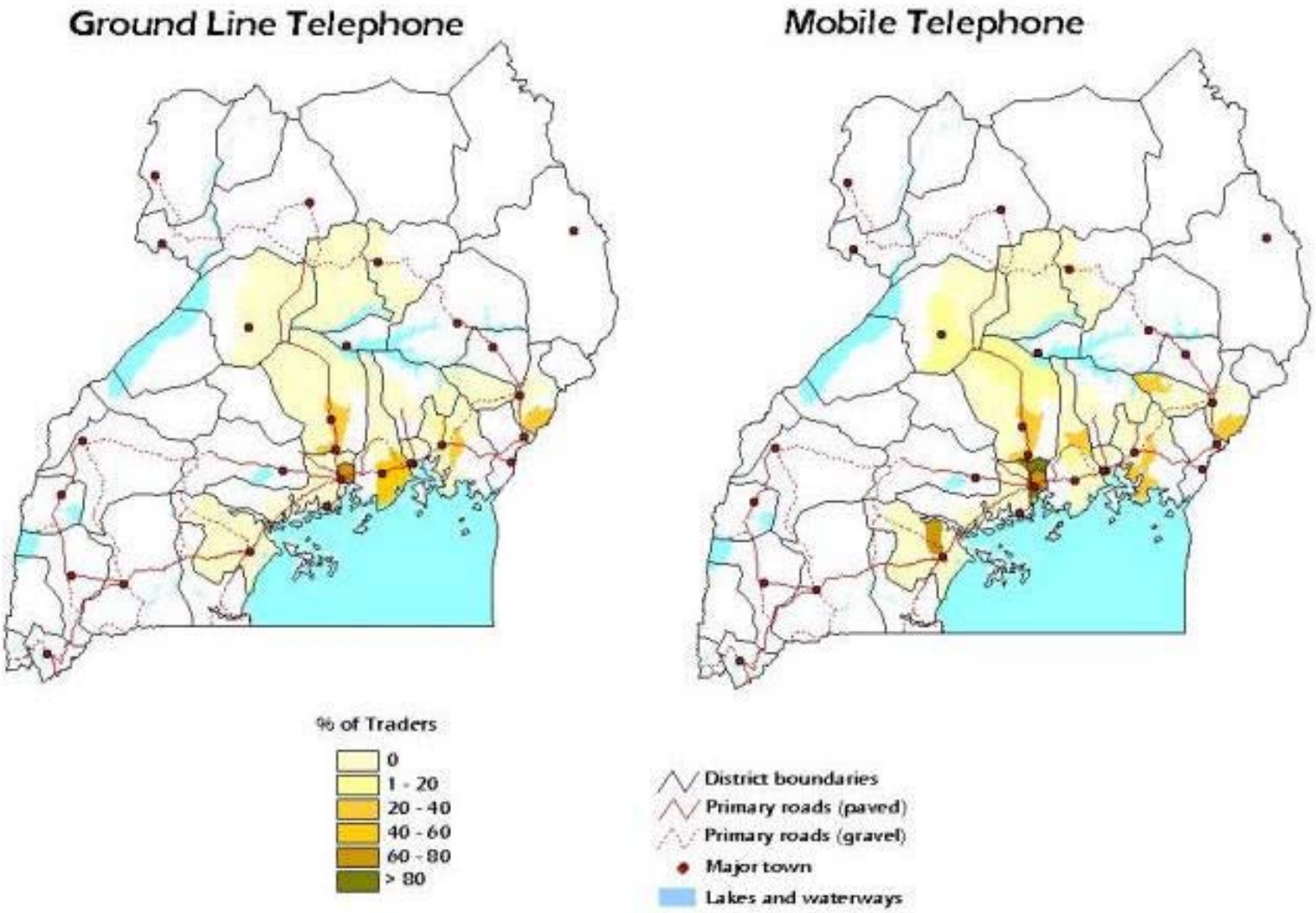
Source: IFPRI Trader survey, 2000

Map 5.5: Telephone access and usage by traders



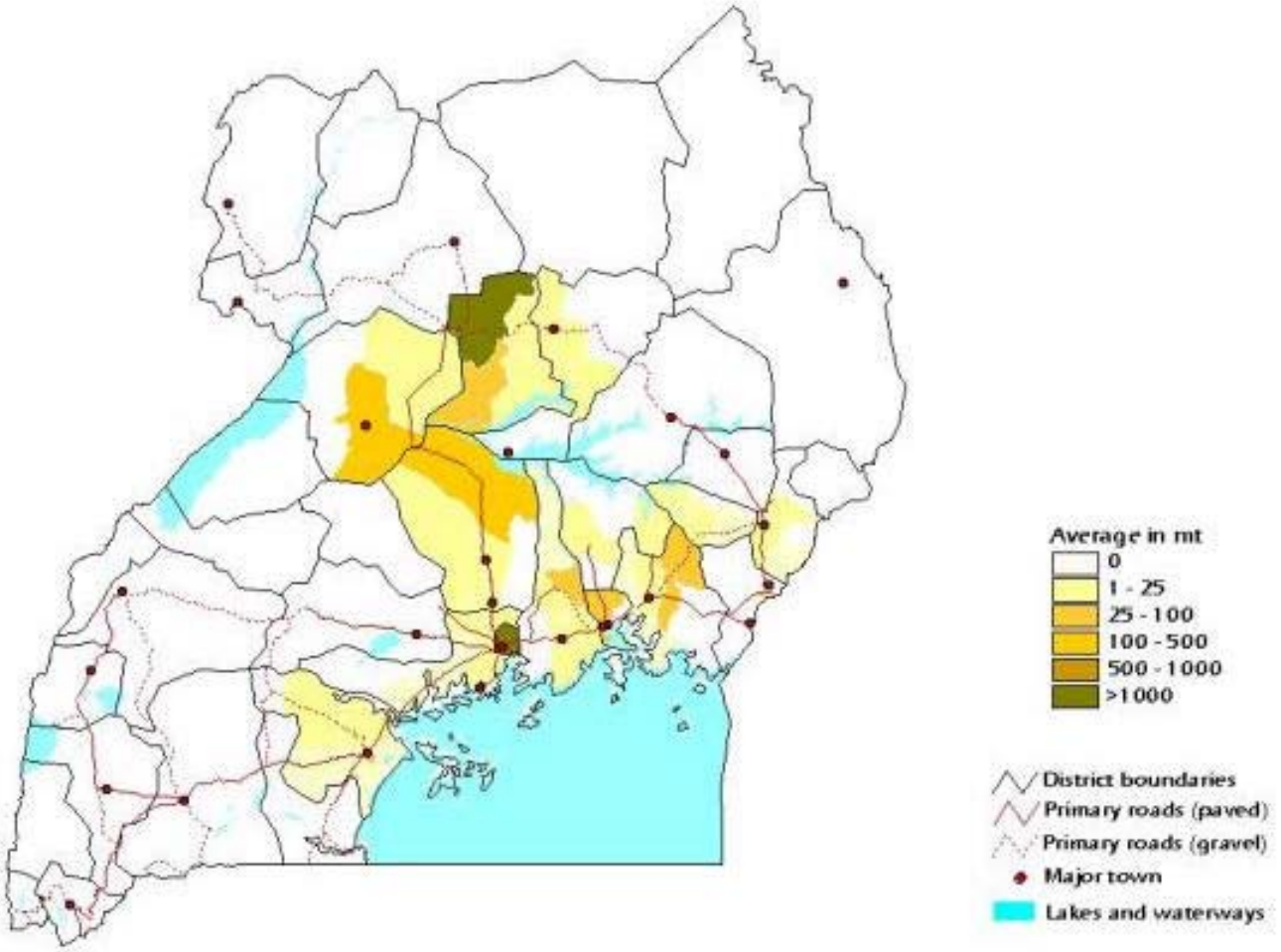
Source: IFPRI Trader survey, 2000

Map 5.5: Telephone access and usage by traders (continued)



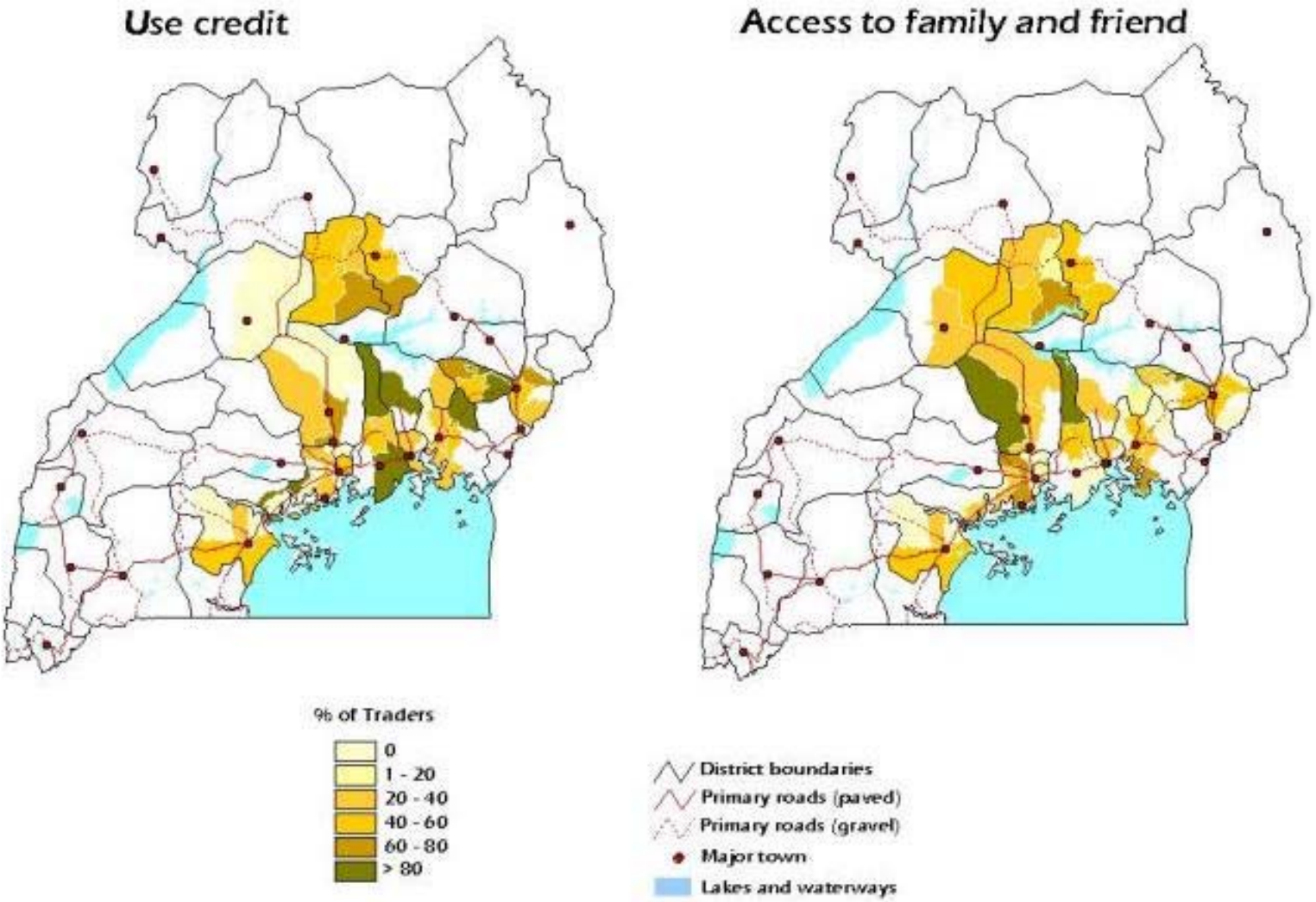
Source: IFPRI Trader survey, 2000

Map 5.6: Average trader storage capacity



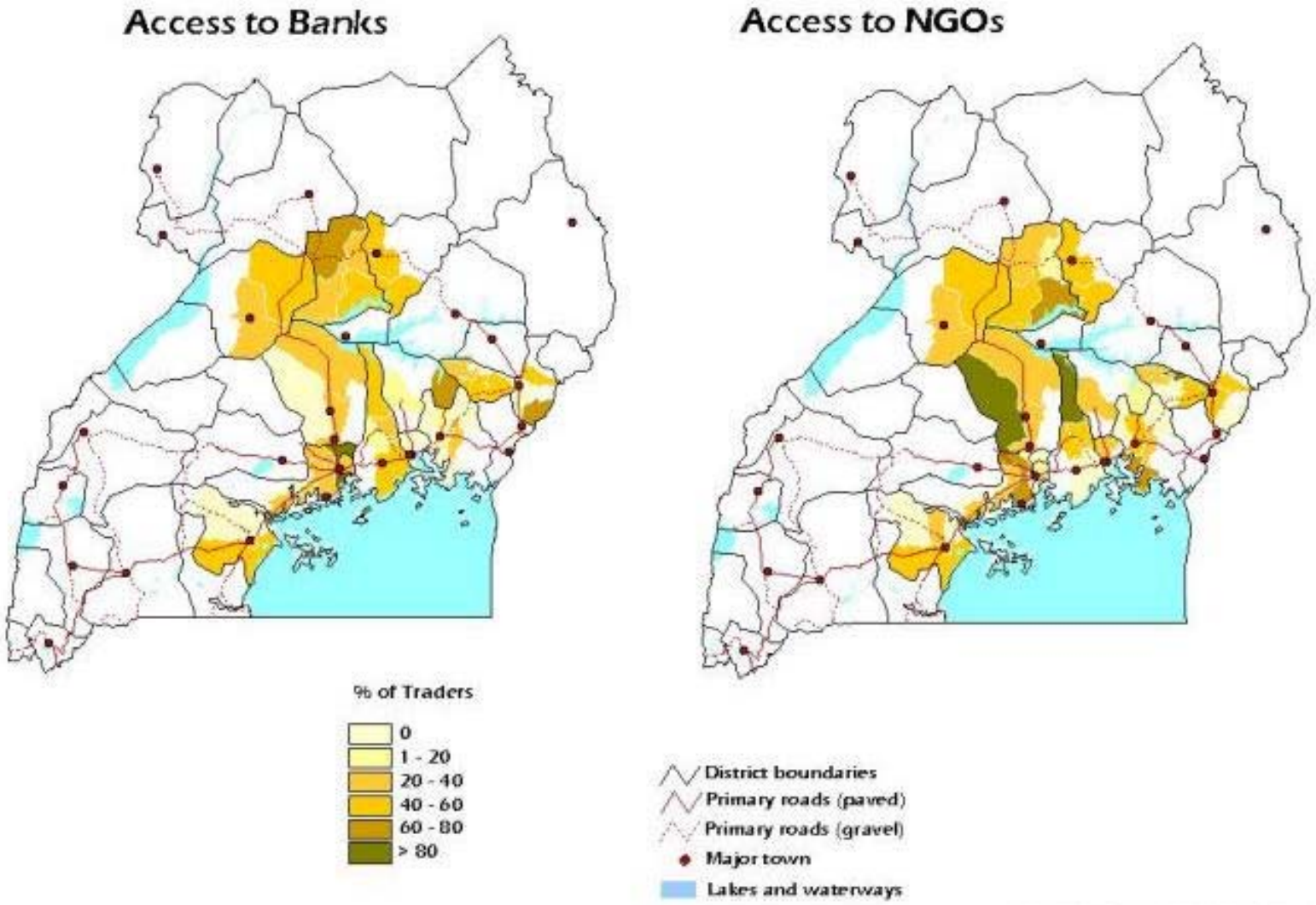
Source: IFPRI Trader Survey, 2000

Map 5.7: Use and access to credit by traders



Source: IFPRI Trader survey, 2000

Map 5.7: Use and access to credit by traders (continued)



Source: IFPRI Trader survey, 2000

ASSESSMENT OF STRATEGIC LAND USE OPTIONS FOR UGANDA

Phase I Draft Completion Report

APPENDIX E

Literature Database in Support of Assessing Strategic Land Use Options for Uganda

Simon Bolwig

Submitted to USAID/Uganda

The International Food Policy Research Institute
2033 K Street, N.W. Washington, D.C. 20006

August 2001

Literature Database in Support of Assessing Strategic Land Use Options for Uganda, August 2001

Agribussiness Development Centre (ADC) and Chemonics International Ltd. 2001. Twelfth semi-annual/sixth annual progress report (Feb 24 - Dec 31, 2000). Rep. 12.

