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Mapping a Better Future

Spatial Analysis and Pro-Poor Livestock Strategies in Uganda

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International Livestock Research Institute
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Contents

Foreword	4
Preface	5
Executive Summary	6
Introduction	8
<i>Rationale and Approach</i>	9
<i>Audience</i>	10
An Overview of Livestock and Poverty	12
<i>Livestock Distribution</i>	14
<i>Role of Livestock in Livelihoods and Poverty Reduction</i>	17
<i>Where are the Poor?</i>	19
Dairy and Poverty	23
<i>Policy Support to the Dairy Sector</i>	23
<i>Milk Surplus and Deficit Areas</i>	24
<i>Milk Surplus and Deficit Areas and Poverty</i>	24
<i>Discussion and Future Analysis</i>	24
Livestock Diseases and Poverty	30
<i>Trypanosomiasis Risk and Livestock</i>	32
<i>Trypanosomiasis Risk and Poverty</i>	34
<i>Discussion and Future Analysis</i>	34
Moving Forward: Conclusions and Recommendations	38
<i>Conclusions</i>	38
<i>Recommendations</i>	39
References	41
Acknowledgments	44

LIST OF BOXES

1. Use of Poverty Maps for Geographic Targeting in East Africa
2. Livestock Production Systems in Uganda
3. Sources of Livestock Data in Uganda
4. 2005 Uganda Poverty Maps: Indicators
5. Mapping Poverty: The Relationship Between Poverty Rate, Poverty Density, and the Number of Poor
6. A Dairy Development Initiative Based on Business Services Delivery Hubs
7. Trypanosomiasis

LIST OF TABLES

1. Land Area and Human Population in Uganda by Livestock Production System, 2005
2. Trypanosomiasis Risk in Uganda: Land and Livestock Profile, 2002
3. Trypanosomiasis Risk in Uganda: People and Poverty Profile, 2005

LIST OF MAPS

1. Livestock Production Systems in Uganda
2. Cattle Distribution, Ownership, and Breeds, 2008
3. Major Livestock Species by Subcounty, 2002
4. Poverty Rate: Percentage of Rural Subcounty Population Below the Poverty Line, 2005
5. Poverty Density by Rural Subcounty: Number of People Below the Poverty Line per Square Kilometer, 2005
6. Potential Milk Surplus and Deficit by Parish, 2002
7. Poverty Rate by Subcounty in Milk Deficit Areas
8. Poverty Density by Subcounty in High Milk Surplus Areas
9. Economic Development Hubs and Poverty Rate by Subcounty
10. Tsetse Distributions: Combined Map of the Distributions of *Glossina fuscipes*, *G. pallidipes*, and *G. morsitans submorsitans*

Foreword

Progress in the livestock sector can play a vital role in meeting Uganda's development goals. Because more than 70 percent of Ugandans own livestock, improvements in livestock productivity, health, and breeding can have a direct and positive effect on the household incomes and economic prospects of many of the nation's residents—particularly the rural poor. But such improvements cannot be taken for granted. They require a deft combination of well-targeted investments in livestock research, infrastructure, and services, facilitated by effective agriculture and poverty policies.

Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda offers a unique analytical basis with which to inform policy and target investments. The spatial approach used here, which meshes subnational poverty and livestock data, is particularly useful for integrating the many different kinds of information that must inform prudent investment decisions in the poverty and livestock sectors. The past decade has seen significant advances in the range and quality of both livestock- and poverty-related data available to decision-makers. What has been lacking is an analytically sound approach to integrate the two sets of data in a manner that yields new insights into the poverty-livestock relationship. This publication demonstrates how to bridge this divide.

This is a propitious time for this report to appear. Government agencies are now outlining their investment priorities for the agricultural sector in support of the National Development Plan covering 2010/11-2014/15. Increasing farmers' income is one of the Plan's key objectives for the agricultural sector. The livestock sector figures prominently in this effort, with plans to increase meat and dairy pro-

duction through targeted investments. But where should these investments be focused and what strategies should they employ? Detailed spatial analyses such as those that appear here can help reveal the answers.

We are confident that the approach proposed in this report will help Uganda to refine its investment priorities so that the livestock sector acts as a sustainable engine of pro-poor agricultural growth. We take note, as outlined in these pages, of the demonstrable benefits of incorporating poverty information in livestock-related interventions, and of using livestock sector information to improve poverty reduction efforts. Finally, we extend our sincere thanks to our international partners in this report, the Food and Agriculture Organization of the United Nations, the International Livestock Research Institute, and the World Resources Institute. Such collaborations bring us measurably closer to the goal of reconciling livestock development and poverty reduction in Uganda.



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Preface

Uganda's well-being is inextricably tied to livestock. Seven in ten households own cattle, sheep, goats, pigs or chickens, rendering livestock essential to the nation's diet, livelihoods, and culture. Recognizing this, the government has made greater meat and dairy production a central plank of its National Development Plan for the next five years.

Over the past decade, Uganda's livestock sector made impressive gains in size, herd quality, and productivity. But even greater gains are required to meet the nation's ambitious plans to attain food security, household income growth, and poverty reduction in line with the UN Millennium Development Goals through targeted agricultural development. *Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda* provides a powerful tool to help achieve these gains.

The report explores a topic of critical importance at the interface of environment and development. Its innovative spatial analysis provides valuable insights that will help decision-makers to better target efforts to increase livestock production while reducing poverty. The maps on the following pages overlay the distribution of poverty, livestock and dairy production, and the incidence of animal disease, illuminating in comprehensive detail how these factors interact. This vitally important information will help decision-makers to provide more effective livestock infrastructure and services as well as disease prevention initiatives to the poor.

These analyses are the product of an ambitious, productive, and longstanding collaboration. The high-quality datasets and maps used in this report were developed and prepared by the Ugandan government. The Uganda Bureau of Statistics—which is affiliated with the Ministry of Finance, Planning and Economic Development—produced the localized poverty maps. The Ministry of Agriculture, Animal Industry and Fisheries provided key insight and knowledge to interpret the maps and propose ways to act on these analyses. In addition, the Food and Agriculture Organization of the United Nations, the International Livestock Research Institute, and the World Resources Institute supplied technical support to derive new maps and analyses.

This report builds on pioneering poverty and ecosystem mapping work undertaken in Kenya, and complements similar map analyses on Ugandan wetlands and environmental health. We hope that the publication's maps, policy implications, and model of collaboration will inform national strategies and inspire poverty reduction planning in Uganda and beyond.

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Executive Summary

Livestock represents an essential part of Uganda's agriculture, culture, and economy. While the growth of Uganda's total agricultural output has declined, livestock trends are up considerably. The total number of cattle, sheep, and goats more than doubled between 2002 and 2008, and the number of pigs and chickens grew by 88 and 59 percent, respectively. Beef and milk production both increased by 8 percent in 2008 alone.

Livestock are particularly important to the subsistence agriculture on which seven out of ten Ugandans rely for their livelihood. While income from livestock provides only one of many sources of income for rural households, people typically rank livestock as their second or third most important means of livelihood. It is not surprising then that over 70 percent of all households in Uganda owned livestock in 2008. Indeed, smallholders and pastoralists dominate the livestock sector. Farming households with mixed crop and livestock production and pastoralists together own 90 percent of Uganda's cattle and almost all of the country's poultry, pigs, sheep, and goats.

Uganda's policymakers have acknowledged the importance of livestock to household incomes, the achievement of national food security and the Millennium Development Goals, as well as to employment creation and poverty reduction. Thus, as part of its National Development Plan covering 2010/11-2014/15, the government intends to boost meat and dairy production by increasing its investments in improved breeds, water infrastructure for livestock, and better management of rangeland and forage resources.

RATIONALE AND APPROACH

Ensuring that government investments in the livestock sector benefit smallholders and high-poverty locations will require more evidence-based local planning supported by data, maps, and analyses. *Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda* is intended to address this need. To do so, it compares the latest 2005 poverty maps with maps of livestock data from the 2002 population and housing census and the 2008 national livestock census. Using these data, it examines the spatial relationships between poverty, livestock production systems, the location of livestock services such as dairy cooling plants, and livestock disease hotspots.

By providing illustrative examples of maps that can be developed with these indicators and analyses of what they mean for policy, this report demonstrates how information on the location and severity of poverty can assist livestock sector decision-makers in setting priorities for interventions. Similarly, decision-makers concerned with poverty reduction will see how comparing levels of poverty in a given location with maps of livestock indicators can inform efforts to fight poverty.

This report is intended for a variety of audiences, including analysts and decision-makers in the livestock and dairy sectors, personnel involved in livestock research and advisory services, officials involved in national planning and budgeting, and civil society and nongovernmental organizations. It is motivated by the fact that, while there is a growing body of knowledge about Uganda's livestock sector, comparatively little is known about the interrelationship between livestock and poverty. Two factors have contributed to this knowledge gap: (1) Household surveys undertaken to date in Uganda have not managed to break down household income into its various components so that an explicit link can be made between welfare and the role of livestock at the household level; (2) Subnational poverty and livestock data for small administrative areas have only recently become available.

The spatial analysis approach taken in this report provides a way forward. It suggests that by integrating more detailed information on livestock distribution, animal husbandry and veterinary service provision, disease incidence, and poverty, planners can more effectively design and target livestock management interventions and policies so that the benefits reach a greater proportion of poor communities and the costs associated with land-use changes or new restrictions on livestock use do not disproportionately affect the poor.

REPORT OVERVIEW

The report comprises five sections:

Introduction: Gives an overview of the importance of livestock in Uganda's agricultural economy and in the household economy of the poor; provides the rationale and policy context for the report; and describes the methods and datasets involved.

KEY FINDINGS AND RECOMMENDATIONS

Findings

While the maps and analyses in this report are primarily designed to demonstrate the value to decision-makers of combining social and livestock-related information, they also support the following conclusions:

- *Maps showing milk surplus and deficit areas can highlight geographic differences in market opportunities for poor dairy farmers and help target knowledge dissemination, market infrastructure investments, and service delivery to dairy farmers.*
- *Maps showing animal (and human) disease risk by livestock production system can help target and prioritize areas for intervention. The impact of disease on livestock and their owners differs geographically because the role of livestock in peoples' livelihoods varies among production systems.*
- *Mapping poverty, livestock production systems, and distribution of disease vectors such as tsetse allows a better understanding of how the disease affects livestock owners in terms of livelihoods, welfare, and food security.*

Recommendations

Strengthening the supply of high-quality spatial data and analytical capacity will provide broad returns to future planning and prioritization of livestock sector and poverty reduction efforts. Priority actions to achieve this include:

- *Fill important livestock data gaps, regularly update data, and continue the supply of poverty data for small administrative areas.*
- *Strengthen data integration, mapping, and analysis through regular and focused training that promotes understanding of the whole livestock production system.*

Promoting the demand for such indicators and spatial analyses will require leadership from several government agencies, including the Ministry of Agriculture, Animal Industry and Fisheries, Ministry of Finance, Planning and Economic Development, Ministry of Local Government, and National Planning Authority. Actions in the following three areas carry the promise of linking the supply of new maps and analyses with specific decision-making opportunities:

- *Incorporate poverty information in livestock-related interventions and in regular performance reporting for the livestock sector.*
- *Incorporate livestock sector information into poverty reduction efforts.*
- *Incorporate poverty maps and maps of livestock production systems, disease risk, etc. into local decision-making.*

An Overview of Livestock and Poverty: Describes and depicts in maps Uganda's various livestock production systems, as well as the composition and distribution of the nation's livestock herd. Explores the connection between livestock and the livelihoods of the poor, and presents poverty maps for the country.