Agricultural Policy Committee and Republic of Uganda. 1993. Report of the technical committee on land tenure law reform.

Agricultural Policy Secretariat. 1999. An assessment of the impact of cotton sub-sector development project (CSDP).

Agricultural Policy Secretariat. 2000. Report on characterisation of policies and institutions affecting land management in Uganda.

Agricultural Policy Secretariat and Agricultural Policy Committee. 2001. Report on economics of crops and livestock production, processing and marketing 1998/99.

Agricultural Policy Secretariat and Agricultural Policy Committee. 1999. Report on economics of crops and livestock production, processing and marketing.

Akwang,A., Kisauzi,D., Boyd,C., and Oryokot,J. 1998. Needs assessment for agricultural research in the Teso farming system. Summary Report.

Akwang,A., Obou,J.P., Okwadi,J., and Oryokot,J. 1998. Needs assessment for agricultural research in the Lango sub-farming system.

Appleton,S. 2001. Poverty in Uganda, 1999/2000. Preliminary estimates from the Uganda National Household Survey (UNHS).

Appleton,S. 2001. Poverty reduction during growth: the case of Uganda, 1992-2000.

Appleton,S., Emwanu,T., Kagugube,J., and Muwonge,J. 2001. Changes in poverty and inequality in Uganda.

ARD community conservation advisor 1995. District environmental action plan (DEAP): a strategic methodology for integrating district environmental programming in district development.

Bank of Uganda. 1998. Bank of Uganda - Annual Report 1997/98.

Bank of Uganda. 2000. Quarterly economic report.

Bashaasha,B. 2001. The evolution and characteristics of farming systems in Uganda.

Beck,P. 2000. Collaboration and credible commitments: experiments with collaborative resource management in Uganda.

Bekunda,M.A. and Woomer,P.L. 1996. Organic resource management in banana-based cropping systems of lake Victoria basin, Uganda. Agriculture, Ecosystems and Environment 56: 171-180.

Bibagambah J.R. 1996. Marketing of smallholder crops in Uganda.

Boyd,C. and Turton,C. 2000. The contribution of soil and water conservation to sustainable livelihoods in semi-arid areas of sub-Saharan Africa. AgRen Network Paper 102: 1-16.

Brett,E.A. 1995. Neutralising the use of force in Uganda: the role of the military in politics. Journal of Modern African Studies 33: 129-152.

Breyer,J. 1996. Land use cover change in central Uganda. Volume One: methodology and data base report.

Bwango,A., Wright,J., Elias,C., and Burton,I. 2000. Reconciling national and global priorities in adaptation to climate change: with and illustration from Uganda. Environmental Monitoring and Assessment 61: 145-159.

Chemonics International. 2001. Economic diversification in Uganda: issues and opportunities.

Chemonics International. 2001. Environmental threats and opportunities assessment for Uganda. Biodiversity assessment. Report submitted to USAID/Uganda.

Chemonics International. 2001. Famine early warning system network - Volume one.

Chemonics International. 2001. Famine early warning system network - Volume two.

Chemonics International. 2001. USAID/Uganda SO 7assessment of strategic agriculture & environment options.

CIAT - Tropical international center for tropical agriculture 2001. Uganda's agroecological zones - A guide for planners and policy makers.

Clausen,R. 2001. A landscape approach for reviewing USAID Uganda activities in the Southwest.

Clausen,R. and Mcgahuey,M. 2001. SW Uganda landscape concept. 1-56.

Corbett and ESRI . USAID's country almanac series. Spatial database for Ethiopia, Kenya, Tanzania, Uganda, Zambia and Zimbabwe. [2.0.1. BRC report no 99-06]. 1999. Texas, Texas A&M University System.

Department for International Development (DFID) 1999. Needs assessment for agricultural research in the Lango sub-farming system.

Development Alternatives Inc. 2000. Evaluation of the USAID/Uganda private sector dairy development activity (DDA).

Dickerman,C.W. 1989. Security of tenure and land registration in Africa: literature review and synthesis (LTC paper 137).

Economic Policy Research Centre. 1999. The structure, conduct and performance of the post-reformed coffee marketing system in Uganda.

Evers,B. and Walters,B. 2000. Extra-household factors and women farmers' supply response in Sub-Saharan Africa. World Development 28: 1341-1345.

FAO 1999. Soil fertility initiative Uganda. Draft concept paper.

FEWSNET and Chemonics International (John Lichte). 2001. Uganda food security assessment.

Fischler,M. and Wortmann,S. 1999. Green manures for maize-bean systems in eastern Uganda: agronomic performance and farmers' perceptions. Agroforestry Systems 47: 123-138.

Flanary,R. and Watt,D. 1999. The state of corruption: a case study of Uganda. Third World Quarterly 20: 515-536.

Fuller,R.M., Groom,G.B., Mugisha,S., and Ipulet,P. 1998. The integration of field survey and remote sensing for biodiversity assessment: a case study in the tropical forests and wetlands of Sango Bay, Uganda. Biological Conservation 86: 379-391.

Gashumba,C.H., Karuhanga,P., and Agricultural Policy Secretariat. 2000. Report on characterization of policies and institutions affecting land management.

Government of Uganda and Ministry of Agriculture Animal Industry and Fisheries. 2000. National agricultural advisory services (NAADS) programme. Master document of the NAADS task force and joint donor group.

Government of Uganda, Minstry of Finance Planning and Economic Development, and Ministry of Agriculture Animal Industry and Fisheries. 2000. Plan for the modernisation of agriculture: eradicating poverty in Uganda (government strategy and operational framework).

Gruhn,P. and Rashid,S. 2001. Problems and constraints in the multiplication of seed and planting material in Uganda: Preliminary findings.

GTZ. 2001. Appraisal study on the ASARECA/GTZ/ISNAR project - "strengthening impact of orientation and the capacity for impact evaluation in agricultural research in Eastern and Central Africa.".

Hansen,H.B. and Twaddle,M. 1998. Developing Uganda. 1 ed. James Currey, Oxford.

Hauser,E. 1999. Uganda relations with Western donors in the 1990s: what impact on democratisation? The Journal of Modern African Studies 37: 621-641.

Himbara,D. and Sultan,D. 1995. Reconstructing the Ugandan state and economy: the challenge of an international Bantustan. Review of African Political Economy 63: 85-93.

Household Agricultural Support Programme (HASP), Tororo District Local Government, and Republic of Uganda. 2001. Baseline survey report on status of agricultural production practices in Tororo District.

Household Agricultural Support Programme (HASP), Tororo District Local Government, and Republic of Uganda. 2000. Baseline survey report on identification of agricultural support organizations' study in Tororo District.

Household Agricultural Support Programme (HASP), Tororo District Local Government, and Republic of Uganda. 2000. Baseline survey report on status of service delivery in Tororo District.

Howard,P. 2001. The opportunity costs of protected areas in Uganda.

Howies,M. 1997. NGOs and the development of local institutions: a Ugandan case-study. Journal of Modern African Studies 35: 17-35.

Hunter,S., Bulirwa,E., and Kisseka,E. 1993. Aids and agricultural production. Report of a land utilization survey, Masaka and Rakai districts of Uganda. Land Use Policy July: 241-258.

Imbernon,J. 1999. Pattern and development of land-use changes in the Kenyan highlands since the 1950s. Agriculture, Ecosystems and Environment 76: 67-73.

International Fertilizer Development Center (IFDC). 1999. The fertilizer market in Uganda: An assessment and strategy for development.

International Fertilizer Development Center (IFDC). 1999. The fertilizer market in Uganda: An assessment and strategy for development.

International Institute of Tropical Agriculture, Uganda National Postharvest Programme, FAO, International Potato Centre, and Matilong Youth Mixed Farmers Organisation. 1999. Marketing opportunities for starch and high quality flour production from cassava and sweet potato in Uganda.

J.E.Austin Associates,I. 1998. Uganda country competitiveness analysis.

Jagger,P. 2001. Evolving roles for programs and organisations: Promoting sustainable land management in rural Uganda.

Jagger,P. and Pender,J. 2001. Markets, marketing and production issues for aquaculture in East Africa: The case of Uganda.

Jagwe,J. 1999. Economics of pineapple marketing in the lake Victoria basin of Uganda.

Kaizzi,C.K. 2001. Strategies, cost and benefit of soil fertility replenishment in soils with different productivity potential in Uganda. Paper presented at a workshop on policies on improved land management in Uganda on June 25-27, 2001.

Kamugisha,J. 1993. Management of natural resources and environment in Uganda. Policy and legislation landmarks, 1890-1990. Rep. 11.

Kayizzi-Mugerwa,S. 1999. Uganda and the end of the 1990s: a medium-term assessment. Rep. 5.

Khadiagala,G. 1993. Uganda's domestic and regional security since the 1970s. The Journal of Modern African Studies 31: 231-255.

Lado,C. 1998. The transfer of technology and the development of small-scale farming in rural Africa: case studies from Ghana, Sudan, Uganda, Zambia and South Africa. GeoJournal 45: 165-176.

Lamprey,R. and Egunyu,F. 1999. Wildlife protected area system plan for Uganda - Volume 2.

Lamprey,R., Buhanga,E., and Oketcha,J. 1999. Wildlife protected area system plan for Uganda - Volume 1.

Langdale-Brown,I., Osmaston,H.A., and Wilson, J.G. 1964. The vegetation of Uganda and its bearing on land use. Government of Uganda, Entebbe.

Lichte,J. 2001. Opportunities for economic growth in agriculture.

Lutz,E., Binswanger,H., Hazell,P., and McCalla,A. 1998. Agriculture and the environment: perspectives on sustainable rural development (a World Bank symposium). World Bank, Washington, DC.

MAAIF, National Agricultural Research Organisation (NARO) - Uganda, and FAO. 1999. Soil fertility initiative.

Macmillan 1998. A new Macmillan social studies atlas of Uganda. Macmillan, Kampala.

Management Systems International, Implementing Policy Change Project, and USAID 1998. Uganda and the national environmental action plan: focusing on implementation.

Masindi District MSD/ENV/SEAP 1999. Masindi port sub-county environmental action plan 2000 - 2003. Rep. 9.

Maxwell,D.G. 1995. Alternative food security strategy: a household analysis of urban agriculture in Kampala. World Development 23: 1669-1681.

Ministry of Natural Resources 1994. State of environment report for Uganda. 1994.

Ministry of Water Lands and Environment. 2000. The Uganda forestry policy.

Ministry of Water Lands and Environment. 2001. The national forest plan.

Ministry of Water Lands and Environment. 2001. The Uganda forestry policy. Draft for cabinet, 3rd November 2000.

Ministry of Finance Planning and Economic Development. 1995. Demographic and health survey 1995.

Ministry of Finance Planning and Economic Development. 1998. Uganda national household survey 1995/96.

Ministry of Finance Planning and Economic Development. 1999. Background to the budget 1999/2000.

Ministry of Finance Planning and Economic Development. 2001. Background to the budget 2001/02.

Ministry of Finance Planning and Economic Development. 2001. Uganda participatory poverty assessment report.

Ministry of Finance Planning and Economic Development and Government of Uganda. 2000. Medium-term competitive strategy for the private sector (2000 - 2005).

Ministry of Finance Planning and Economic Development and Republic of Uganda. 2000. Background to the budget 2000/01. (Increasing efficiency in poverty reduction service delivery through output oriented budgeting).

Ministry of Finance Planning and Economic Development and Republic of Uganda. 2000. Revised volume I of the poverty eradication action plan (PEAP) .

Ministry of Finance Planning and Economic Development and Republic of Uganda. 2000. Uganda participatory poverty assessment report.

Mosley,P. 2000. Financial services diversification and agricultural development in Africa: the case of microinsurance.

Muganga,A.K., Okoboi,G., and Nahamya,M.T. 2000. Market information service - Third report.

Muganga,A.K., Okoboi,G., and Nahamya,M.T. 2000. Market information service - Second report.

National Agricultural Research Organisation (NARO) - Uganda. NARO Bulletin. NARO 5[1]. 1999.

National Agricultural Research Organisation (NARO) - Uganda. NARO Bulletin. NARO 5[2]. 1999.

National Agricultural Research Organisation (NARO) - Uganda . The NARO Bulletin. NARO 5[4]. 1999.

National Agricultural Research Organisation (NARO) - Uganda 1999. NARO achievements, 1998/99 and plans and budgets,1999/2000.

National Agricultural Research Organisation (NARO) - Uganda 2000. Facing the research challenges for the modernisation of agriculture. A strategy for 2000 - 2010.

National Agricultural Research Organisation (NARO) - Uganda 2001. NARO Medium Term Plan 2001 - 2005. Responding to research challenges for the modernisation of agriculture.

National Agricultural Research Organisation (NARO) - Uganda, Department for International Development (DFID), SRI, and MUK 1999. Needs assessment for agricultural research in the Mt. Elgon hill-sides farming systems - Kapchorwa and Mbale districts.

National Environment Management Authority (NEMA). 1998. State of environment report for Uganda 1998.

National Environment Management Authority (NEMA). 1999. Mbale Decentralised Environmental Planning Process.

National Environment Management Authority (NEMA). 2001. Environmental economics guidelines for Uganda.

National inputs coordination unit 1990. Report on agricultural inputs situation in Uganda.

National inputs coordination unit and Agricultural Secretariat - Bank of Uganda. 1992. Report on agricultural inputs situation (July 1991 to march 1992).

Nielsen,F. 1999. Issues in the utilization of indigenous knowledge in agroforestry research in Uganda. PhD dissertation. Institute of Geography, University of Copenhagen.

Nkonya,E. and Kato,E. 2000. Agricultural input marketing in Uganda (Preliminary report).

Nkonya,E. and Kato,E. 2001. Agricultural input marketing in Uganda.

Nkonya,E., Goletti,F., Gruhn,P., and Kato,E. 2001. Agricultural input marketing in Uganda.

NN. 2001. District profiles.

NN. 2001. Study to define modalities for the proposed PMA “non-sectoral conditional grant”. Draft final report submitted to the PMA steering committee.

Omagor,N. 1999. Swamp forest plant resources in Uganda: their uses and conservation challenges. International Tree Crops Journal 10: 107-120.

Otimoduch,P. and Singh,S. 2000. Vegetable oil development project - A study to establish oil milling capacity in Uganda.

Pender,J., Jagger,P., and Nkonya,E. 2001. Development pathways and land management in Uganda: Causes and implications. Paper presented at a workshop on policies on improved land management in Uganda on June 25-27, 2001.

Place,F. and Otsuka,K. 2000. Population pressure, land tenure and tree resource management in Uganda. Land Economics 76: 233-251.

Raussen,T., Ebong,G., and Musiime,J. 2001. More effective natural resources management through democratically elected, decentralised government structures in Uganda.

Republic of Uganda. 1998. The land act, 1998.

Republic of Uganda. 1997. The local governments act, 1997.