Dairy and Poverty: Considers the importance of dairy income to small-scale farmers. Maps areas of milk surplus and milk deficit (areas where production either exceeds or falls short of demand) and compares these to poverty maps and to areas where dairy development hubs are planned.

Livestock Diseases and Poverty: Examines the incidence of African animal trypanosomiasis (sleeping sickness) throughout Uganda and compares it to the distribution of livestock production systems, livestock densities, and poverty rates and densities. It considers the implications for investments in programs to control the tsetse fly (the insect vector of the disease in livestock and also in people).

Moving Forward: Conclusions and Recommendations: Summarizes observations from the map analyses presented in the report and makes recommendations on how to improve and expand upon these analyses and catalyze greater use of the resulting information in decision-making.



Introduction

Uganda's diverse agroclimatic and soil conditions support various agricultural activities, but livestock are an essential part of agricultural systems in most parts of the country. About 71 percent of all households in Uganda owned livestock in 2008 (MAAIF and UBOS, to be published).

Agriculture plays a key role in Uganda's economic development. For the majority of Ugandans, the agricultural sector (including crops, livestock, and fisheries) is the main source for livelihoods, employment, and food security. The sector provided 73.3 percent of employment in 2005/06, and most industries and services in the country are dependent on it (UBOS, 2009). Despite its significance, growth in agricultural output has declined from 7.9 percent in 2000/01 to 2.6 percent in 2007/08 (UBOS, 2009; NPA, 2010) with almost no growth in output in 2005/06 and 2006/07. A combination of factors including drought, instability, pest outbreaks, and productivity and price declines for selected crops and commodities contributed to the decline (NPA, 2010). Combined with faster growth in the services and industrial sectors, it has reduced agriculture's share of Uganda's gross domestic product (GDP). Agriculture's contribution to GDP fell from 20.6 in 2004 to 15.6 percent in 2008, measured in constant 2002 prices (UBOS, 2009).

Smallholder production dominates the agricultural sector with the exception of tea and sugar, which are primarily large-scale commercial efforts (Matthews et al., 2007). About 68 percent of Ugandan households depend on subsistence farming for their livelihood (UBOS, 2007), with the majority located in rural areas. Most subsistence farmers are involved in a combination of agricultural activities—growing crops and raising various poultry and livestock—but also rely on other means for their livelihood, such as remittances and wage labor.

While growth rates in total agricultural output have declined, livestock trends are up considerably. According to the Uganda Bureau of Statistics, there were an estimated 11.4 million cattle in Uganda in 2008, up from 5.5 million in 2002 (UBOS, 2009).¹ Milk production in 2008 reached 1,458 million liters, up from 1,320 million liters in 2005 (UBOS, 2009). Beef and milk production both increased

by 8 percent during 2008. The total number of sheep and goats more than doubled between 2002 and 2008, and the number of pigs and chickens grew by 88 and 59 percent, respectively (MAAIF and UBOS, to be published). Strong domestic and regional demand for livestock products contributed to this growth. In 2008, Ugandans raised 12.5 million goats, 3.4 million sheep, 3.2 million pigs, and 37.4 million poultry (MAAIF and UBOS, to be published).

Smallholders and pastoralists dominate the livestock sector. Farming households with mixed crop and livestock production, and pastoralists together own 90 percent of Uganda's cattle and almost all of the country's poultry, pigs, sheep, and goats (Turner, 2005). Livestock production in Uganda contributed 1.6 percent to total GDP in 2008 (measured in constant 2002 prices), down from 1.8 percent in 2004 (UBOS, 2009).

Livestock play multiple roles and provide many valuable services and products for rural households (LID, 1999), many of them not captured in standard household surveys and national accounts. A detailed livelihoods study in three districts of Uganda shows that while income from livestock provides only one of many sources of income for rural households, people typically rank livestock as their second or third most important means of livelihood (Ashley and Nanyeeena, 2002). The same study found that livestock are valued by the majority of poor livestock-keepers in Uganda for the multiple contributions they make to livelihoods, including enabling saving, providing security, accumulating assets, financing planned expenditures, providing livestock products (e.g., meat, milk, eggs, manure, draft power), and maintaining social capital (reflected, for example, by the number of social contacts who can be expected to provide support and resources in case of an emergency).

Livestock production has drawbacks: the animals can degrade the environment when not managed in a sustainable manner, they harbor disease agents that transmit illnesses between cattle and humans (for example, trypanosomes in cattle and highly pathogenic avian influenza viruses in poultry), and animal-source foods can contribute to health risks. However, when compared to the much larger benefits of livestock-keeping to livelihoods and human well-being for poverty reduction, these risks are relatively small and can be mitigated, especially when applied in less intensive subsistence farming systems (Randolph et

1. See Box 3 on the limitations of the 2002 livestock data and the compatibility of national livestock estimates between 2002 and 2008.

al., 2007; Perry and Grace, 2009). Managing the negative environmental impacts of intensive livestock production systems, however, requires a more concerted effort which includes a careful examination of intensive production schemes, better management of inputs, elimination of perverse subsidies, and full accounting of off-farm externalities.

Uganda's policymakers have acknowledged the importance of livestock to household incomes, the achievement of national food security and the Millennium Development Goals, as well as employment creation and poverty reduction (MFPED, 2004). The 2000 Plan for the Modernisation of Agriculture (PMA) has 'poverty eradication' as its overarching goal (MAAIF and MFPED, 2000). The focus of the PMA is the reorientation of farmers toward commercial agriculture. It does not lay out a livestock sector development strategy per se, but mentions increased productivity through improved breeds and feeding strategies.

The government is currently outlining priorities for the agricultural sector to support the new National Development Plan covering 2010/11 to 2014/15 (NPA, 2010). Under that plan, Uganda's national livestock sector is expected to follow and expand upon the priorities established under the PMA. Stakeholders contributing to the drafting of the plan have identified increasing farmers' income as a key objective for the agricultural sector. To achieve this, government would provide targeted support for six agricultural commodities in specific production zones, in addition to strengthening agricultural advisory services and research. For the livestock sector, the government intends to boost meat and dairy production, and preliminary plans are proposing increased investments in improved breeds, water infrastructure for livestock, and better management of rangeland and forage resources (NPA, 2010). Ensuring that these investments reach smallholders and disadvantaged high-poverty locations will require more evidence-based planning supported by data, maps, and analyses.

Why Mapping Matters

A primary challenge for government agencies working on livestock and poverty issues is that planning and implementing effective interventions requires coordination among multiple actors and across many sectors within and outside government. It involves reconciling a multiplicity of plans and policies introduced to deal with poverty reduction, agricultural modernization, rural development, land use, and other issues.

Maps—and the geographic information systems (GIS) that underlie them—are powerful tools for integrating data from various sources and therefore can be the vehicle necessary to overcome these coordination challenges. Maps showing poverty, livestock distribution, animal diseases, extension services, markets, and other indicators can provide decision-makers with a more coherent picture of how these

indicators are related, leading to more effective plans and interventions. Better and more detailed spatial analyses of these indicators can be used to examine whether current policies and interventions are targeting the crucial issues and localities. Maps can also be an effective vehicle for communicating to experts across sectors. In addition to informing various government actors, access to improved spatial information can help empower the public to query government priorities, advocate for alternative interventions, and exert pressure for better decision-making. Of course, spatial analysis of the type used here, though powerful, does have limitations. For one, the ability to show spatial relationships between livestock management and poverty depends greatly on the availability of high-resolution georeferenced data. Even when the required data are available, the complexities of the poverty-livestock relationship often make interpretation of map analyses and their application to policy challenging. Nonetheless, map analyses offer a unique window on how physical, social, ecological, and economic factors interact to determine the livelihood options available to rural Ugandans.

RATIONALE AND APPROACH

Today, decision-makers have access to a growing body of information about Uganda's livestock sector. For example, a study of how the sector can best contribute to the overall goal of poverty reduction in Uganda drew on field data collected from the districts of Mubende, Mbale, and Kamuli (Ashley and Nanyeenya, 2002), and an analysis of the Uganda dairy sector looked at trends in dairy development and associated factors (Staal and Kaguongo, 2003). However, knowledge about the intricate interrelationships between livestock and poverty is still limited. Two factors, among others, have contributed to the knowledge gap: (1) Household surveys undertaken to date in Uganda have not broken down household income into its various components so that an explicit link can be made between welfare and the role of livestock at the household level; (2) Subnational poverty and livestock data for small administrative areas have not been available until recently (see Boxes 3 and 4). In addition, analytical approaches to integrate relevant spatial datasets are lacking.

Mapping a Better Future, the outcome of a partnership of Ugandan and international organizations, helps address these barriers by comparing the latest 2005 poverty maps with maps of livestock data from the 2002 population and housing census, and the 2008 national livestock census. By providing illustrative examples of maps that can be developed with these indicators and analyses of what they mean for policy, this report demonstrates how information on the location and severity of poverty can assist livestock sector decision-makers in setting priorities for interventions. Similarly, decision-makers concerned with reducing poverty levels will see how comparing levels of poverty in a given location with maps of livestock indicators can inform efforts to fight poverty.

This report aims at motivating analysts and planners to develop their own maps (for example by using livestock data from the 2008 national livestock census), to fill remaining analytical gaps with new information, and to align livestock sector development and poverty reduction strategies. By integrating more detailed information on livestock distribution, animal husbandry and veterinary service provision, disease incidence, and poverty, planners can more effectively design and target livestock management interventions and policies so that the benefits reach a greater proportion of poor communities and the costs associated with land-use changes or new restrictions on livestock use do not disproportionately affect the poor.

Livestock present both opportunities and challenges for poor households as they try different strategies to improve their well-being. *Mapping a Better Future* highlights two examples where maps and spatial analyses are being used by various agencies and government planners to target livestock sector investments (e.g., milk cooling plants) and interventions (e.g., disease vector control programs):

- **Creating new market opportunities for poor dairy farmers and others involved in the dairy marketing chain, such as traders and processors.**
- **Assessing the impact of trypanosomiasis: a serious and widespread disease that transmits between humans and cattle (called nagana in cattle and sleeping sickness in people).**

Differentiating subcounties by their poverty and livestock profiles is a first step to formulate questions and hypotheses to better integrate livestock (or other environmental parameters) and development objectives into planning. However, this publication is not intended to explain causal relationships between poverty and specific livestock uses. For that, other factors would need to be examined that reflect different poverty dimensions and measure poverty not just at the subcounty level but also at other scales such as parish, village, and household levels. Rather, this publication is meant to trigger questions about livestock-poverty linkages by identifying the spatial relationships between them. The answers to these questions can then help inform and improve poverty and livestock management interventions.

AUDIENCE

The maps, analytical examples, and ideas for future analyses are intended to be of value to a variety of audiences for the following purposes:

- **Ministry of Agriculture, Animal Industry and Fisheries:** to highlight the widespread and important role livestock play in the livelihoods of the poor, and help better target their efforts to improve lives through livestock-related research and development efforts, and disease control policies and plans.

- **National Agricultural Research Organization:** to identify knowledge gaps and research opportunities in the livestock sector, and to strengthen the capacity of researchers to use spatial analysis for policy-relevant livestock research.
- **National Agricultural Advisory Services:** to identify service gaps and opportunities and support efforts and pro-poor investments in the livestock sector.
- **Dairy Development Authority:** to consider the linkages between poverty and dairying and support activities that are of particular benefit to poorer households and ensure the full participation in dairy sector development of more vulnerable groups, including women.
- **Ministry of Finance, Planning and Economic Development and decision-makers at all levels of government:** to change budgeting and planning so that it reflects the importance of livestock in livelihoods and the national economy; to support investments that boost the benefits of livestock such as income diversification, better household nutrition, and enhanced access to livestock assets; and to enhance the capacity of decision-makers to absorb policy research that employs spatial analysis.
- **National Planning Authority and Budget Monitoring and Accountability Unit:** to recognize the important role livestock play in the livelihoods of poor households and to monitor performance in implementing the National Development Plan through improved livelihoods from livestock.
- **Uganda Bureau of Statistics:** to account for the many livelihood roles played by livestock in future data collection.
- **Analysts and planning experts:** to provide decision-makers with more integrated analyses of livestock and poverty indicators.
- **Civil society and nongovernmental organizations:** to improve the capacity of civil society organizations to participate in policy processes and to hold decision-makers accountable for livestock-related efforts to reduce poverty and environmental degradation.

The geographic approach used in this publication will help Uganda's decision-makers "see" the livestock sector in a new light, and visualize ways to ensure the sector's optimal contribution to poverty alleviation. Moreover, better and more detailed spatial analyses of poverty-livestock relationships can then be used to scrutinize existing government priorities and examine whether current policies and programs target crucial issues and localities.

Box 1**USE OF POVERTY MAPS FOR GEOGRAPHIC TARGETING IN EAST AFRICA**

Both Kenya and Uganda have relied on poverty maps to allocate government resources to disadvantaged areas. Planners establishing priorities in Uganda's livestock sector could rely on similar approaches to design more specific geographic targeting or an allocation formula.

In Kenya, the national Water and Sanitation Programme, a 5-year (2005-2009) US\$ 65.5 million effort funded by Danida and Sida, the Danish and Swedish development agencies, used poverty maps to reach the most disadvantaged administrative areas. The Programme selected the poorest 362 of 2,500 Locations (an administrative unit with on average 10,000 people in rural areas). These Loca-

tions were chosen in stakeholder workshops with the help of an index showing the poorest ones with the lowest water and sanitation coverage. Half of the index value was determined by the poverty level in the Location, using data provided by Kenya's Central Bureau of Statistics and based on the country's poverty map. The other half of the index incorporated indicators of safe drinking water access, sanitation coverage, and past investments.

Uganda has relied on poverty maps to determine transfer amounts from central government to local governments in its Agriculture Extension Conditional Grant. Districts with higher poverty levels receive a higher share of the grant. The Min-

istry of Agriculture, Animal Industry and Fisheries has included population (60 percent), land area (20 percent), and poverty level (20 percent) in its formula to direct funds from the national budget to districts. The Agricultural Extension Conditional Grant was established in fiscal year 2007/08, and the total budget allocation for that and the following year has been equivalent to \$US 15 million. Districts are using the funds to expand agricultural extension services that provide training and information to farmers.

Sources: Jorgensen, 2005 and MFPED, 2009



An Overview of Livestock and Poverty

The combination of crops and livestock produced across Uganda varies considerably. In the north, large areas are too dry to support much cropping, thus households rely extensively on livestock for their living. In contrast, across much of the rest of the country, a wide range of crops and livestock can be found. Agricultural research and development strategies, therefore, need to be well targeted to the heterogeneous landscapes and diverse biophysical and socioeconomic contexts within which the agricultural production system operates. Information that spatially delineates landscapes with broadly similar livestock production strategies, constraints, and investment opportunities can be very useful for planners and policymakers.

Livestock production systems in Uganda can be categorized into two main groups based on their biophysical characteristics: the rangeland-based livestock-only system, and the mixed rainfed crop-livestock system. Each system can be further disaggregated by average temperatures and length of growing period into temperate and tropical highlands, humid and sub-humid zones, and arid and semi-arid zones (Thornton et al., 2002). Map 1 shows the prevalence of rangeland-based livestock-only systems

(tan colors) across the north. Uganda's largest livestock production area falls in the mixed rainfed crop-livestock category in the humid and subhumid zone (medium shade of turquoise) across the center of the country. The dark turquoise areas are the mixed rainfed crop-livestock system in the temperate and tropical highland zone, seen in the higher altitude areas of southern and western Uganda and along the Kenyan border in eastern Uganda.

Table 1 presents the amount of land and number of people found in each livestock system as of 2005. Almost 13 million people—about 55 percent of Uganda's population—live within the mixed rainfed crop-livestock system in the humid and sub-humid zone (within an area of 97,000 square kilometers, or 48 percent of Uganda's land area). The mixed rainfed crop-livestock system in the temperate and tropical zone follows second with a population share of 15 percent.

The human population in these two systems is projected to almost triple by 2050 (Thornton et al., 2002) and is expected to be associated with a growing importance of the livestock sector for the following reasons:

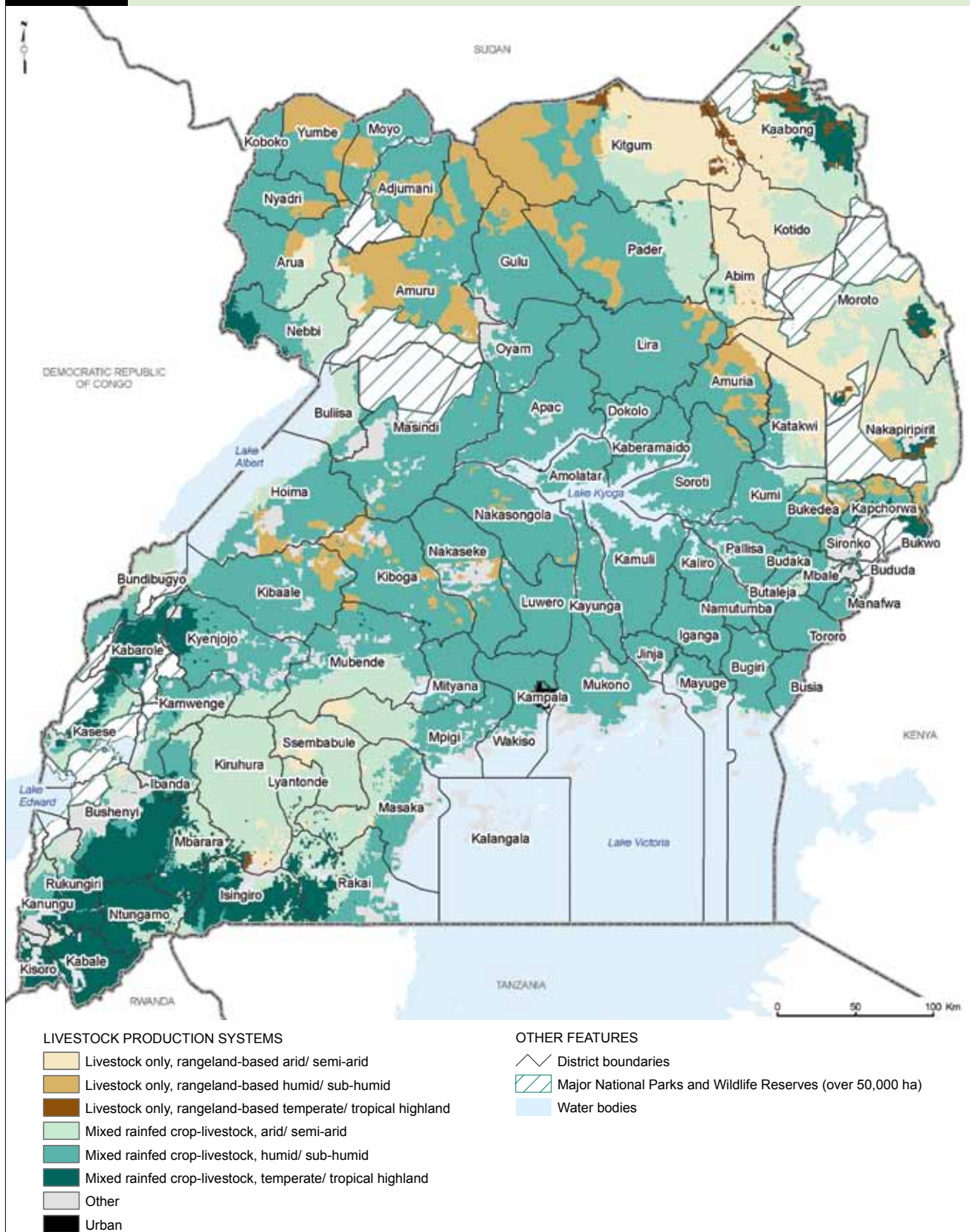
Table 1 LAND AREA AND HUMAN POPULATION IN UGANDA BY LIVESTOCK PRODUCTION SYSTEM, 2005

Production System		Land Area		Population		
		(000 square kilometer)	(percent)	Total Population in all Rural Subcounties (000)	(percent)	Average Population Density for all Rural Subcounties (persons/square kilometer)
Rangeland-Based Livestock-Only Systems	Arid and Semi-arid	19	9.4	653	2.8	35
	Humid and Sub-humid	17	8.6	727	3.1	42
	Temperate and Tropical Highlands	1	0.6	75	0.3	62
Total: Rangeland-Based Livestock-Only Systems		37	18.5	1,455	6.3	39
Mixed Rainfed Crop-Livestock Systems	Arid and Semi-arid	36	18.0	2,822	12.2	77
	Humid and Sub-humid	97	47.8	12,759	55.3	132
	Temperate and Tropical Highlands	16	7.9	3,490	15.1	219
Total: Mixed Rainfed Crop-Livestock Systems		149	73.7	19,072	82.6	128
Other Livestock Systems		16	7.7	2,554	11.1	164
TOTAL		202	100.0	23,081	100.0	114

Source: Authors' calculation. The data are derived from combining the livestock production systems (Map 1) with the rural population figures from the 2002 Uganda population and housing census (UBOS, 2002b), using GIS overlay functions.

Map 1

LIVESTOCK PRODUCTION SYSTEMS IN UGANDA



Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and livestock production systems (Thornton et al., 2002).

- Increased overall demand for livestock products driven by population growth and dietary shifts resulting from higher incomes (assuming new or better income opportunities are provided by all economic sectors).
- Increased local importance of livestock, especially in rangelands with limited cropping opportunities, to help feed, generate biogas, and provide livelihoods to a larger number of rural people.

Future livestock research and development efforts will need to focus on this dual challenge.