Republic of Uganda and Ministry of Natural Resources 1995. National policy for the conservation and management of wetland resources.

Republic of Uganda and Ministry of Water Lands and Environment. 2001. Wetland sector strategic plan 2001-2010.

Republic of Uganda and National Environment Action Plan (NEAP). 1995. The National Environment Management Policy.

Rwabwogo,M.O. 1998. Uganda districts information handbook.

Semalulu,O., Akwang,A., and Nakileza,B. 1999. Needs assessment for agricultural research in the Mt. Elgon hill-sides farming systems.

Smit,N. 1997. The effect of the indigenous cultural practices of in-ground storage and piecemeal harvesting if sweetpotato on yield and quality losses caused by sweet potato weevil in Uganda. Agriculture, Ecosystems and Environment 64: 191-200.

Ssali,H. 2000. Soil resources of Uganda and their relationship to major farming systems.

Sserunkuma,D. 2001. Copping with the problem of low and declining agricultural productivity in the banana-coffee lakeshore system. Paper presented at a workshop on policies on improved land management in Uganda on June 25-27, 2001.

Sserunkuma,D., Pender,J., and Nkonya,E. 2001. Land management in Uganda: Characterization of problems and hypotheses about causes and strategies for improvement.

Statistics department, MFED. 1994. The 1991 population and housing census (national summary).

Statistics department, MFED. 1997. Uganda national household survey, 1995-1996.

Stover,J., Bollinger,L., and Kibirige,V. 1999. The economic impact of AIDS in Uganda.

The Economist Intelligence Unit. 1999. Country profile Uganda.

The Economist Intelligence Unit. 1999. Uganda country report, 4th quarter 1999.

The Economist Intelligence Unit. 2000. Uganda country report, November 2000.

The National Biomass Study and Ministry of Water Lands and Environment. 2000. The future of the national biomass study. Analysis of opportunities and future organisation.

Tukahirwa,J.M. 1999. Diagnostic and charaterisation studies conducted from 1945 to 1995 in southwest Uganda. Rep. 10.

Tukahirwa,J.M. 1999. The African initiative - diagnostic and characterisation studies conducted from 1945 to 1995 in Southwest Uganda.

Tumushabe,G.W. 2001. SO7 analytical agenda. Analysis of policy issues and legal frameworks for natural resource-based economic growth.

Uganda Bureau of Statistics. 1999. 1999 Statistical abstract.

Uganda Bureau of Statistics. 2000. 2000 Statistical abstract.

Uganda Bureau of Statistics. 2000. Report on the community survey 1999/2000.

Uganda Bureau of Statistics. 2000. Report on the socio-economic survey 1999 - 2000.

Uganda Bureau of Statistics. 2001. Uganda national household survey 1999/2000. Report on the socio-economic survey.

Uganda Coffee Development Authority. 1999. Uganda coffee development authority annual report 1998/99.

Uganda Coffee Development Authority. 2000. The coffee year book - 1999-2000.

Uganda Coffee Development Authority. 2001. Uganda coffee development authority Annual report October 1998 - September 1999.

Uganda Coffee Development Authority. 2001. Uganda coffee development authority Annual report October 1997 - September 1998.

Uganda Coffee Trade Federation (UCTF). 1999. The coffee book 1998/99.

Government of Uganda. 2001. Constitution of the Republic of Uganda 1995.

Uganda Oil Seed Producers and Processors Association (UOSPA). 1999. The way foward in the development of the edible oil industry. UOSPA.

Uganda Oil Seed Producers and Processors Association (UOSPA). 2001. Oil seed production contribution towards food security and income. UOSPA.

USAID/Uganda. 1999. Annual program statement, USAID/Uganda strategic objective no. 2 (SO 2).

Villadsen,S. and Lubanga,F. 1996. Democratic decentralisation in Uganda: a new approach to local governance. 1 ed. Fountain Publishers, Kampala.

Vinlaw Associates. 1997. Farm gate to export market study of maize and beans (covering the districts of Kapchorwa, Mbale, Iganga, Masindi, Kasese, Rakai and Masaka.

Vinlaw Associates Ltd. 2001. Farm gate to export market study of maize and beans - covering the districts of Kapchorwa, Mbale, Iganga, Masinda, Kasese, Rakai and Masaka.

Vredeseilanden-Coopibo, SNV, and Oxfarm-Uganda. 1998. Effects of agricultural price and market liberalisation and other factors on food security in selected districts in Uganda.

Woelcke,J. Modeling program-induced development pathways. A case study for Eastern Uganda. 2001. Paper presented at a workshop on policies on improved land management in Uganda on June 25-27, 2001.

World Bank. 1996. Uganda: the challenge of growth and poverty reduction. A World Bank country study.

World Bank. 1998. Agricultural Operations for Eastern and Southern Africa. Uganda Agricultural Sector Memorandum.

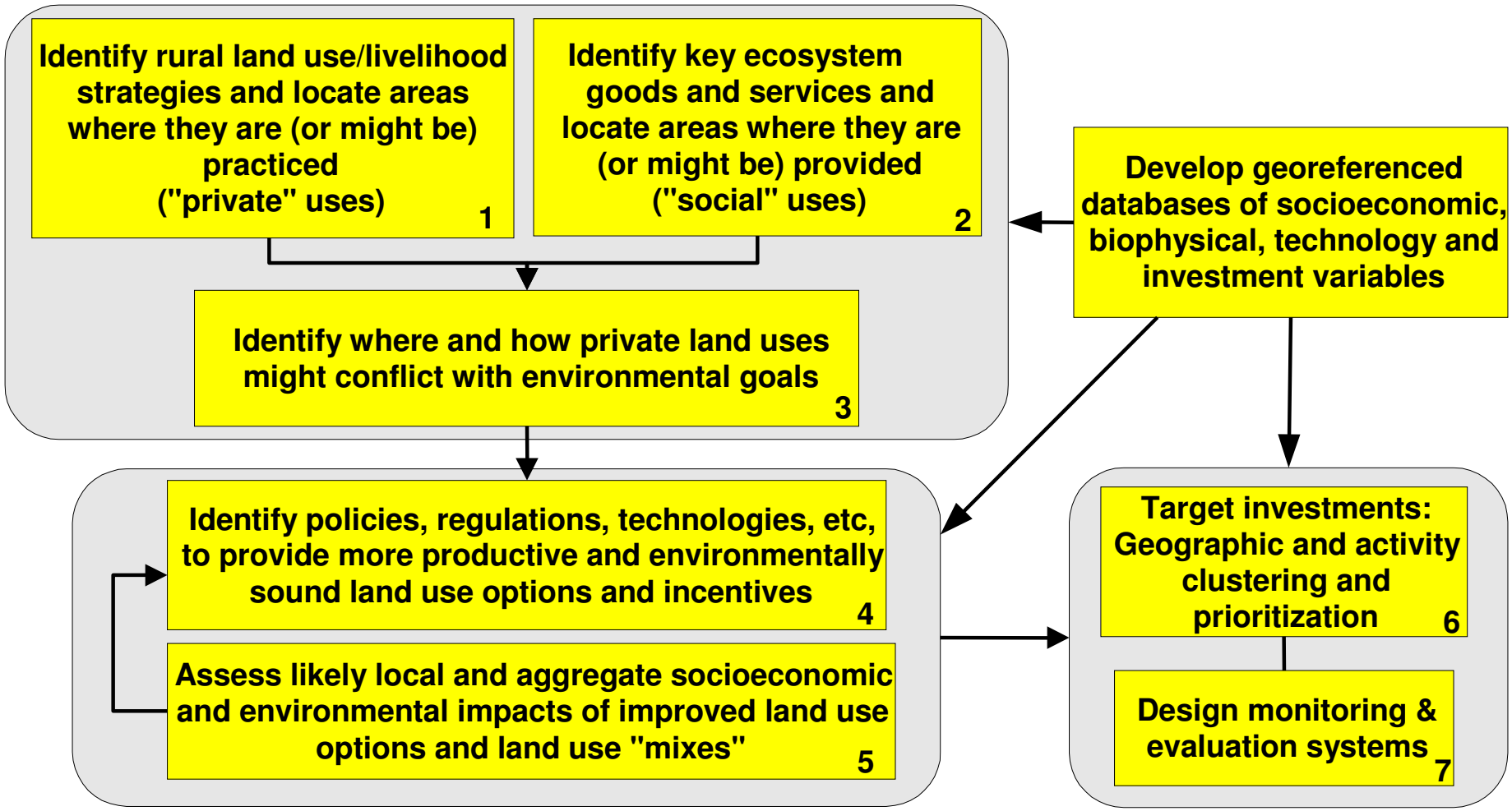
World Bank and Republic of Uganda. 1996. Agriculture sector management project. Staff appraisal report (14889-UG).

World Bank/ UNDP/ Project UGA/91/R02. 2001. Report on the Uganda national integrated household survey 1992-93.

Wortmann,C.S. and Kaizzi,C.K. 1998. Nutrient balances and expected effects of alternative practices in farming systems in Uganda. Agriculture, Ecosystems and Environment 71: 115-129.

Zake,J., Magunda,M.K., and Nkwiine,C. 1997. Integrated soil management for sustainable agriculture and food security: the Ugandan case.

Fig 1: Analytical Framework for USAID/Uganda's SO7



Source: IFPRI, 2001

Fig 2: Geographical Coverage of IFPRI's Community Survey

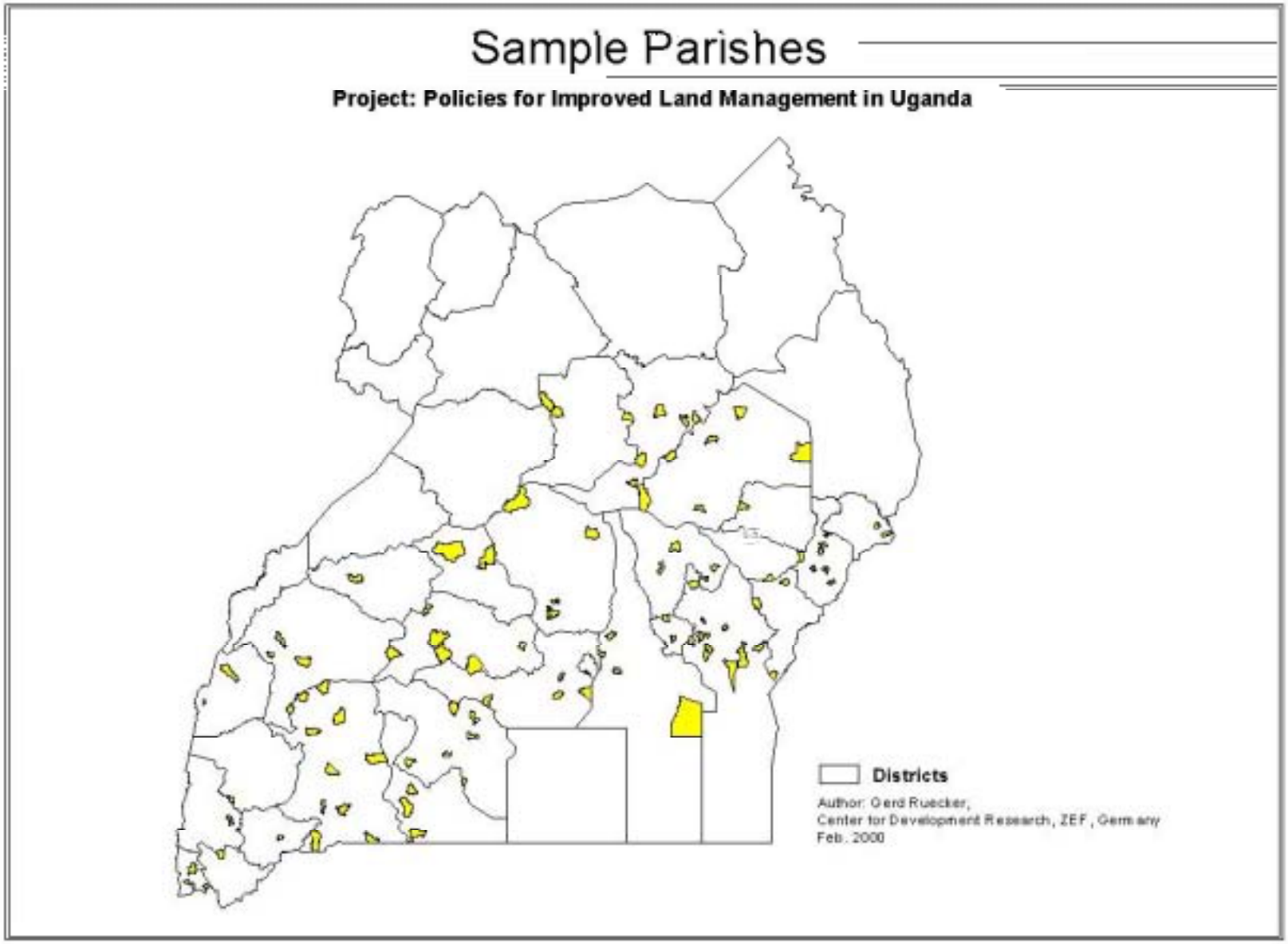
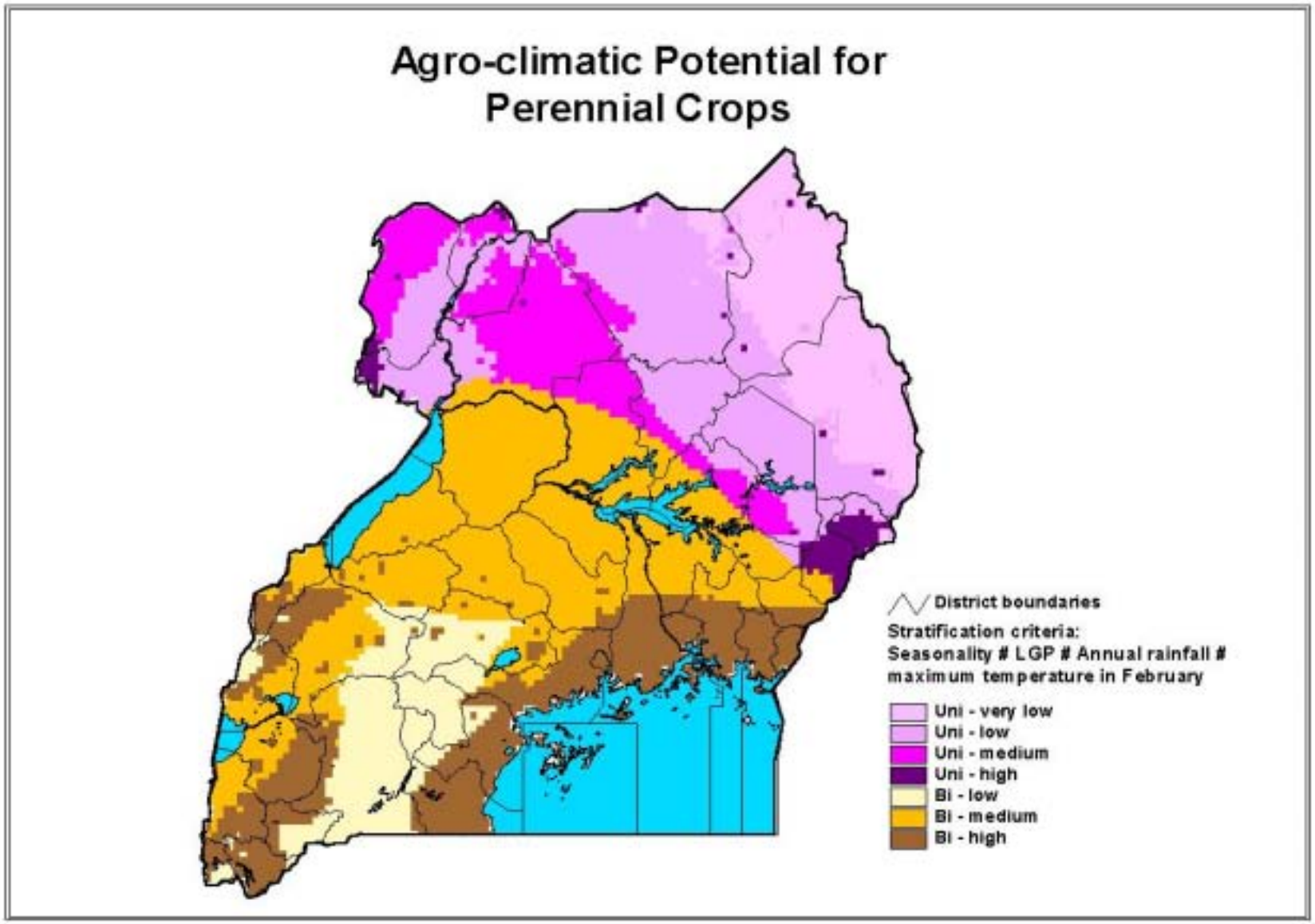
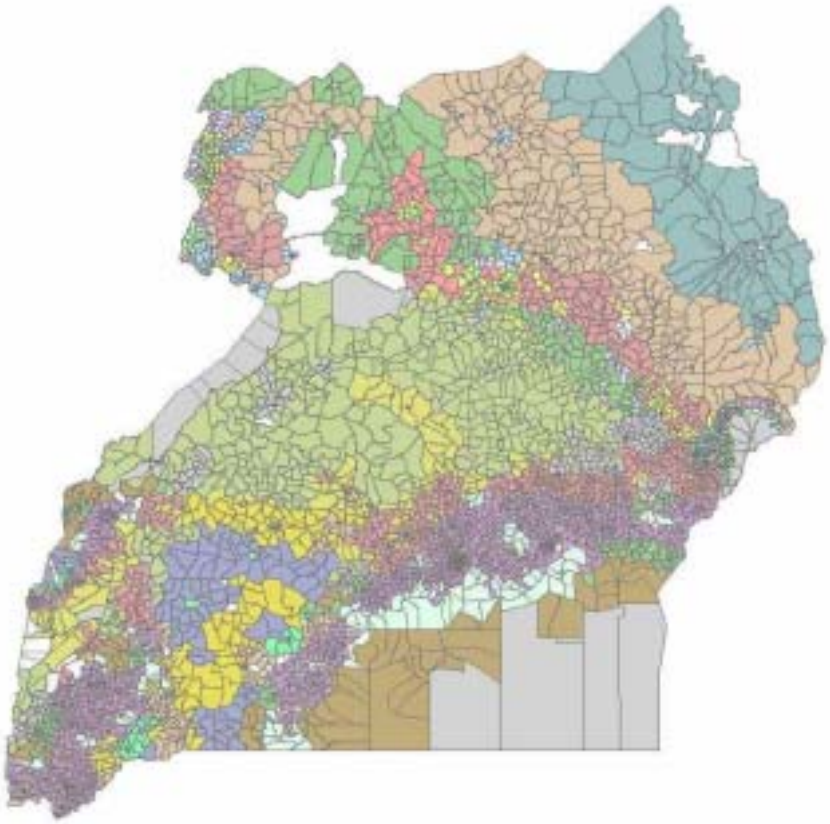