Box 2

LIVESTOCK PRODUCTION SYSTEMS IN UGANDA

Rangeland-based livestock-only systems: In these systems, more than 90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages, and purchased feeds, and less than 10 percent of the total value of production comes from crops. There is a high degree of importance of livestock in the farm household economy, and the land available per head of cattle is relatively high. Depending on the length of the growing period and the average temperature during the growing seasons, this system can be disaggregated into temperate and tropical highlands, humid and sub-humid zone, and arid and semi-arid zone.

Mixed rainfed crop-livestock systems: In these systems, more than 10 percent of the dry matter fed to animals comes from crop by-products and stubble, or more than 10 percent of the total value of production comes from non-livestock farming activities. There is another source of income besides livestock and relatively low land holdings per head of cattle. This system can also be further disaggregated by temperature and length of growing period.

Other livestock production systems: These include landless production systems with very high animal density per area such as intensive poultry production, pig and cattle feedlot operations, and large-scale dairy facilities. Many of the large-scale operations are located in peri-urban areas in close proximity to high demand areas for livestock products.

Area estimates shown in Table 1 represent potential extent and are based on landcover, population, and agroclimatic data. The area estimate for 'other livestock systems' is a residual and does not represent a precise number for landless production systems in Uganda, which include large-scale operations and small-scale stall-fed dairy.

Sources: Thornton et al., 2002 and Seré and Steinfeld, 1996.

LIVESTOCK DISTRIBUTION

The 11.4 million head of cattle counted in Uganda's 2008 national livestock census (see Box 3 for more detail) are not evenly distributed across the districts (see Map 2a). Kotido, Nakapiripirit, and Kaabong are the districts with the highest cattle numbers followed by Kiboga, Moroto, Kiruhura, Rakai, and Soroti Districts (MAAIF and UBOS, to be published). Another 21 districts, shown in light tan on Map 2a have cattle numbers between 140,000 and 270,000, slightly above Uganda's district average. Many

of these districts are in Uganda's 'cattle corridor,' an area stretching from northeast (e.g., Kotido District), through central (e.g., Nakasongola District) to southwest Uganda (e.g., Rakai and Ntungamo Districts).

In 2008, 1.7 million households owned cattle, representing 26 percent of all Ugandan households (MAAIF and UBOS, to be published). Cattle ownership is more widespread in northeast Uganda (Map 2b), where more than half of the households own cattle (e.g., Kaabong, Kotido, Nakapiripirit, Katakwi, Bududa, Amuria, Dokolo, Amolatar, Kumi, Bukedea, Sironko, and Kapchorwa Districts). Ownership of cattle is above the country average (30 percent) in most districts bordering Lake Kyoga and below the national average in the remaining districts.

Data from the 2008 national livestock census reveal the potential for a greater share of improved breeds in the livestock sector: Only 5.6 percent of the total cattle herd in Uganda were exotic or crossbred dairy cattle, 0.8 percent were exotic or crossbred beef cattle, and the remaining 93.6 were indigenous breeds such as Ankole and Zebu/Nganda (MAAIF and UBOS, to be published). Only 10 percent of cattle-owning households in Uganda owned exotic or crossbred dairy cattle; Map 2c highlights districts with such households. Districts with the highest share of households with exotic or crossbred dairy cattle are geographically concentrated in southwest, central, and south-eastern Uganda. Bududa, Bushenyi, Kampala, Wakiso, and Sironko are the top five districts with the largest herds (MAAIF and UBOS, to be published) and all have a high percentage of households owning improved breeds.

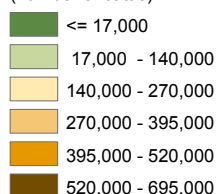
Numbers (and associated stocking rates) of cattle and other livestock increased considerably between 2002 and 2008, but the relative importance of different production zones has not changed greatly across the country. Maps 3a-e give a visual representation of average livestock densities in number of animals per square kilometer of cattle, goats, sheep, pigs, and poultry in subcounties across Uganda, drawing on modeled data from the 2002 population and housing census (see Box 3 for more detail).

The importance of cattle across Uganda in 2002 as captured in Map 3a (cattle density by subcounty) is similar to 2008 as displayed in Map 2a (number of cattle by district): The northeastern part of the country – Kotido, Kaabong, and Nakapiripirit Districts – has some of the highest cattle densities with over 150 cattle per square kilometer. In central Uganda, areas with similarly high cattle densities exist such as in Kiboga, Nakaseke, and Nakasongola Districts. Areas with cattle densities of 50–150 cattle per square kilometer extend from central Uganda down through the southern region, as seen in Kiruhura, Ssembabule, Mbarara, and Ntunguma Districts covering most of the 'cattle corridor' of Uganda. Densities of fewer than 25 cattle per square kilometer are found in many subcounties in central and western Uganda. Very low cattle densities (less than 10 cattle per square kilometer) are found in the

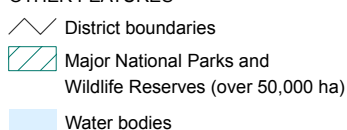
Map 2

CATTLE DISTRIBUTION, OWNERSHIP, AND BREEDS, 2008

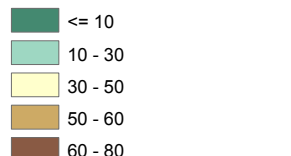
2a: Cattle Distribution

CATTLE DISTRIBUTION
(number of cattle)

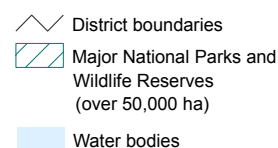
OTHER FEATURES



2b: Cattle Ownership

CATTLE OWNERSHIP
(percent of households with cattle)

OTHER FEATURES

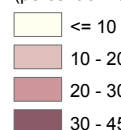


2c: Dairy Cattle Ownership

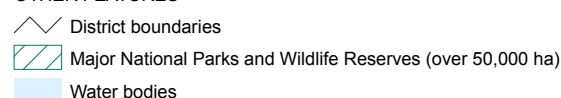


DAIRY CATTLE OWNERSHIP

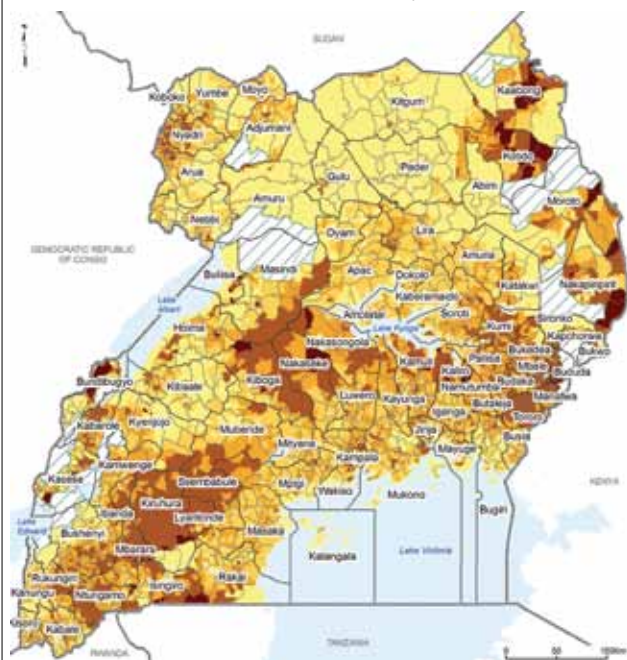
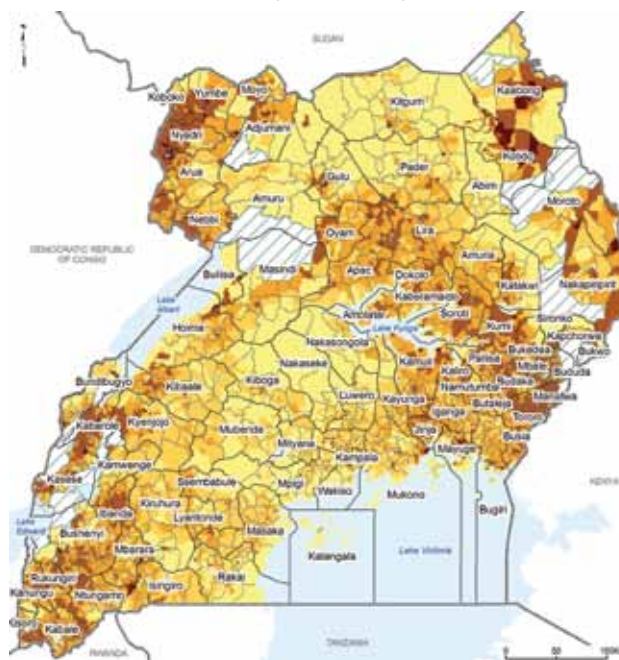
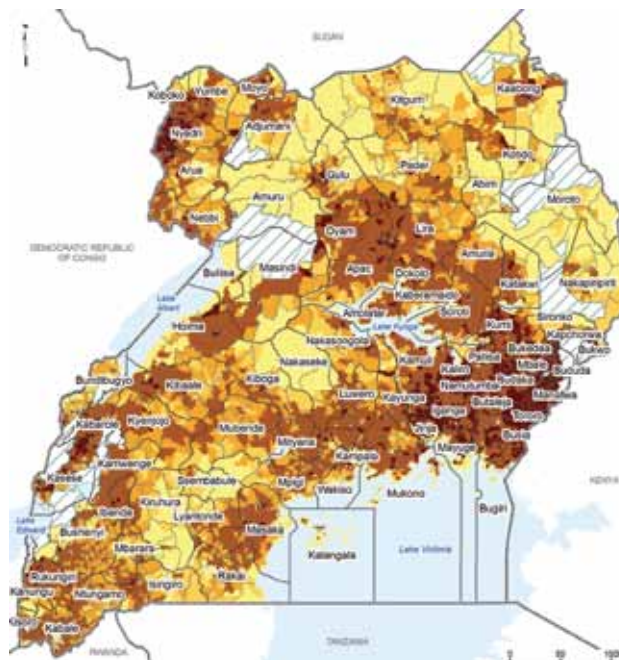
(percent of households with crossbred and exotic dairy cattle)



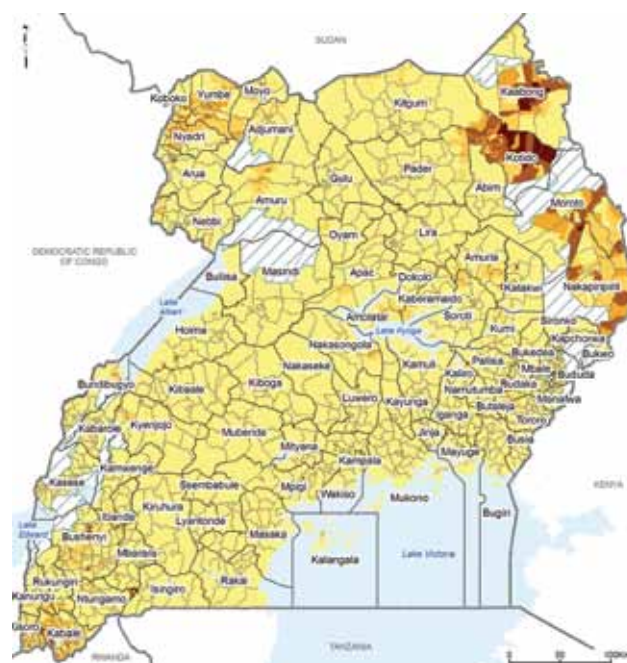
OTHER FEATURES



Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and number of cattle, cattle ownership, and dairy cattle ownership (MAAIF and UBOS, 2009).