Fig 3: Major Agro-Climatic Zones of Uganda



Source: Gerd Ruecker and IFPRI

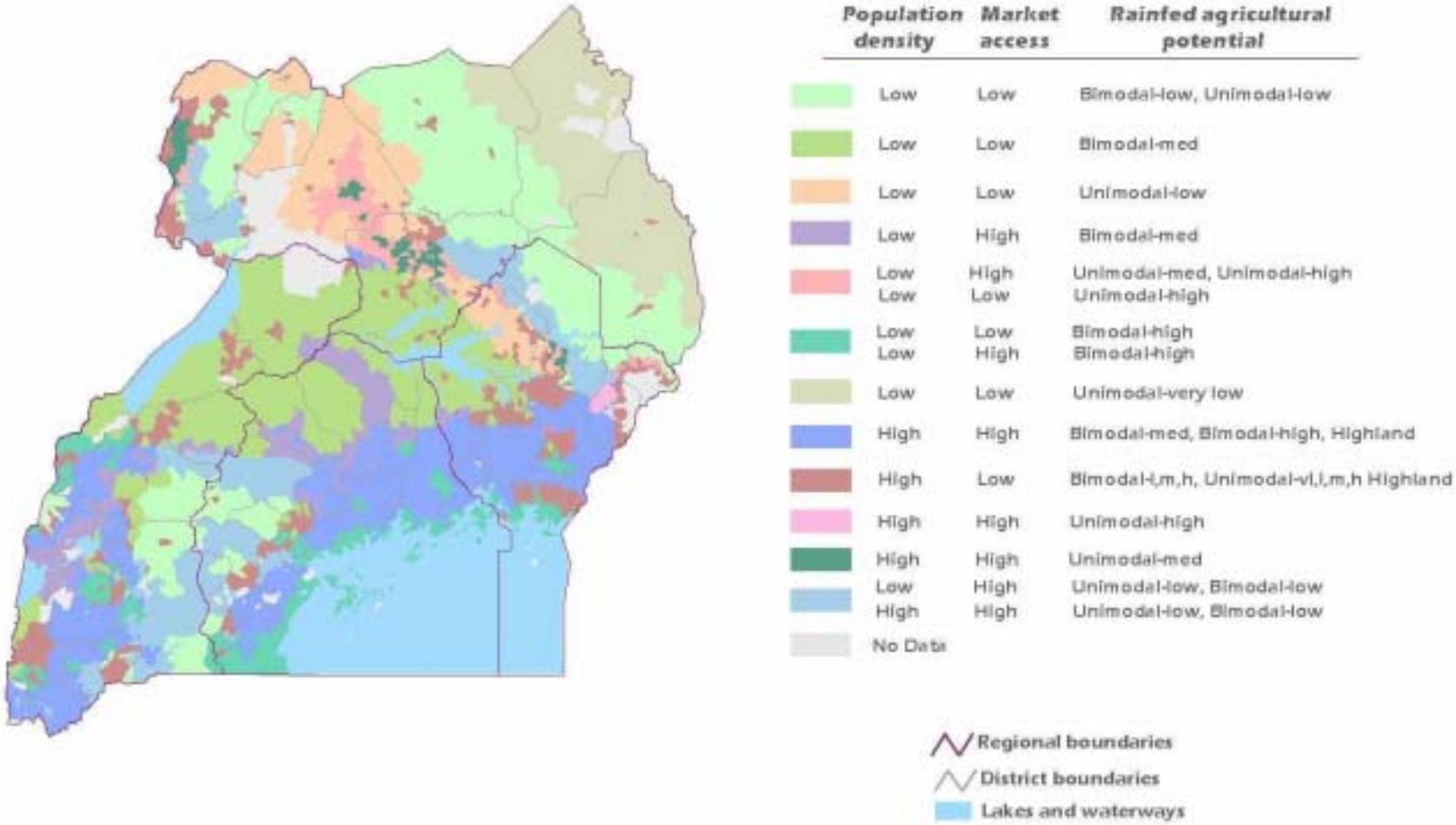
Fig 4: Development Domains in Uganda



Population density	Market access	Rainfed agricultural potential
low	low	Unimodal - very low
low	low	Unimodal - low
low	low	Unimodal - medium
low	high	Unimodal - low
low	low	Unimodal - high
low	high	Unimodal - medium
low	low	Bimodal - low
low	low	Bimodal - medium
low	high	Unimodal - high
low	high	Bimodal - low
high	low	Unimodal - very low
low	low	Bimodal - high
low	high	Bimodal - medium
high	low	Unimodal - low
high	low	Unimodal - medium
low	high	Bimodal - high
high	high	Unimodal - low
high	low	Unimodal - high
high	high	Unimodal - medium
high	low	Bimodal - low
high	low	Bimodal - medium
high	high	Unimodal - high
high	high	Bimodal - low
high	low	Bimodal - high
high	high	Bimodal - medium
high	high	Bimodal - high
No Data		
National Park or Lake		

Source: Gerd Ruecker and IFPRI

Fig 5: Aggregated Development Domains – Components for Selected Potential Land Use Strategies