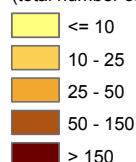
Map 3**MAJOR LIVESTOCK SPECIES BY SUBCOUNTY, 2002****3a: Cattle Density****3b: Goat Density****3d: Pig Density****3e: Chicken Density**

3c: Sheep Density

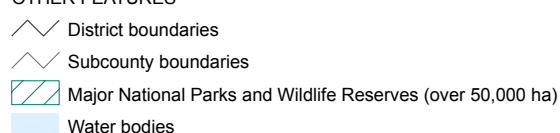


ANIMAL DENSITY

(total number of animals per sq. km)



OTHER FEATURES



Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and animal density (UBOS, 2002b).

center of the northern region and in a few subcounties in the western, central, and eastern regions.

The distribution of other livestock species follows different spatial patterns, but in both 2002 and 2008 the relative importance of different production zones for each species did not change considerably. The following maps show animal densities by subcounty in 2002.

The greatest number of goats per square kilometer, as shown in Map 3b, can be found in the northeast (Kaabong, Kotido, Nakapiripirit, and Moroto Districts), in the northwest (from Yumbe to Nebbi Districts), and in the southwest (Bushenyi and Ntungamo Districts). Goat density is also high in districts bordering Lake Albert, subcounties north of Lake Kyoga, and in southeast Uganda close to Kenya.

There are relatively few sheep in comparison to cattle or goats (Map 3c). Highest densities are in the northeast, northwest, and in Kabale and Kisoro Districts bordering Rwanda.

Pig production is spatially more concentrated (Map 3d). The highest density of pigs is found in areas of high human population density along Lake Victoria and near urban areas, along the Kenyan border, and in parts of the central and western regions. Masaka, Wakiso, and Mukono Districts are important production areas.

Africa is on alert for bird flu, with many African states—Benin, Burkina Faso, Cameroon, Djibouti, Egypt, Ghana, Ivory Coast, Niger, Nigeria, Sudan, and Togo—now having confirmed cases of the highly pathogenic H5N1 strain in poultry (EMPRES, 2010). The chicken densities shown in Map 3e provide information on areas potentially at risk in the event of bird flu reaching Uganda. Map 3e also shows the high densities of chickens around major urban centers such as Kampala, Jinja, Entebbe, Masaka, Mpigi, and Mbarara. In these densely populated areas, demand for chicken has outstripped the local supply.

ROLE OF LIVESTOCK IN LIVELIHOODS AND POVERTY REDUCTION

To examine the relative importance of livestock in rural livelihoods across Uganda, analysts have to turn to household survey data from smaller samples. With respect to the mixed crop-livestock systems, a 2002 study by Ashley and Nanyeenya examined livestock ownership and benefits in three districts: Mbale, Kamuli, and Mubende (Ashley and Nanyeenya, 2002). It showed that 78 percent of households in these systems held livestock of one kind or another. The majority of livestock in these areas were kept in small herds and flocks (less than five animals), with 65 percent of households owning chickens and 44 percent owning goats. Cattle were held by 29 percent of households and pigs by 23 percent. The authors found that livestock were kept by the poorer households as well as the wealthier,

Box 3 SOURCES OF LIVESTOCK DATA IN UGANDA

To overcome limitations in the supply and quality of crop and livestock statistics during the 1990s, Uganda developed an Integrated Framework for Agricultural Statistics in 2000 (Magezi-Apuuli, 2000) and invested in the collection of new agricultural data, including the following:

- an agricultural module as part of the Population and Housing Census (2002),
- an agricultural module as part of the Uganda National Household Survey (2005/06),
- a National Livestock Census (2008), and
- a National Crop Census (2008-2009).

The first three sources provide livestock data useful for mapping and subnational analyses, although the spatial resolution and the quality of the data vary.

Agricultural Module in the 2002 Population and Housing Census

The Uganda Bureau of Statistics (UBOS) conducted the Population and Housing Census in September 2002 which incorporated a short questionnaire (i.e., agricultural module) inquiring about household-based agricultural activities such as crop growing, livestock rearing (including poultry), and fish farming. The main purpose of this module was to collect

data for constructing appropriate sampling frames to be used for a planned agriculture and livestock census and other surveys. In 2004, UBOS released the final version of the data for the 3.8 million households with agricultural activity.

In its report accompanying the release of the census data (UBOS, 2004), UBOS provided the following caveats regarding the agricultural module:

- The census did not cover private, large-scale, and institutional farms, which have large crop holdings and raise large numbers of livestock.
- The questionnaire was brief compared to those designed for a conventional agricultural survey or census, and the quality of the agricultural module may have suffered because of being last in the sequence of questions.
- There was only limited training of enumerators on agricultural concepts, and field supervision was not as thorough as UBOS would have wished.
- The questions on the agricultural activities did not filter between activities within the enumeration area where the household was located and those outside the enumeration area. For example, it was possible that a respondent in an enumeration area in Kampala answered that

he had 500 head of cattle, yet those cattle were physically located in a different district.

- When the livestock numbers are shown for small administrative areas such as a parish, some obvious errors are revealed. UBOS recommended using data at such spatial resolution with some caution.

Despite these drawbacks, UBOS felt that the 2002 census represented a unique source of agricultural data that could be put to further use. Since the census included enumeration of all households, it is possible to aggregate the data to small administrative areas.

In the current publication, we aggregate census data to the subcounty level to show maps of livestock densities (cattle, goats, sheep, and chickens) for 2002 and to estimate the number of cattle in areas with high trypanosomiasis risk in 2002. To produce the maps, the original subcounty data were first converted to a density number (animals per square kilometer), checked for consistency across subcounties, then spatially reallocated to exclude areas most likely without livestock (for example by excluding protected areas or steep slopes), and finally converted to 1 kilometer by 1 kilometer grid

continued next page

with the poorer households more likely to have small stock and the wealthier more likely to own cattle. Wealthier households also kept proportionately more animals than poorer households.

Ashley and Nanyeenya also showed that farmers ranked livestock among the most important means of livelihood, despite the fact that they only contributed around five percent of households' total cash income. This reflects the common practice of investing in livestock rather than putting money in a bank. The return on investments in livestock, which continue to grow, produce milk, meat, and eggs, and have offspring, are often higher than other investment options accessible to poor households (but they are also exposed to the risk of animal diseases and drought).

Recent studies looking at the role of livestock in pathways out of poverty in Uganda and western Kenya (Krishna et al., 2006; Kristjanson et al., 2004) suggest that diversification of income through livestock is an important factor in

helping households escape poverty. They provide a kind of 'asset stairway' out of poverty, first through investments in chickens, then goats and sheep, and finally local and then improved breeds of cattle. Livestock-related activities were found to have contributed to improved welfare for many poor households in Kenya and Uganda (Burke et al., 2007; Krishna et al., 2006).

Livestock also play an important 'safety net' role, keeping households from falling into poverty (Burke et al., 2007). They are often sold when there is an emergency or unplanned expenditure, for example, when someone in the household becomes ill. Different types of livestock play different roles across poor households, and the kind of livestock and livestock breeds that matter vary across regions, so research approaches that lead to a better understanding of this are critical, and will contribute to more targeted and effective pro-poor livestock-related policies and interventions.

cells. The final numbers are robust enough to create a national map with a consistent spatial representation of important production zones and to provide a national estimate of cattle in high risk trypanosomiasis areas by production system.

Agricultural Module in the 2005/06 Uganda National Household Survey

After testing a diagnostic agricultural survey in 2003/04, the Uganda Bureau of Statistics (UBOS) decided to include an agricultural module as a core component of its long-term household survey program. The purpose of this module is to provide regular updates and more detail about Uganda's farm economy and farm incomes. The module includes questions on the following topics: investments in land, crop areas, labor and nonlabor inputs for both the first and second cropping season, crop disposition, land rights, disputes and certificates, livestock ownership including small animals and poultry, expenditure on livestock, agricultural extension services, and technologies. Results of the Uganda National Household Survey are only statistically valid at a national scale and for subnational regions, because of the relatively small sample size.

In the current publication, we did not map the data from the 2005/06 survey because of its coarse spatial resolution, but we examined the data when discussing national livestock trends.

The National Livestock Census 2008

The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), together with the Uganda Bureau of Statistics (UBOS), undertook the field enumeration of the National Livestock Census from 18–25 February, 2008. Data processing and report preparation were completed during 2008 and 2009. MAAIF and UBOS released the new livestock data in October 2009.

The National Livestock Census obtained data on basic livestock characteristics (breed, sex, and age) of selected species such as cattle, goats, sheep, pigs, poultry, and rabbits. The questionnaire also captured important information about milk and honey production, farm infrastructure, equipment, ownership and tenure of land used for livestock rearing, and use of labor by source and gender.

The Census used information on households with livestock from the 2002 Population and Housing Census to establish a sampling frame that would generate reliable estimates at district, regional, and na-

tional levels (see MAAIF and UBOS, to be published, for more detail on the two-stage stratified cluster sampling design). A total of 8,870 enumeration areas (villages) were selected from 80 districts. This resulted in a sample of 964,047 households, representing 15.1 percent of the total number of households in Uganda in 2008 (more comprehensive than other livestock or agricultural censuses conducted in the past and in other developing countries, which typically have sample sizes between 1–5 percent of the total number of households). As a result of its large sample size, the National Livestock Census provides the most precise estimate of total livestock number by type and is considered a benchmark for future surveys and censuses.

In the current publication we used the National Livestock Census data when reporting on national trends in livestock numbers. Maps of cattle distribution, cattle ownership, and share of improved dairy breeds by districts for 2008 are based on the same source.

WHERE ARE THE POOR?