Source: IFPRI, 2001

Fig 6: Sample of Agriculture-based Potential Land Use Strategies

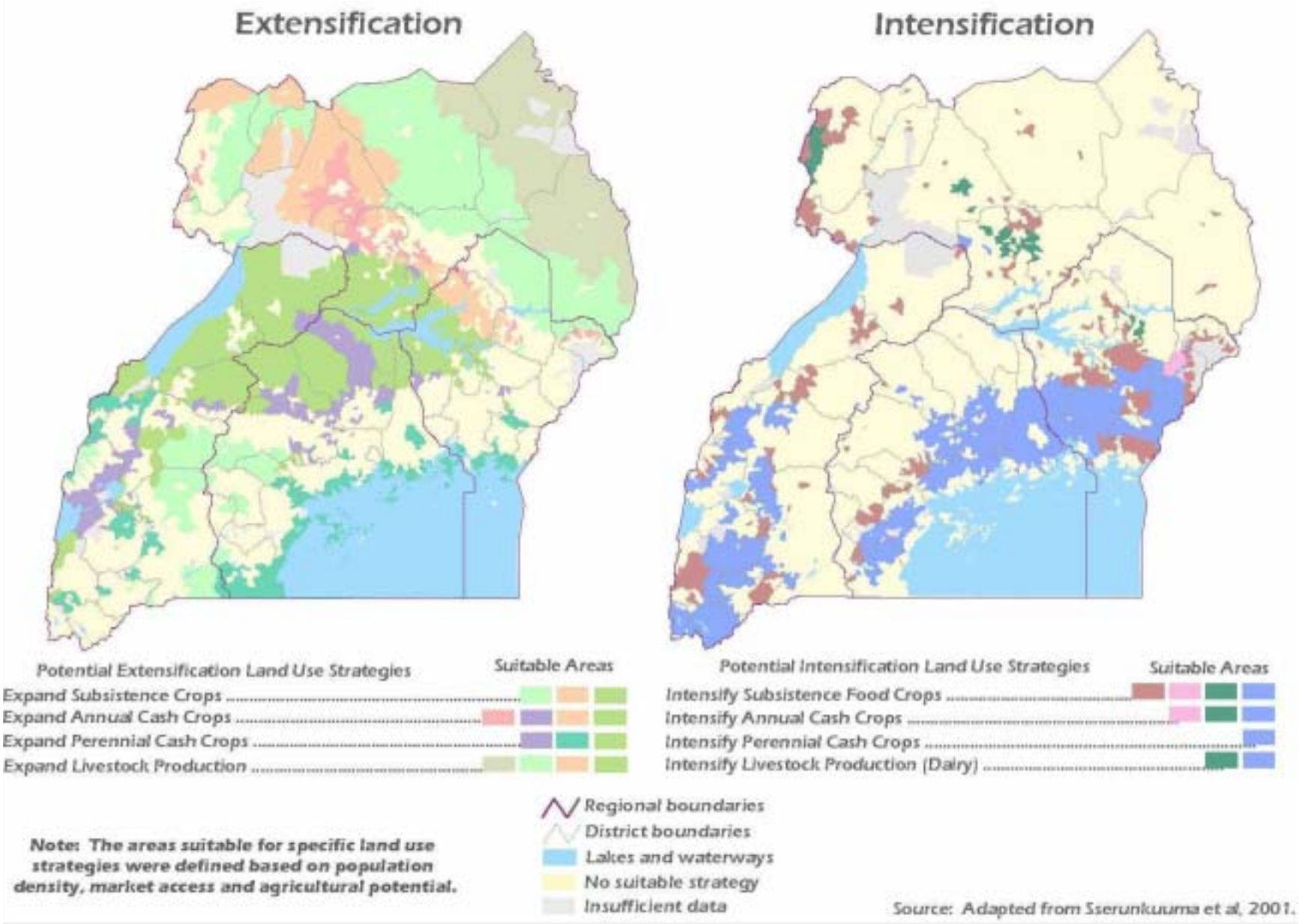


Fig 7: Non Agriculture-based Potential Land Use Strategies

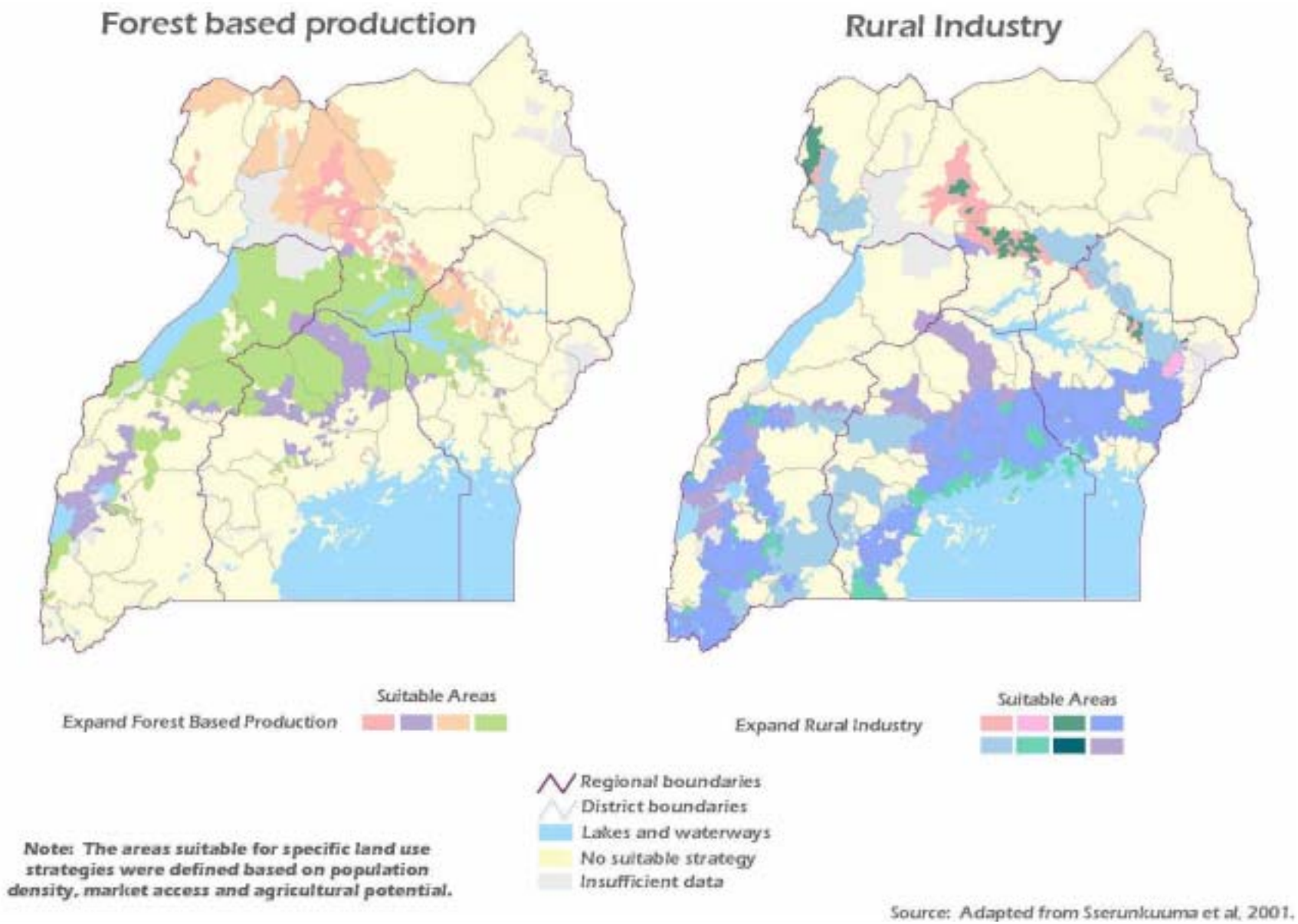
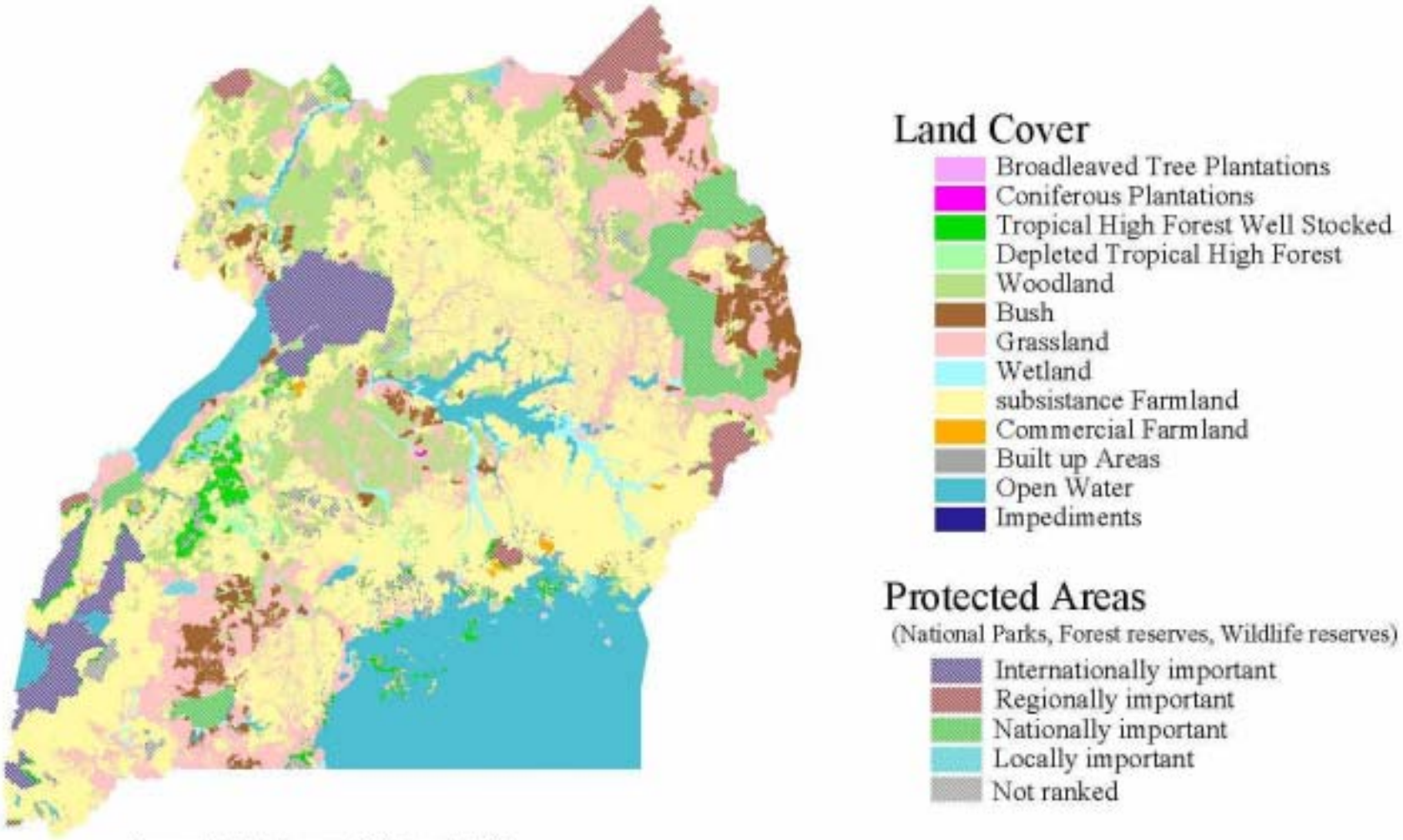


Fig 8: Land Cover and Protected Areas



Source: Protected areas: ACT-Uganda, 2001;
Importance: Uganda Wildlife Authority, 1999;
Land cover: National Biomass Study, 1996.

IFPRI, 2001

Figure 9: Sand Content In Ugandan Soils

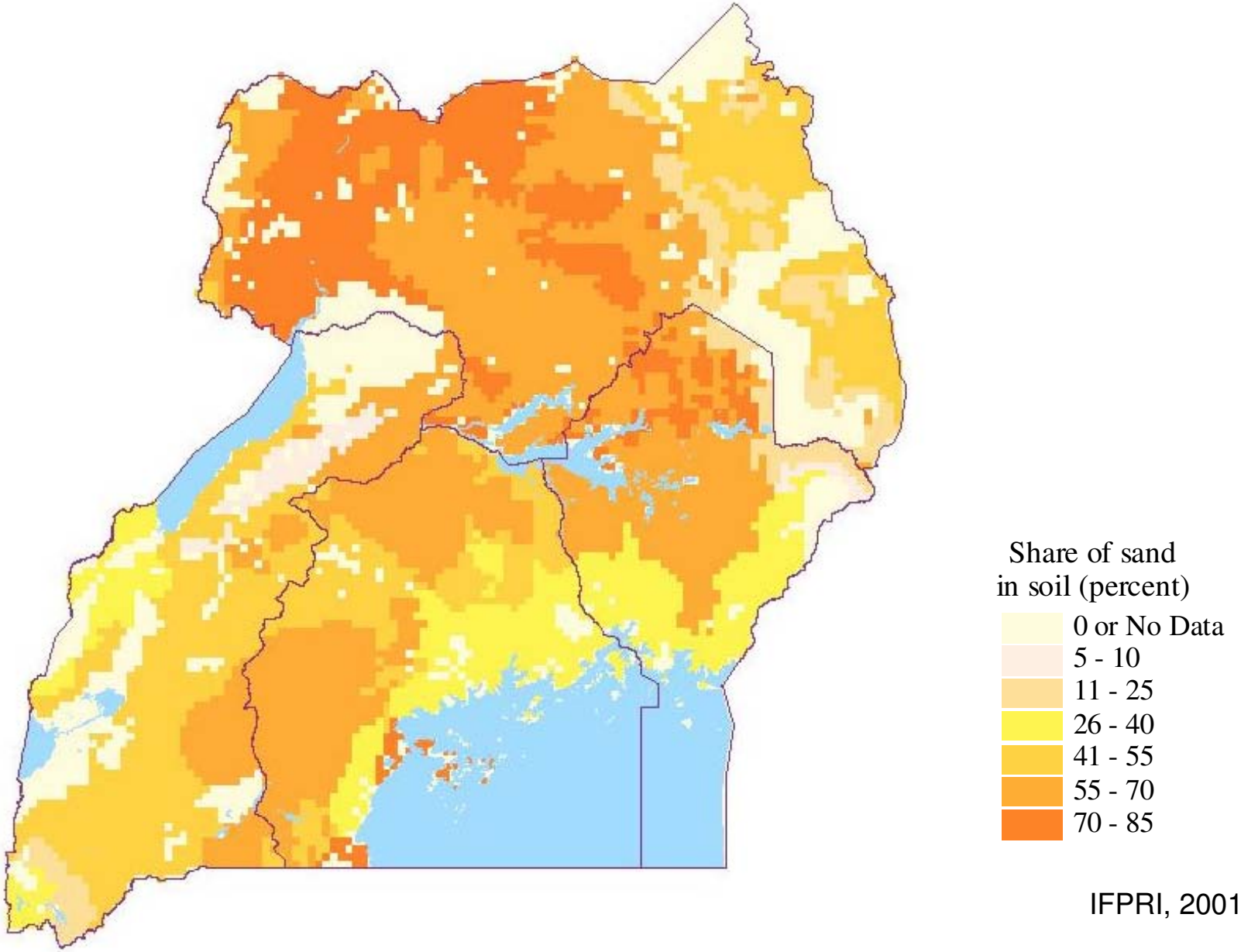
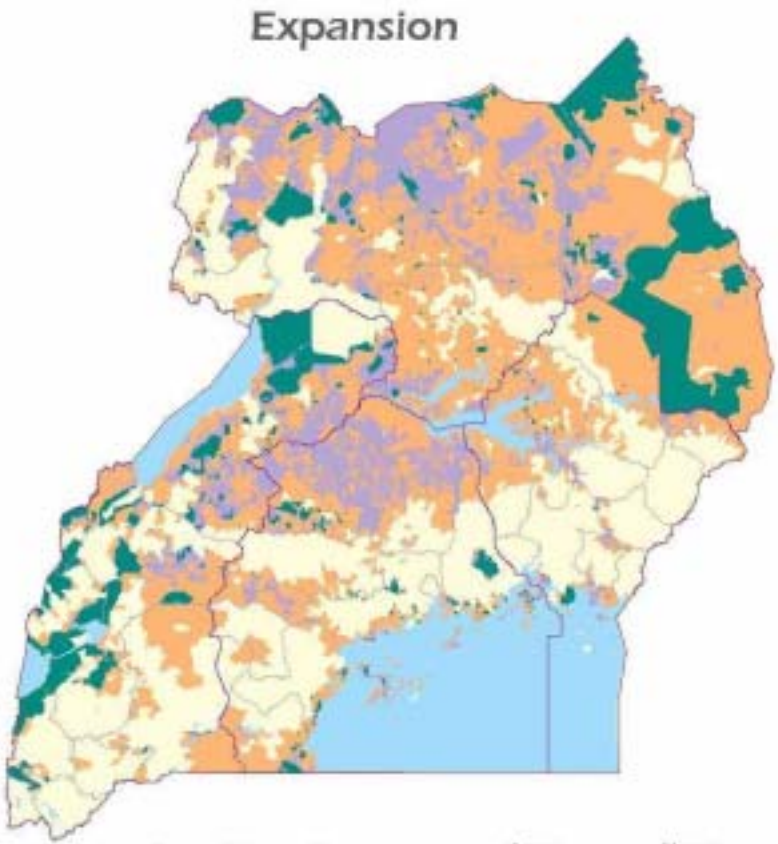
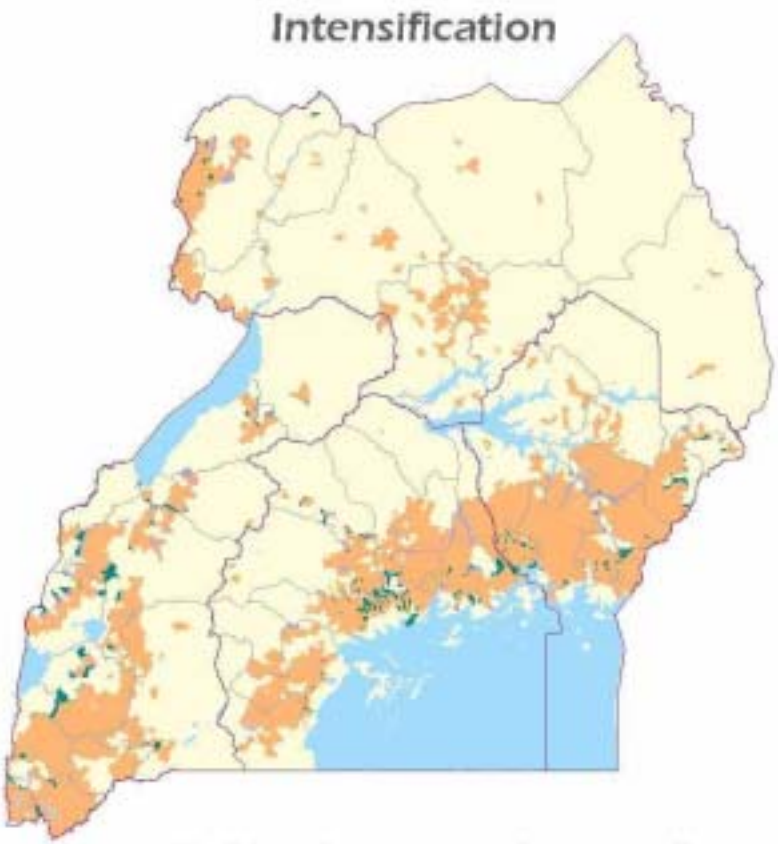


Fig 10: Environmental Feasibility of Agriculture-based Land Use Options ("Hot Spots")





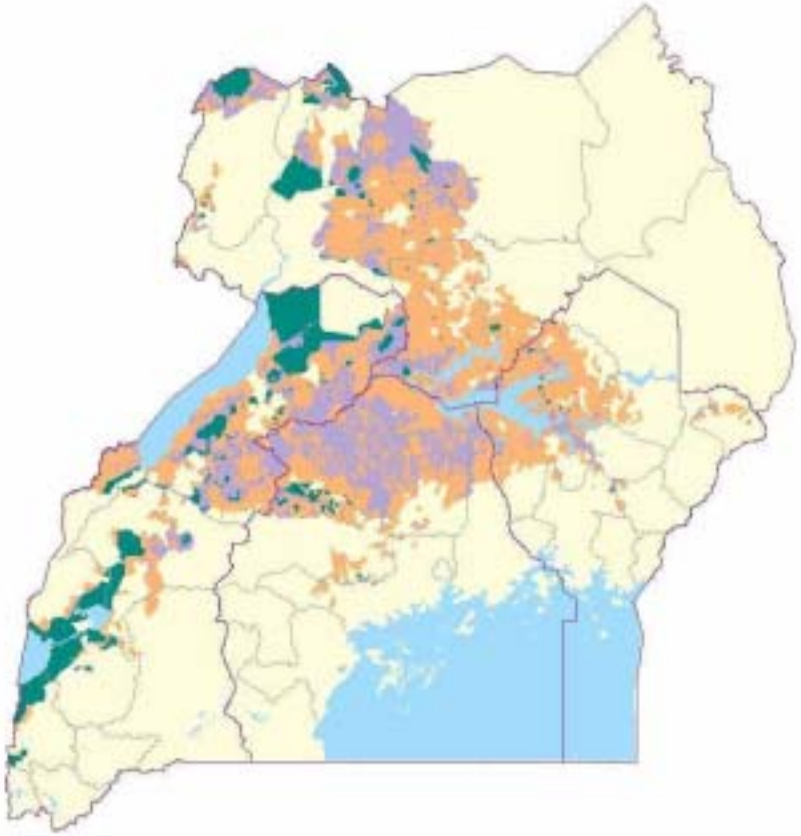
Potential area for agricultural expansion	Area (000 sq km)	Share (percent)
High feasibility: no conflict	68.6	52.3%
Feasible: conflict with potential conservation areas	40.5	30.8%
Low feasibility: conflict with existing protected areas	22.1	16.9%

Potential area for agricultural intensification	Area (000 sq km)	Share (percent)
High feasibility: no conflict	41.4	90.4%
Feasible: conflict with potential conservation areas	2.5	5.4%
Low feasibility: conflict with existing protected areas	2.0	4.3%

Regional boundaries
Lakes and waterways
No potential agriculture-based strategies

Source: Based on Sserunkuuma et al. 2001; National Biomass Study, 1996.