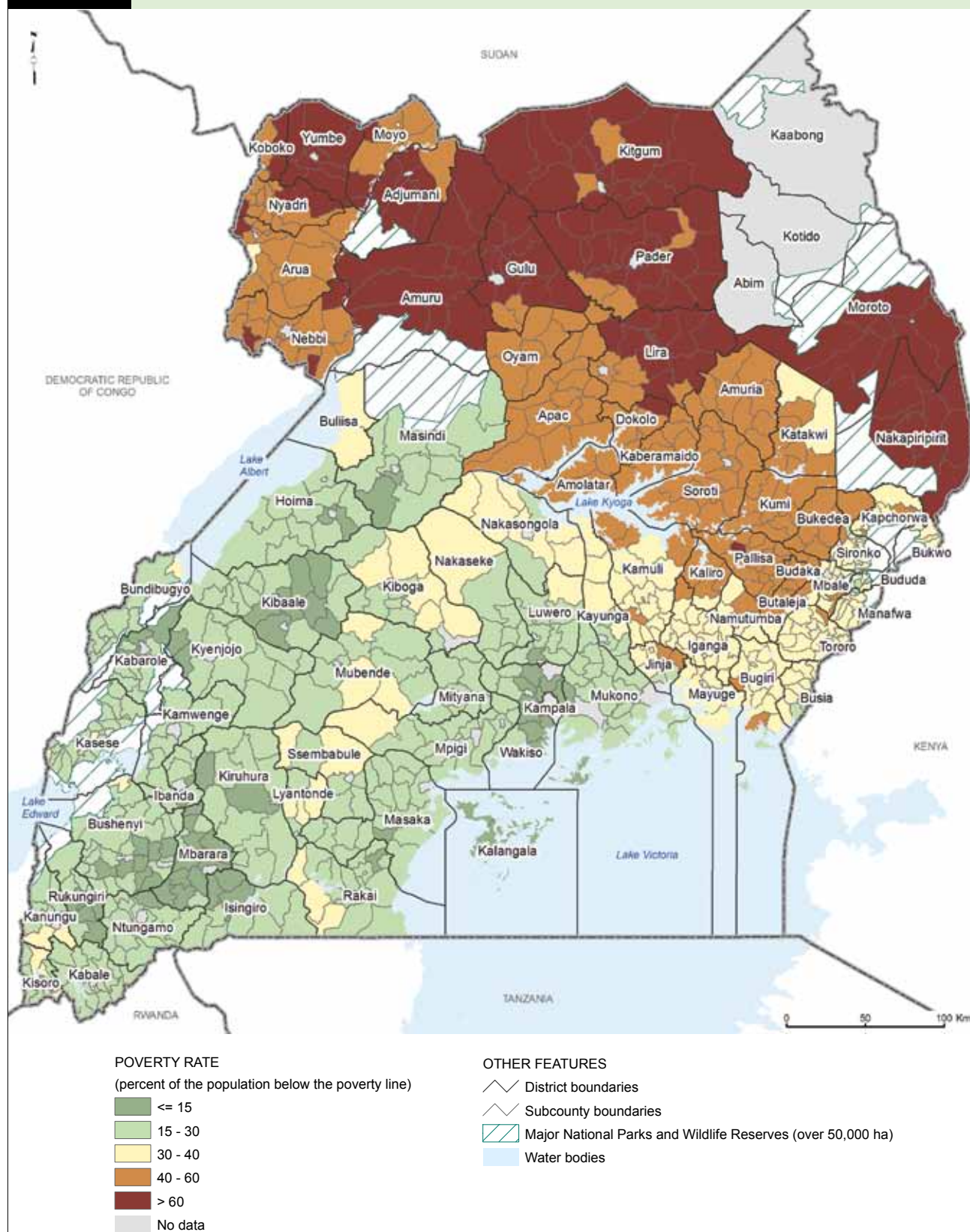
Geography can play a role in determining relative levels of household well-being, as can be seen in Uganda's latest poverty maps (for 2005). Subcounties with high poverty levels tend to be clustered, as are the wealthier subcounties (Map 4). The highest incidences of poverty—greater than 60 percent of the population living below Uganda's official rural poverty line—are seen across the north of the country (see Box 4 for more detail). Still high, at 40–60 percent, are the districts of Nyadri, Arua, and Nebbi in the northwest, with another dozen districts stretching across to eastern Uganda, where most of the districts fall in the 30–40 percent poverty range. Low poverty levels (less than 15 percent) are found in pockets of western and southern Uganda, and around Kampala. The reasons for this spatial pattern are complex, and include factors such

as rainfall and soil quality (which determine agricultural potential), land and labor availability, degree of economic diversification, level of market access, and issues of security and instability.

Map 5 gives a visual representation of the poverty density: the number of poor per square kilometer in 2005 (see Box 5 for a discussion of mapping poverty rate, poverty density, and the number of poor). This map looks different from Map 4 because there are relatively few people living in the north where the highest poverty incidences are found, for example. The areas of highest poverty densities in Uganda lie in the east, the northwest (parts of Nyadri, Arua, Nebbi, Koboko, and Yumbe Districts), in pockets in the far west (Kasese and Kabarole Districts), and in Kisoro District in the southwest.

Map 4

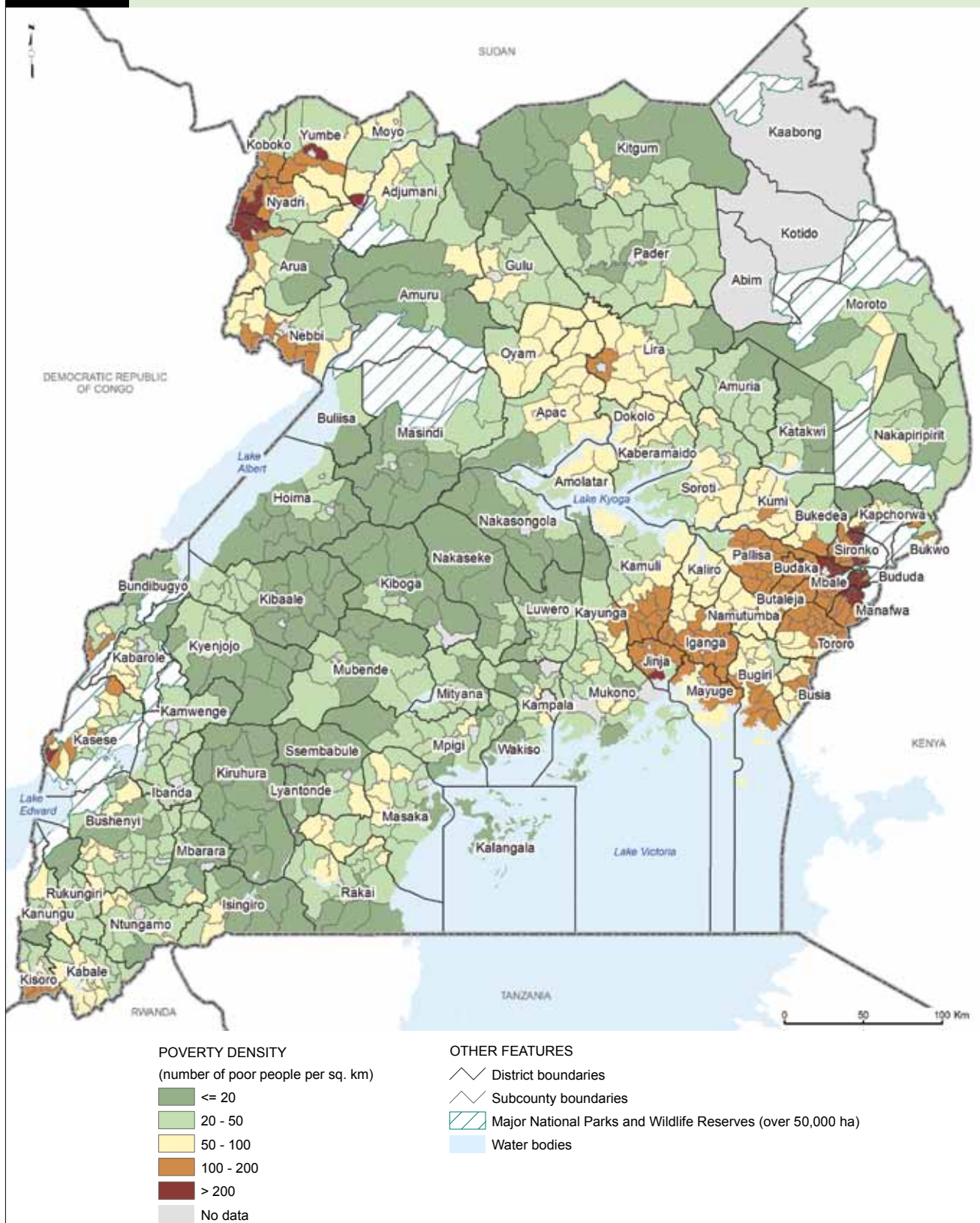
POVERTY RATE: PERCENTAGE OF RURAL SUBCOUNTY POPULATION BELOW THE POVERTY LINE, 2005



Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and poverty rate (UBOS and ILRI, 2008).

Map 5

POVERTY DENSITY BY RURAL SUBCOUNTY: NUMBER OF PEOPLE BELOW THE POVERTY LINE PER SQUARE KILOMETER, 2005



Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and poverty density (UBOS and ILRI, 2008).

Box 4 2005 UGANDA POVERTY MAPS: INDICATORS

Human well-being has many dimensions. Sufficient income to obtain adequate food and shelter is certainly important, but other dimensions of well-being are crucial as well. These include good health, security, social acceptance, access to opportunities, and freedom of choice. Poverty is defined as the lack of these dimensions of well-being (MA, 2005).

The poverty indicators produced by the Uganda Bureau of Statistics (UBOS) are based on household consumption and cover some but not all dimensions of poverty. Consumption expenditures include both food and a range of non-food items such as education, transport, health, and rent. Households are defined as poor when their total expenditures

fall below Uganda's rural or urban national poverty lines. These lines equate to a basket of goods and services that meets basic monthly requirements (UBOS and ILRI, 2007).

In 2005, the national poverty line (an average of the poverty lines in Uganda's four regions) was 20,789 Uganda Shillings (US\$ 12) per adult equivalent per month in rural areas, and 22,175 Uganda Shillings (US\$ 13) per month in urban settings. With these poverty lines, the 2005 poverty rate (percentage of the population below the poverty line) was 31.1 percent at the national level, translating to about 8.4 million Ugandans in poverty (UBOS, 2006b). Rural and urban poverty rates dif-

fered significantly, at 34.2 percent for rural areas and 13.7 percent for urban areas.

The poverty maps shown in this report are based on the 2005/06 Uganda National Household Survey (UBOS, 2006b). They rely on a statistical estimation technique (small area estimation) that combines information from the 2002 population and housing census and the 2005/06 household survey. This analysis allows a high level of spatial resolution, providing data for all rural subcounties except those in Kotido, Kaabong, and Abim Districts (UBOS and ILRI, 2008).

Box 5 MAPPING POVERTY: THE RELATIONSHIP BETWEEN POVERTY RATE, POVERTY DENSITY, AND THE NUMBER OF POOR

Understanding the complementarity between poverty rate and poverty density is important for designing and implementing pro-poor interventions. Using either poverty rate or poverty density alone may be ineffective, either missing many poor people or wasting resources on families that are not poor. For example, targeting only subcounties with the highest poverty rates will not reach the vast majority of Uganda's poor. In densely settled areas, the proportion of the poor relative to the non-poor may be low, but these areas contain large numbers of poor people. Relying exclusively on poverty rates for targeting would lead to "under-coverage" of the poor in these areas. On the other hand, providing resources only to areas with the highest poverty densities will bypass the poor in drier and less densely settled areas.

The total number of the poor in a given area is also an important metric. Poverty rate and poverty density measures alone are not sufficient to identify the most promising subcounties for pro-poor targeting. Subcounties may have high poverty rates or high poverty densities but still differ in their total count of poor persons. Two subcounties, for example, could each have a poverty density of 50 poor persons per square kilometer, but only 5,000 poor persons may be living in the 100 square kilometers of the first subcounty versus 50,000 poor persons inhabiting the 1,000 square kilometers of the second subcounty. Examining the total number of poor people per subcounty is necessary because Uganda's subcounties differ greatly in population size (ranging from as few as 2,500 to more than 200,000 inhabitants) and in area.

In this publication, poverty rate and poverty density were selected to portray the geographic distribution of the poor. While there are other useful poverty indicators, these were chosen as a first approximation to show how poor each subcounty is, and where poor households are spatially concentrated. With this information, decision-makers can gain first insights in order to develop more effective support and services for the poor. In most cases, additional analyses using metrics that capture the depth and severity of poverty (e.g., poverty gap and squared poverty gap) and other dimensions of well-being will be needed to better understand poverty patterns, and different types of analyses are needed to examine cause-and-effect relationships.

Dairy and Poverty

Raising dairy cattle and processing dairy products provide a steady and important source of income. Dairy supplies high-quality protein and micronutrients generally lacking in cereal-based diets and is especially important for children and child-bearing women. This section highlights levels of milk production in different areas of Uganda and, in particular, shows areas where the amount of milk produced is estimated to be more than needed by the local population (see box below on calculating milk surplus and deficit). In these areas of apparent surplus, development strategies can aim at improving market infrastructure and reducing market transaction costs. In areas of apparent milk shortages, on the other hand, policymakers need to consider initiatives aimed at increasing production or improving market linkages to supply milk (for example by reducing transport costs through road construction). This information can also be used by dairy researchers and development agencies to better target knowledge dissemination and service delivery to dairy farmers.

The dairy sector contributes 40-50 percent of the livestock gross domestic product (GDP) (DDA, 2002), which in turn contributes 17-19 percent of the overall agricultural GDP in Uganda. Dairy is an important livelihood option for many rural Ugandans, and is a dynamic sector of the economy. Ugandans consume an average of 28 liters of milk per year, although this varies considerably across households and regions (Staal, 2004; Staal and Kaguongo, 2003). In general, the supply of milk in Uganda has not kept up with demand (Staal and Kaguongo, 2003).

Uganda's dairy production has changed considerably over the past 30 years. Before the 1980s, two contrasting systems produced all of the country's milk: large commercial dairy farms grazing exotic and crossbred dairy cattle on natural pastures, primarily in the wetter parts of southwest Uganda; and pastoralists raising large numbers of local cattle under traditional management systems, mostly in the drier eastern and northeastern parts of Uganda (Baltenweck et al., 2007).

Since the mid-1980s, a third production system—zero-grazing—was introduced. In such a system, farmers keep high-yielding, genetically improved cows (pure or crossbred with local cattle) in stalls, feeding the animals daily with fodder cut and carried to them. Development agencies promoted these more 'intensive' dairy systems and trained Ugandan farmers in managing dairy breeds

and growing fodder. As a result, many smallholders bought exotic dairy cows or upgraded their indigenous stock by cross-breeding them with exotic breeds. Uganda's small farmers also varied their production approach, depending on resources and local conditions: some of them adopted strict zero-grazing practices while others combined grazing paddocks with stall feeding, a hybrid dairy production system that came to be known as 'semi-intensive' (Baltenweck et al., 2007).

Consequently, the number of improved dairy cows in Uganda has grown steadily since the 1980s and led to concomitant increases in national milk production, per capita milk consumption, smallholders' share in national milk production, and dairy's contribution to the national economy (Baltenweck et al., 2007).

POLICY SUPPORT TO THE DAIRY SECTOR

In 1992, the government launched a 'Milk Master Plan' to simultaneously improve rural incomes, farm living standards, national self-sufficiency in milk production, and yields of surplus milk for export. Milk market liberalization occurred in 1993 with the termination of the government's monopoly on milk processing. This resulted in the emergence of many medium and small-scale private milk processors. To realize the objectives of its 'Milk Master Plan,' Uganda established a Dairy Development Authority in 1998.

A recent study examined profits from, and environmental impacts of, stall-fed dairying (Baltenweck et al., 2007). The results show that Uganda's booming dairy farming is profitable regardless of the level of 'intensification' that farmers employ through use of feeds and other inputs. Even relatively small-scale, poor farmers can benefit from dairy; it is not just an activity for relatively wealthy households with lots of land. Another finding of the study was that all of Uganda's dairy farmers, whether intensive, semi-intensive or agro-pastoral, tended to underutilize their animal manure as organic fertilizer for crops. The study found soil quality on Uganda's mixed dairy-crop farms to be below a level considered critical for crop production, and that it was continuing to fall. This deteriorating situation is fast eroding the long-term sustainability of these farming systems, despite the fact that farmers have adequate amounts of manure from their dairy cows to fertilize the soil. The study suggested that the reason for underutilizing livestock manure as fertilizer was

the shortage of labor needed to save, transport, and apply the manure (Baltenweck et al., 2007).

MILK SURPLUS AND DEFICIT AREAS

Map 6 compares potential local milk supply and demand and shows clear patterns of net milk surplus and deficit. The map comes from an analysis using geographic information system (GIS) data coupled with national surveys (not local consumption data) (see box below on calculating milk surplus and deficit).

Areas in the west and south, and around Lake Victoria, particularly near Kampala and Jinja, are producing more milk than they can consume locally (areas of high surplus shown in shades of purple). The same is true for parishes in Nyadri, Arua, and Nebbi Districts in northwest Uganda. In the east of the country, however, there are major areas of apparent overall milk deficit (tan areas) mostly concentrated in parishes of Pallisa, Budaka, Mbale, Kaliro, and Kamuli Districts.

This map can help inform development strategies: dairy development actions in surplus areas could aim to improve market infrastructure and reduce market transaction costs, while those in milk deficit areas could target increased production and market linkages (Staal and Kaguongo, 2003). The map can also guide dairy research and development efforts to better direct knowledge dissemination and service delivery to dairy farmers.

CALCULATING MILK SURPLUS AND DEFICIT

Milk production is calculated by assessing the number and type of dairy cattle in an administrative area and then estimating liters of milk produced within that area based on average milk production per cow. Demand for milk is calculated by estimating the average milk consumption per person nationally and applying that number to the population density of each area. Areas with more milk produced than could theoretically be consumed by the population are considered 'surplus' areas, while those with more demand than can be met by current production are considered to be in 'deficit'. The study relied on data from 1999/2000 National Household Survey and the 2002 Population and Housing Census.

Source: Baltenweck et al., 2007.

MILK SURPLUS AND DEFICIT AREAS AND POVERTY

A milk surplus and deficit map can be compared with maps showing poverty rates and poverty densities in order to plan more pro-poor dairy interventions. Such overlays can, for example, pinpoint locations with multiple deprivations (e.g., high levels of poverty and a shortfall of milk) or with greater potential to reach a higher number

of poor in an investment area. This section will highlight such examples.

Focusing on milk deficit areas (with shortfalls greater than 500 liters of milk per square kilometer per year) and overlaying them with poverty rates shows the following patterns in Map 7:

- Mid- to high poverty rates and high milk deficits are more widespread in eastern Uganda such as in Pallisa, Kumi, Budaka, and Kaliro Districts. These areas also have comparably high poverty densities (40-60 poor persons per square kilometer, as shown in Map 5).
- Low poverty rates with high milk deficits are scattered across the central and southwestern parts of the country. Many of these areas appear to be in locations that are more remote and further from big cities.

This brief comparison suggests that investment in dairy development efforts in the highlighted eastern parishes could potentially achieve two objectives: help move households out of poverty and improve local milk supply with nutritional benefits for poor households.

Map 8 looks at the high milk surplus areas (with a surplus greater than 3,000 liters of milk per square kilometer per year) in relation to poverty density. Most high milk surplus areas are in central and southwestern Uganda and almost all of them have lower poverty densities. Other milk surplus areas are in the northwest, eastern Uganda, and parts of Jinja District, but here poverty densities are much higher. All areas with high milk surplus and higher poverty densities also have medium to high poverty rates (as shown in Map 4). It is in these areas where value chain and marketing improvements could have the greatest pro-poor potential. While all surplus areas—those with low and those with high poverty densities—can benefit from these improvements, targeting poor households in areas with low poverty densities (and low poverty rates) has to be much more precise compared to an area with a high average number of poor per square kilometer (and high poverty rates).

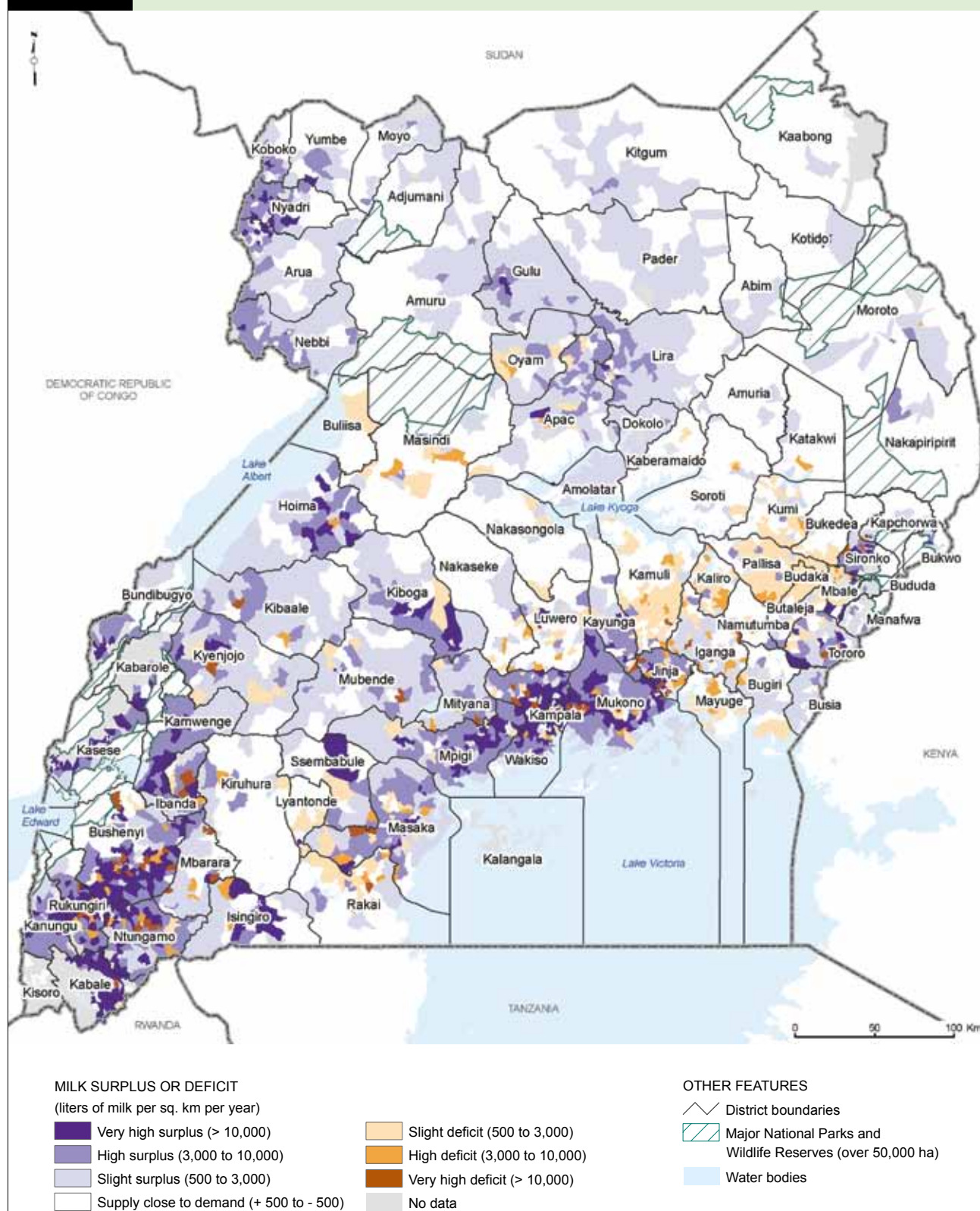
DISCUSSION AND FUTURE ANALYSIS

The maps developed throughout this section illustrate how spatial analysis can inform efforts to improve planning for Uganda's dairy sector. Based on the data presented here, the following conclusions can be drawn:

- Both milk surplus and milk deficit areas include clusters of subcounties with high levels of poverty.
- These clusters are more concentrated in southeastern and northwestern Uganda.
- Subcounties with high poverty rates and a high total number of poor could be prime candidates for pro-poor targeting of future dairy investments and warrant a more detailed analysis of why such areas exist.