Fig 11: Environmental Feasibility of Expansion of Annual Cash Crops ("Hot Spots")



Potential area for expansion of annual cash crops	Area (000 sq km)	Share (percent)
High feasibility: no conflict	27.8	46.2%
Feasible: conflict with potential conservation areas	23.7	39.4%
Low feasibility: conflict with existing protected areas	8.7	14.4%

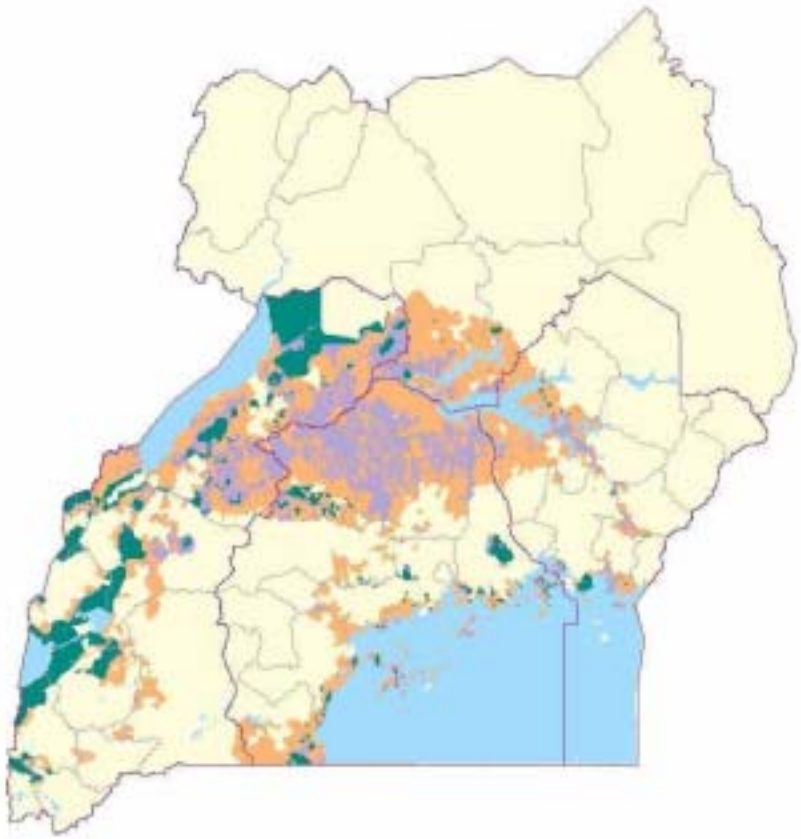
Regional boundaries

Lakes and waterways

No potential for expansion of annual cash crops

Source: Based on Sserunkuuma et al, 2001; National Biomass Study, 1996.

Fig 12: Environmental Feasibility of Expansion of Perennial Cash Crops ("Hot Spots")



Potential area for expansion of perennial cash crops	Area (000 sq km)	Share (percent)
High feasibility: no conflict	21.8	43.6%
Feasible: conflict with potential conservation areas	19.6	39.2%
Low feasibility: conflict with existing protected areas	8.6	17.3%

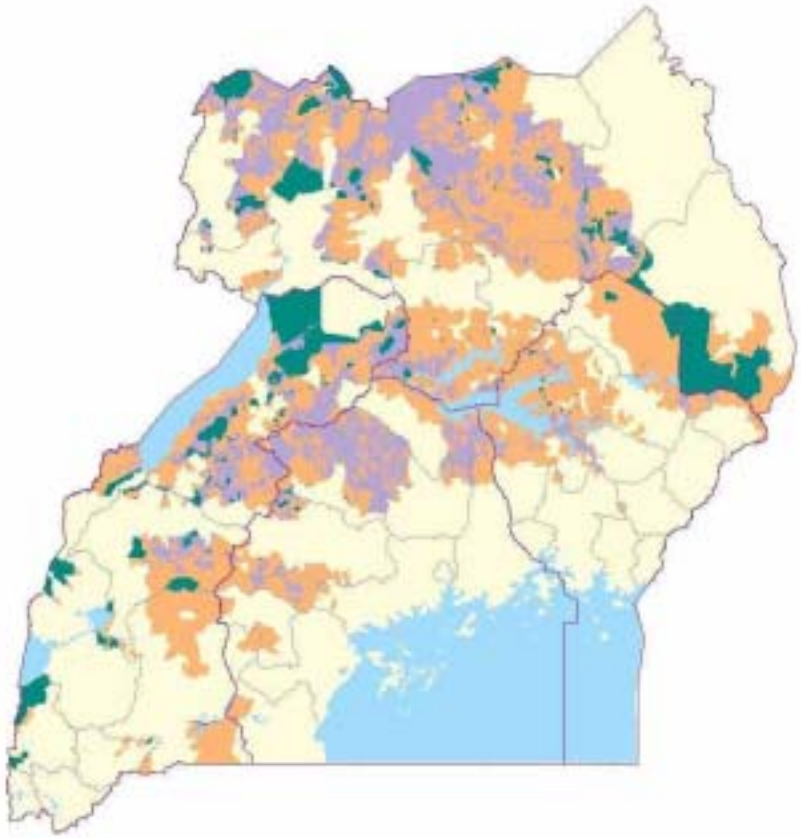
Regional boundaries

Lakes and waterways

No potential for expansion of perennial cash crops

Source: Based on Sserunkuuma et al. 2001; National Biomass Study, 1996.

Fig 13: Environmental Feasibility of Expansion of Subsistence Food Crops ("Hot Spots")



Potential area for expansion of subsistence crops	Area (000 sq km)	Share (percent)
High feasibility: no conflict	44.4	50.8%
Feasible: conflict with potential conservation areas	31.6	36.1%
Low feasibility: conflict with existing protected areas	11.4	13.0%

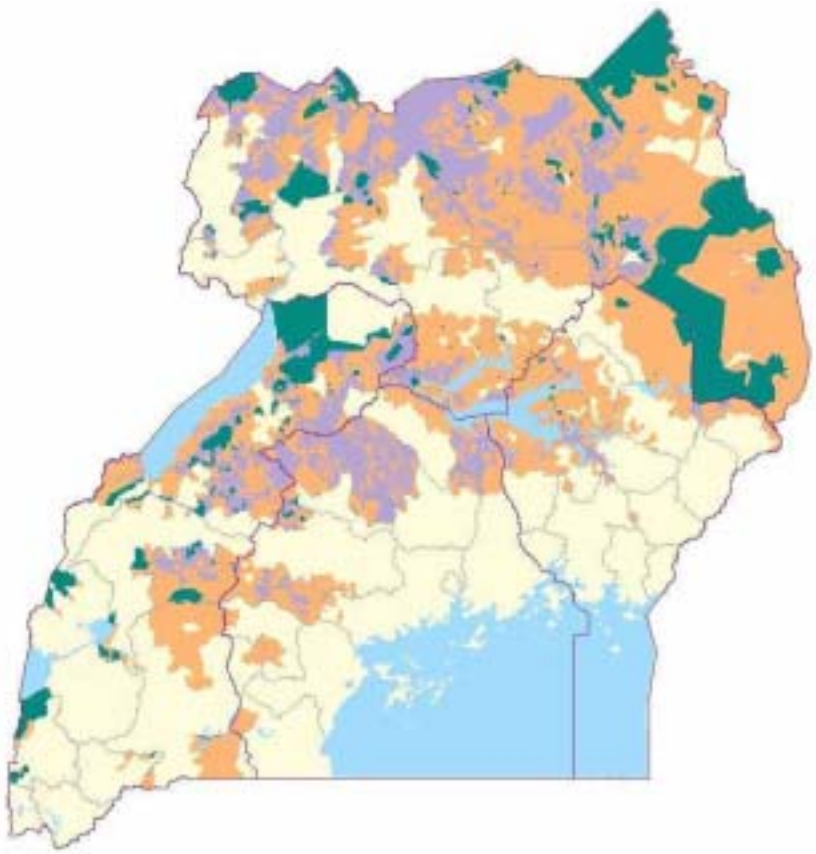
Regional boundaries

Lakes and waterways

No potential for expansion of subsistence crops

Source: Based on Sserunkuuma et al, 2001; National Biomass Study, 1996.

Fig 14: Environmental Feasibility of Expansion of Livestock Production ("Hot Spots")



Potential area for expansion of livestock production	Area (000 sq km)	Share (percent)
High feasibility: no conflict	56.7	52.2%
Feasible: conflict with potential conservation areas	34.0	31.3%
Low feasibility: conflict with existing protected areas	17.9	16.5%

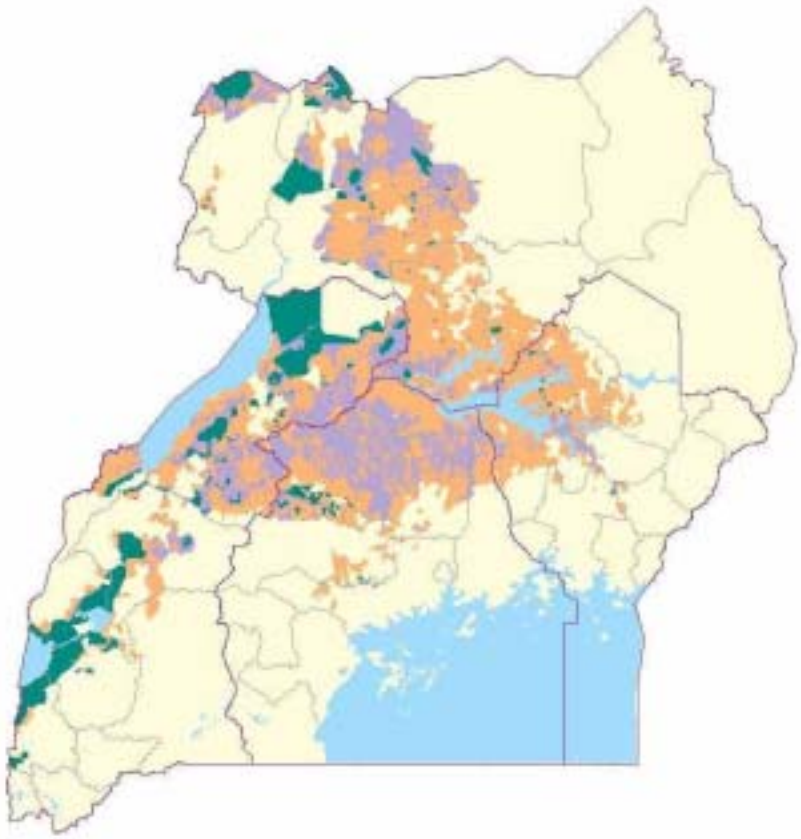
Regional boundaries

Lakes and waterways

No potential for expansion of livestock production

Source: Based on Sserunkuuma et al, 2001; National Biomass Study, 1996.

Fig 15: Environmental Feasibility of Expansion of Forestry ("Hot Spots")



Potential Area for Expansion of Forestry	Area (000 sq km)	Share (percent)
High feasibility: no conflict	27.5	45.9%
Feasible: conflict with potential conservation areas	23.7	39.6%
Low feasibility: conflict with existing protected areas	8.7	14.5%

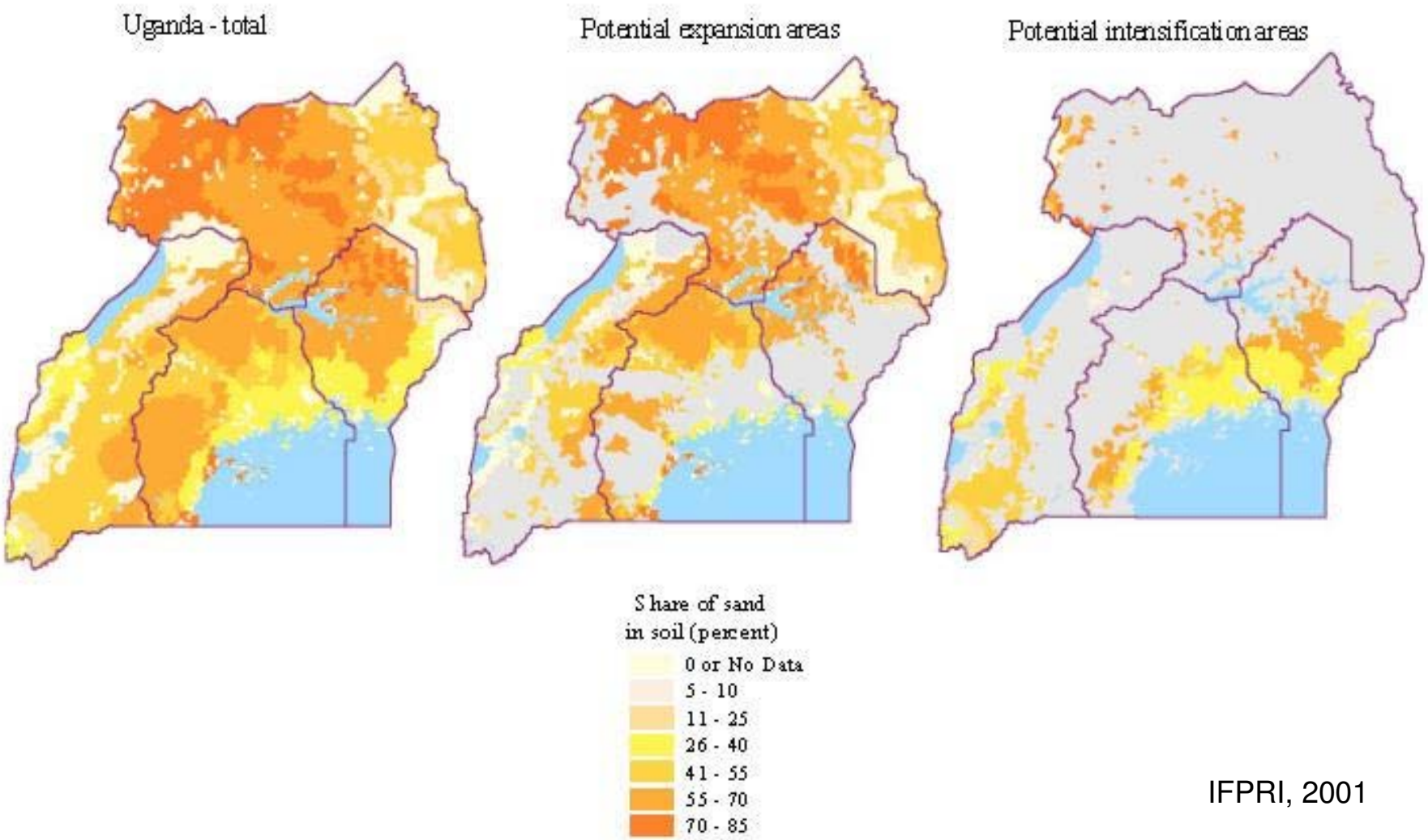
Regional boundaries

Lakes and waterways

No potential for expansion of forestry

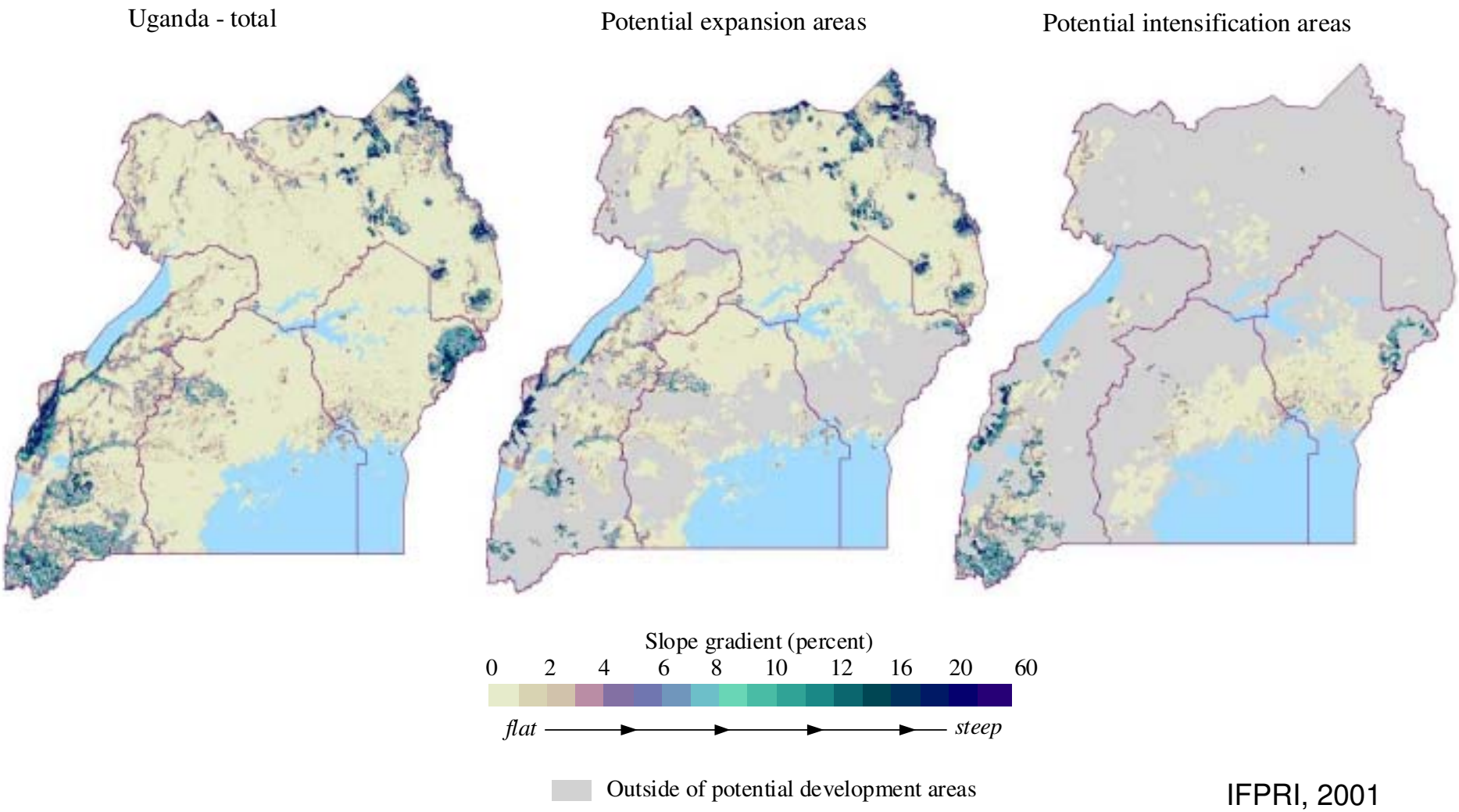
Source: Based on Sserunkuuma et al, 2001; National Biomass Study, 1996.

Fig 16: Potential Soil Degradation Effects of Agriculture-based Land Use Options ("Hot Spots")



IFPRI, 2001

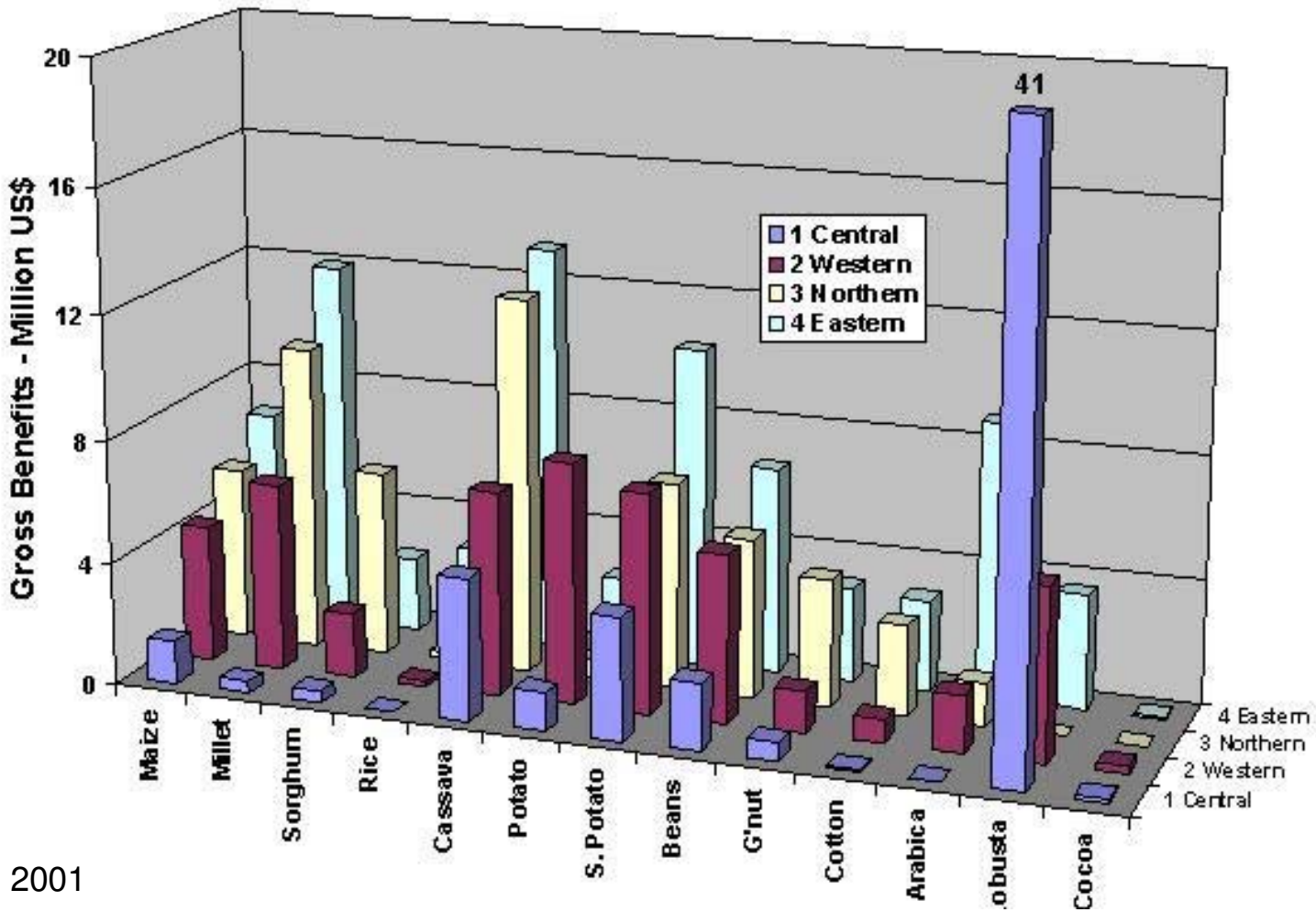
Fig 17: Potential Soil Erosion Effects of Agriculture-based Land Use Options ("Hot Spots")



IFPRI, 2001

Fig 18: Potential Economic Benefits of Increased Agricultural Productivity

Graph shows the gross benefit of a single-shot 1% increase in productivity at the district level



IFPRI, 2001

Fig 19: Producer Benefits by District for Selected Food Crops

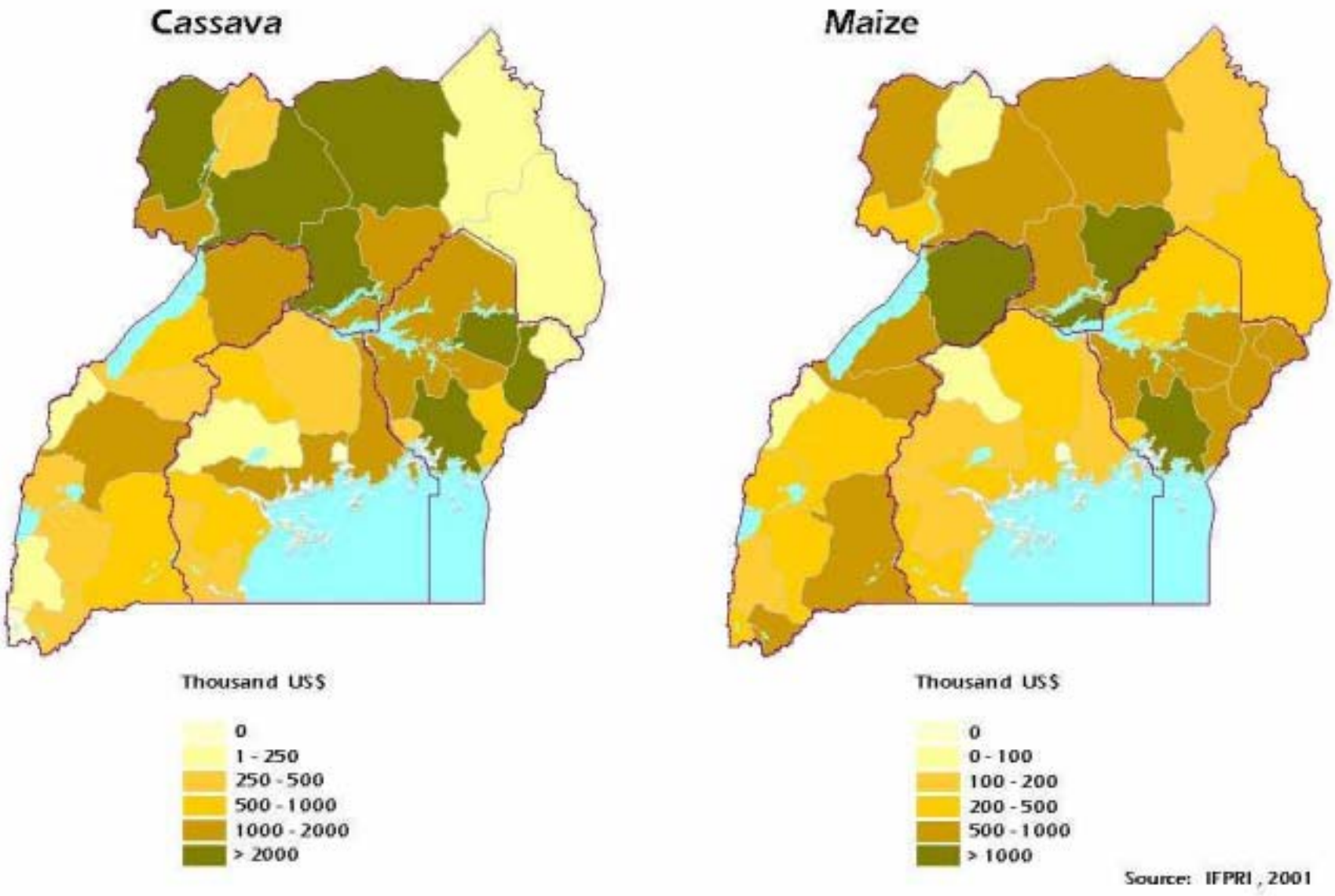
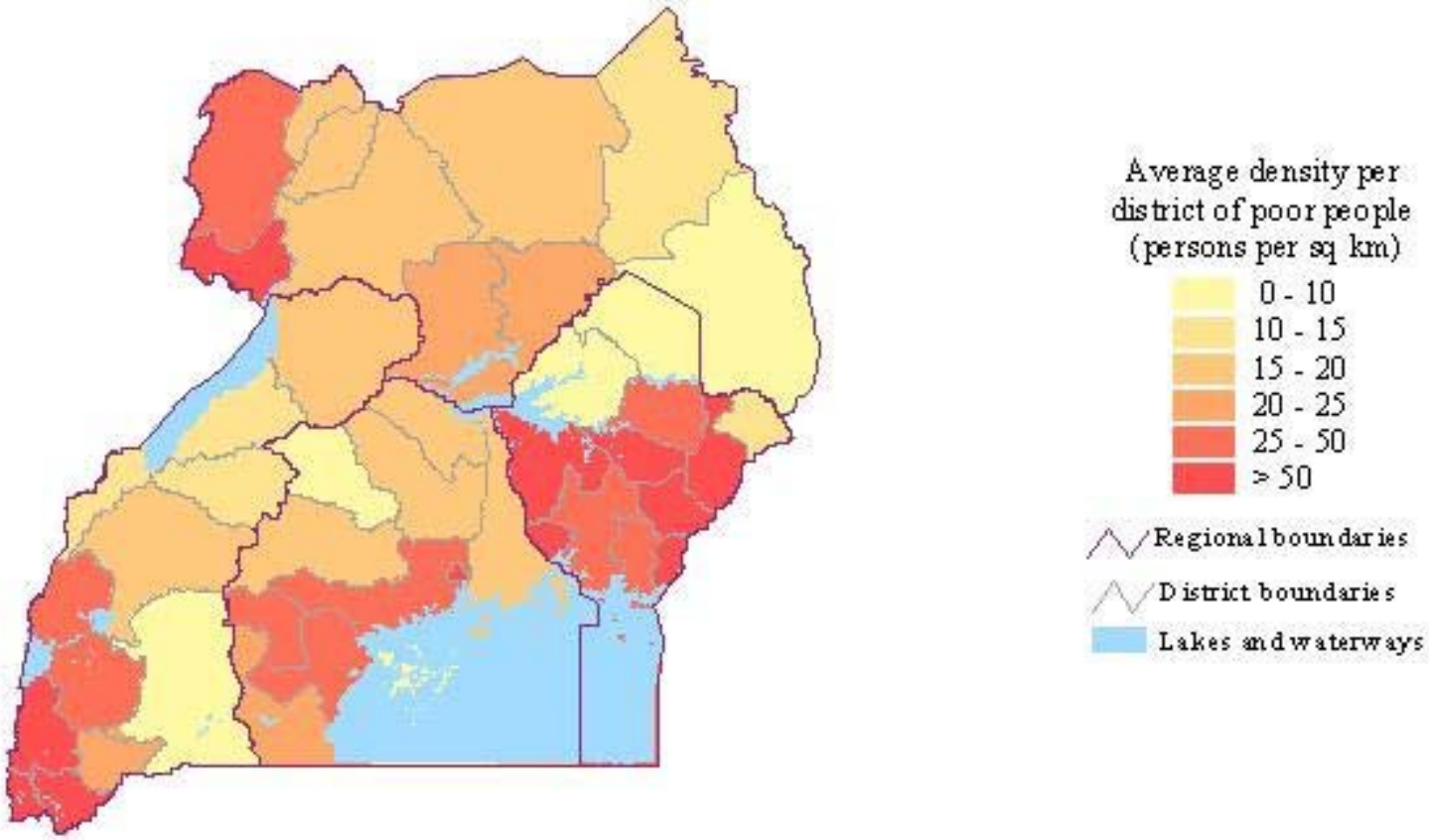


Fig 20: Producer Benefits by District for Selected Cash Crops

Source: IFPRI, 2001

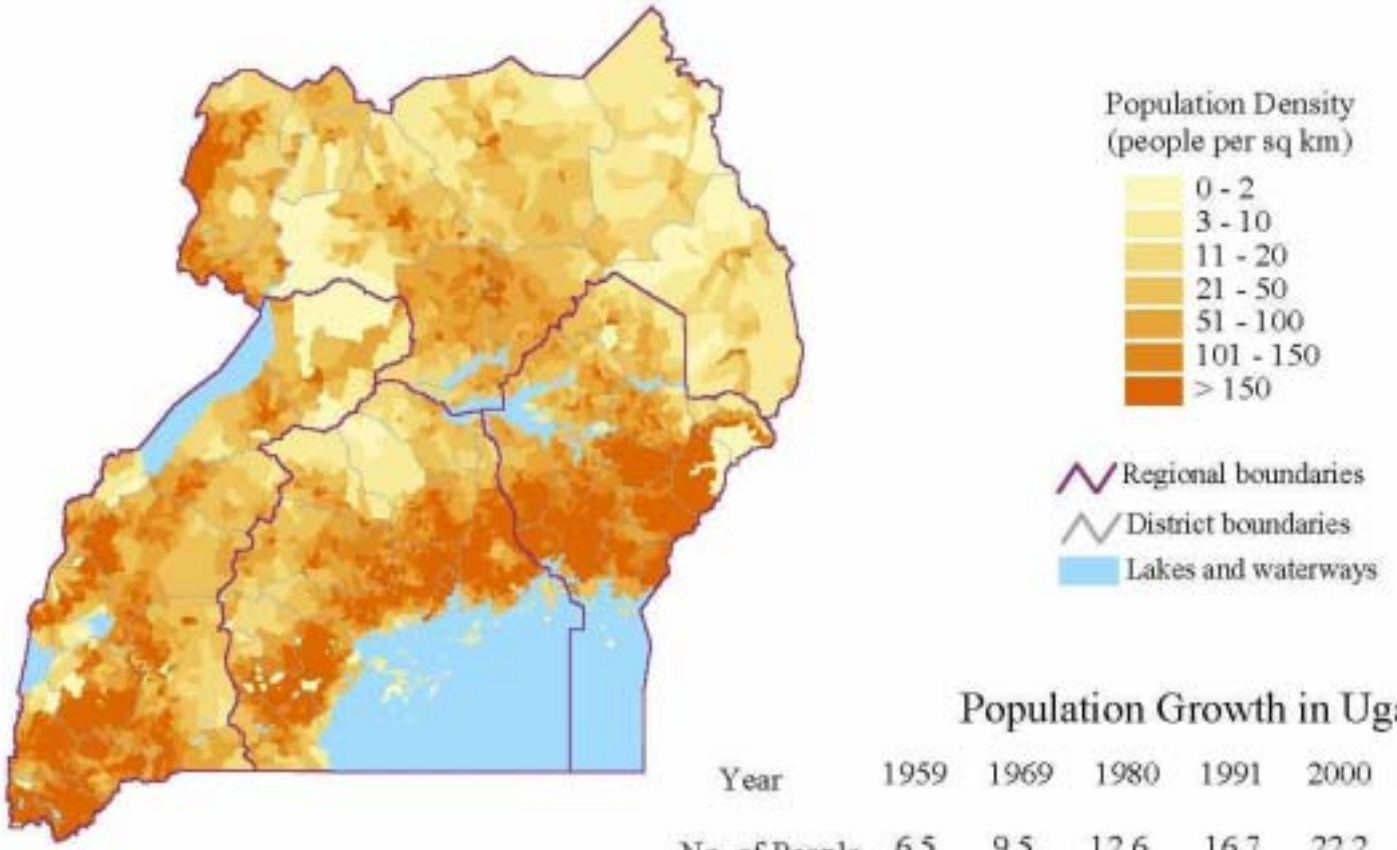
Fig 21: Poverty Density
(District level estimates: 1992/93)



Poverty is defined as falling within Uganda's lowest national expenditure quartile

Source : Chemonics (2000) based on Integrated Household Survey 1992/93.

Fig 22: Population Distribution
(Parish level estimates: 2000)



Population Growth in Uganda

Year	1959	1969	1980	1991	2000	2010	2025
No. of People (millions)	6.5	9.5	12.6	16.7	22.2	28.4	45.0

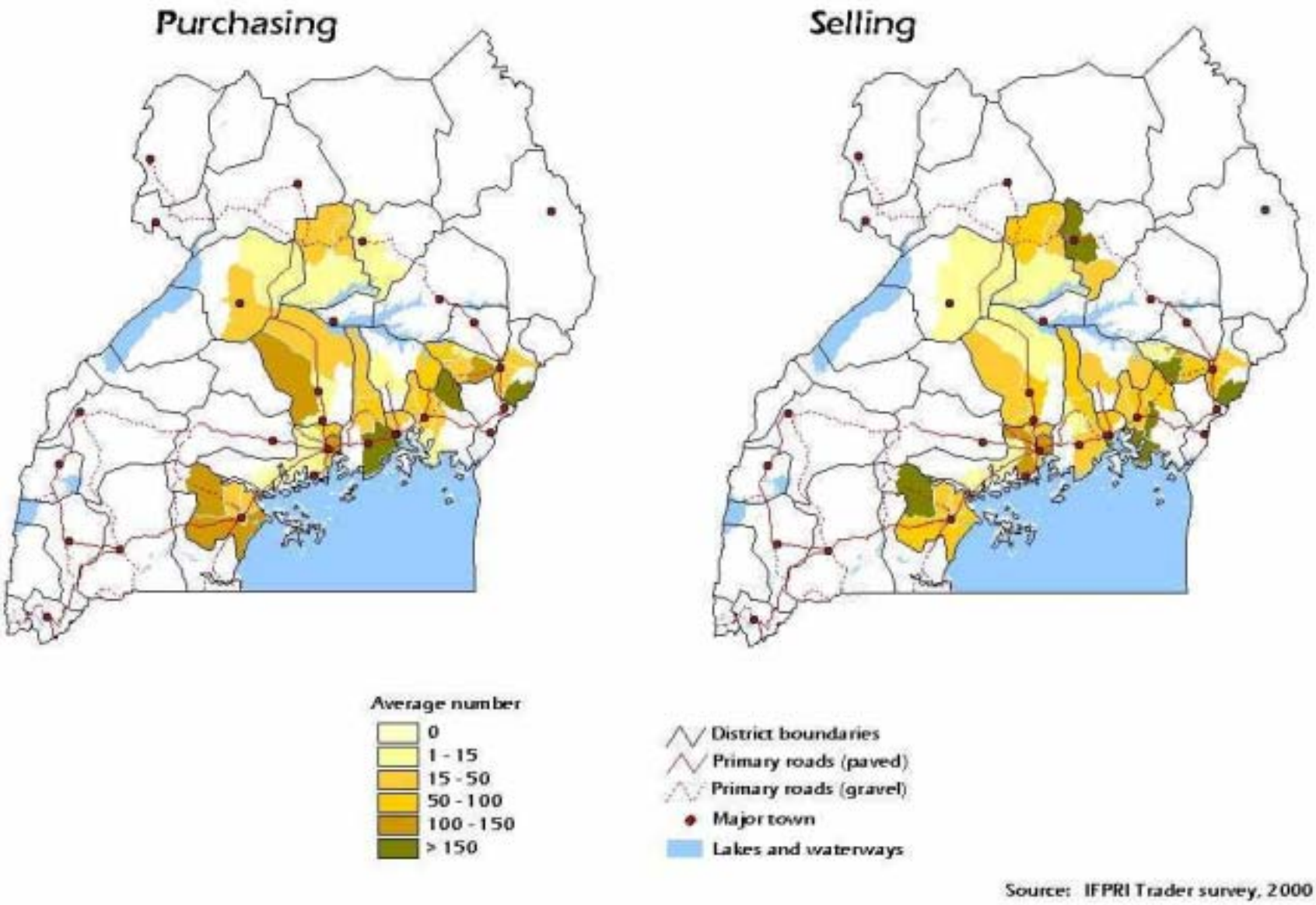
Source: Density: Gerd Ruecker (2001) based on Uganda Bureau of Statistics: 2000 Statistical Abstract (June, 2000); Growth: UBOS, 2000; Chemonics, 2001.

IFPRI, 2001

Fig 23: Market Access and Infrastructure

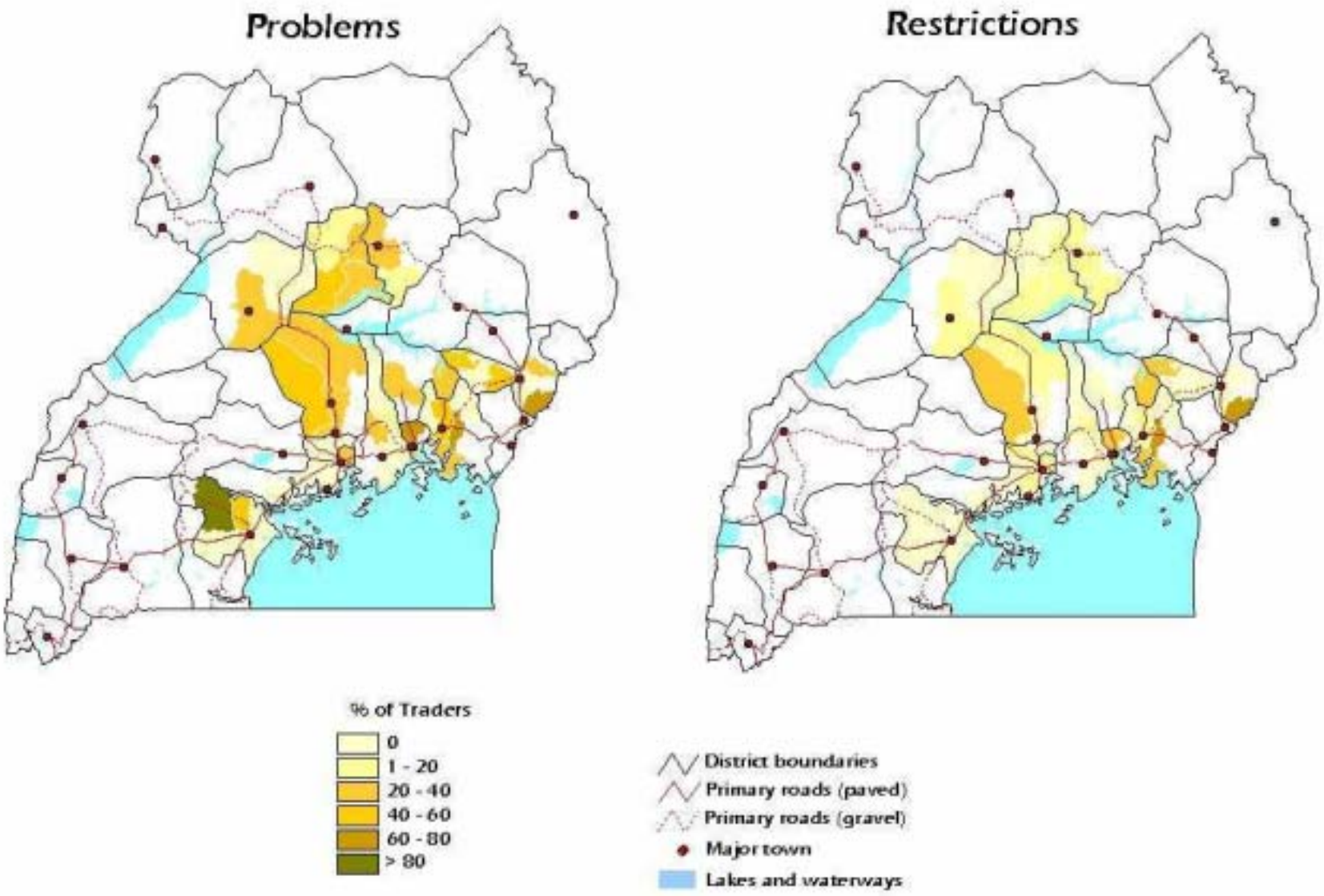
Source: ESRI 1995; Wood et al 1999.

Fig 24: Average Number of Competitors



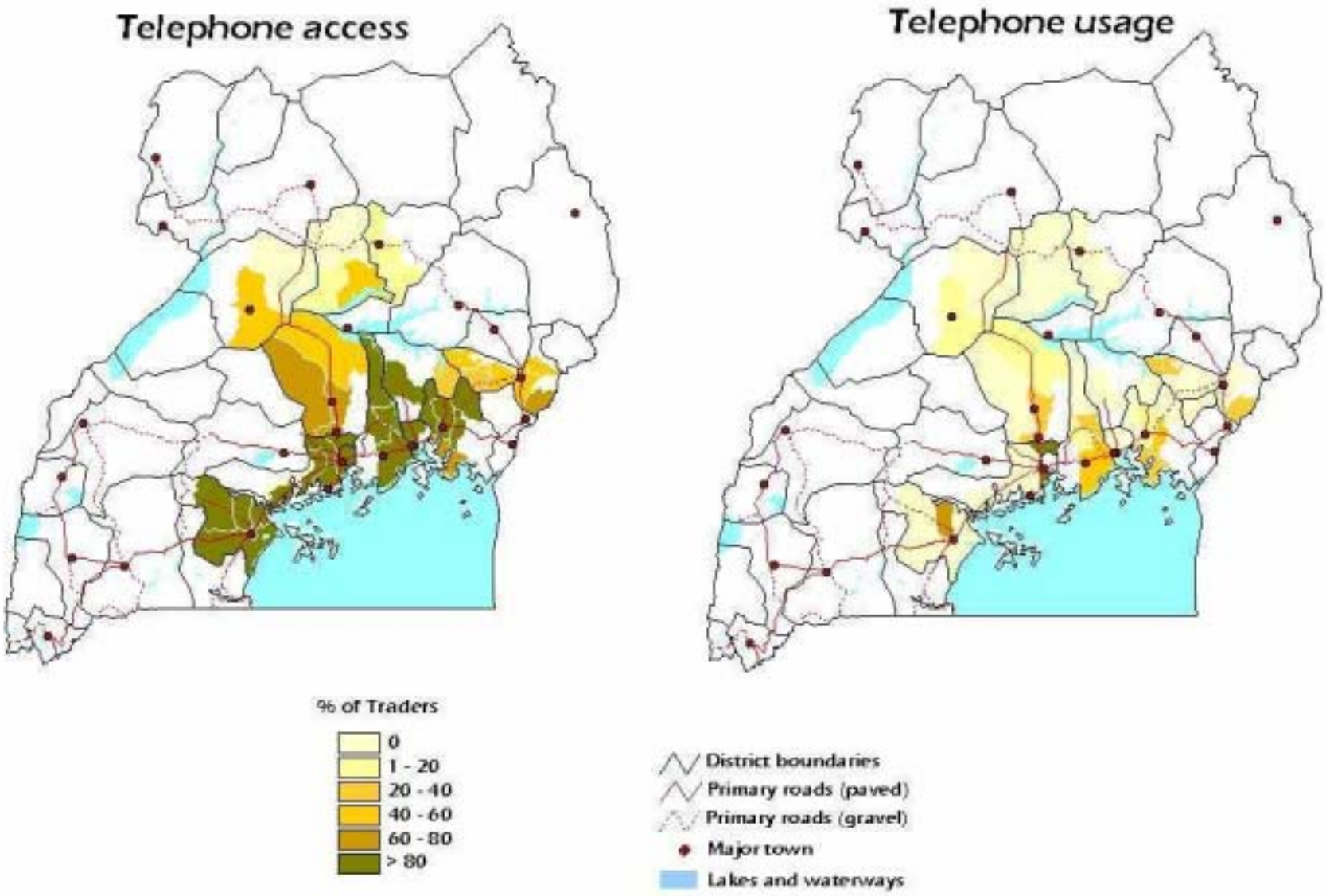
Source: IFPRI Trader survey, 2000

Fig 25: Percentage of Traders Reporting Transport Problems and Restrictions



Source: IFPRI Trader survey, 2000

Fig 26: Telephone Access and Usage by Traders



Source: IFPRI Trader survey, 2000