Map 6

POTENTIAL MILK SURPLUS AND DEFICIT BY PARISH, 2002



Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and milk surplus or deficit (ILRI calculation based on IFPRI, 2002).

Map 7

POVERTY RATE BY SUBCOUNTY IN MILK DEFICIT AREAS

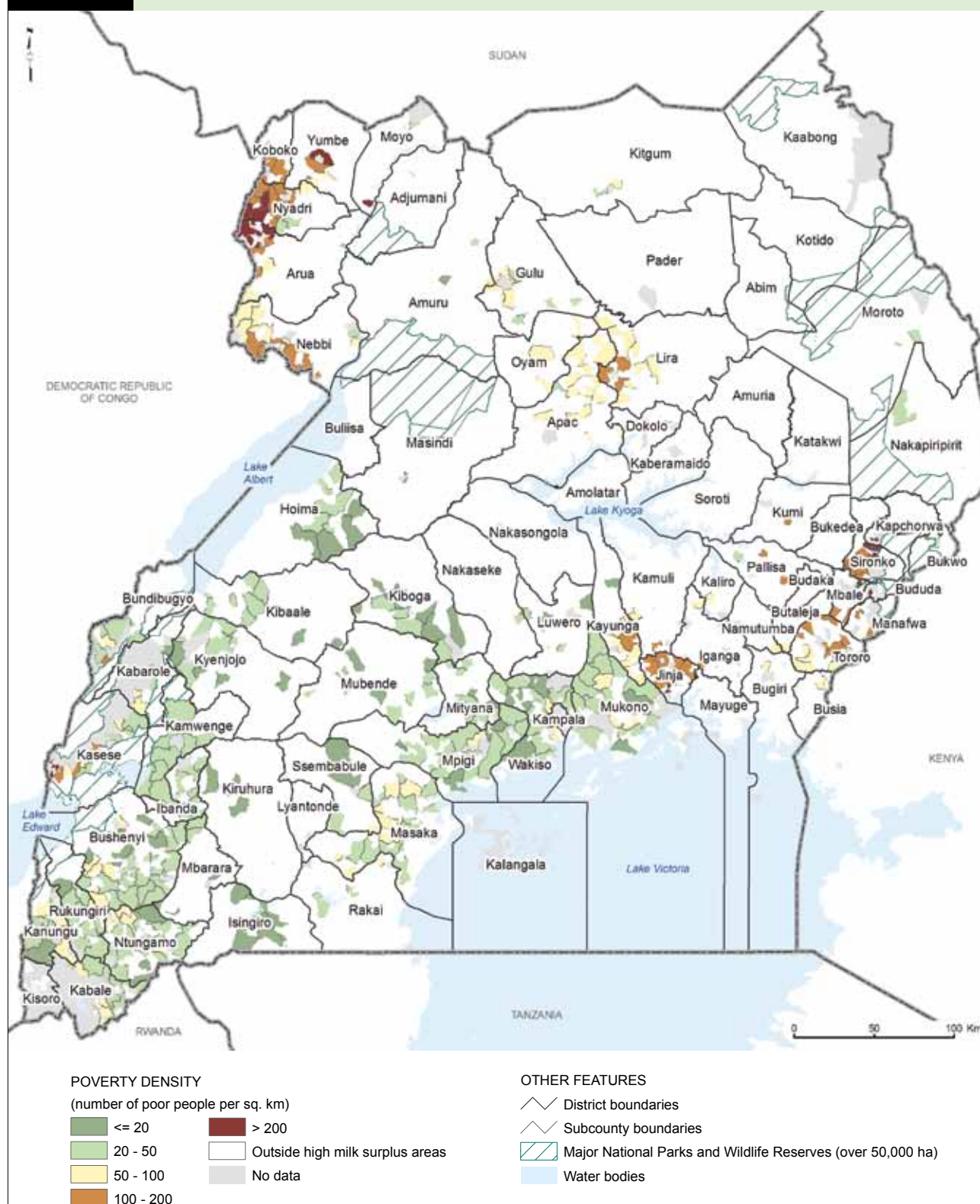


Note: Milk deficit areas have a potential shortfall greater than 500 liters of milk per square kilometer per year (see Map 6).

Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), milk deficit (ILRI calculation based on IFPRI, 2002), and poverty rate (UBOS and ILRI, 2008).

Map 8

POVERTY DENSITY BY SUBCOUNTY IN HIGH MILK SURPLUS AREAS



Note: Milk surplus areas have a potential surplus greater than 3,000 liters of milk per square kilometer per year (see Map 6).

Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), milk surplus (ILRI calculation based on IFPRI, 2002), and poverty density (UBOS and ILRI, 2008).

Box 6**A DAIRY DEVELOPMENT INITIATIVE BASED ON BUSINESS SERVICES DELIVERY HUBS**

In 2008 Heifer International, in collaboration with four other organizations, launched the East Africa Dairy Development Project, which seeks to transform the lives of one million people in Kenya, Uganda, and Rwanda by doubling household dairy income over the next 10 years through integrated interventions in dairy production, market access, and knowledge application. The core project team is taking an innovative 'dairy value chain' approach that aims to expand opportunities for farmers, traders, transporters, processors, and consumers in these three countries. A key strategy of the project is to build the business skills of farmers within local 'business hubs,' where farmers' milk is bulked and cooled, and where they can access credit, training, knowledge, and inputs through farmer-owned enterprises.

In Uganda, the project initially planned to establish ten dairy hubs with chilling plants that support access to formal markets, along with another five hubs that develop an improved traditional market for milk sales. These dairy hubs serve as community anchors for industry knowledge, business services, and market access. When fully functioning, the dairy hub is a dynamic cluster of services and activities that generate greater income for farmers. By us-

ing this system, the quality of milk passing through the traditional market will be improved and access to formal markets will be facilitated through farmer owned-and-operated chilling plants.

Map 9 displays these dairy development hubs and a 20-kilometer 'buffer' zone. The circles (outlined in blue for ten hubs with chilling plants and in red for five traditional market hubs) approximate catchment areas from where the milk is expected to be supplied by local farmers. All hubs have a milk surplus when aggregated over their envisioned catchment area, and none is located in the high milk deficit areas shown in Map 6. This will ensure adequate deliveries of milk to the chilling plants.

Chilling plants store and cool (or chill) milk for pickup by commercial dairies or other market agents. They help to reduce milk spoilage and allow farmers to negotiate more competitive prices. Most of the areas with chilling plants shown in Map 9, for example, were dominated by smallholder farmers selling raw milk directly to consumers or vendors, resulting in low prices for farmers. The East African Dairy Development Project seeks to achieve broad market access for these farmers by supporting the formation of farmers' dairy groups and requiring

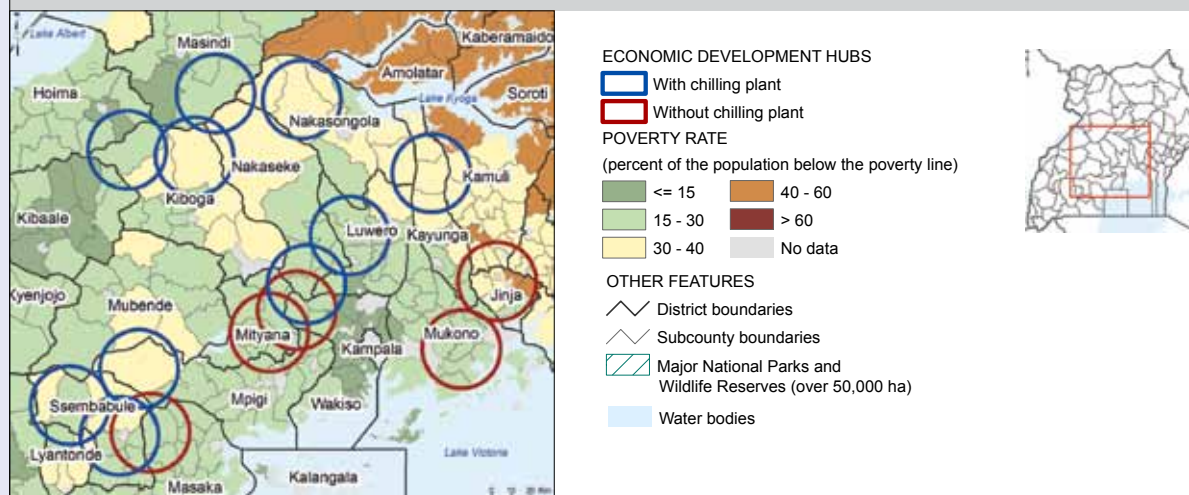
dairy farmers to "literally buy-in to the dairy value chain through purchase and management of milk-chilling facilities." Over 280 registered farmer members in Masindi District, for example, raised one million Uganda Shilling (about \$US 500) in share equity to invest in a chilling plant in 2008.

When selecting the geographic area for the initiative and determining the location of these hubs in Uganda, the project team relied on expert opinion to first prioritize districts and then select sites using a detailed checklist. Criteria included level of milk supply and seasonality, distance to demand centers, level of farm gate milk prices, access to water and electricity, and existence of farmers' groups among other factors. The experts did not geographically target poor areas explicitly—although by selecting areas with low farm gate milk prices, for example, they included locations with a large share of smallholder farmers with lower incomes. Map 9 shows the differences in poverty rates in the subcounties surrounding the dairy development hubs. Hubs in Nakasongola, Kiboga, Mpigi, Kayunga, and Jinja districts are located in communities with much higher poverty levels than the other ten hubs. Future evalu-

continued next page

This highlights other issues for research and follow-up analyses:

- Analysts working with the Ministry of Agriculture, Animal Industry and Fisheries, as well as local and national planning efforts can build upon the explorative analysis in this publication using the new data from the 2008 National Livestock Census on distribution of dairy cattle (including indigenous, exotic, and cross-bred species), average milk production, and milk prices.
- While the analysis in this section highlights only overlays of poverty with selected milk deficit and surplus areas, a more systematic analysis would be useful to understand spatial patterns of poverty with milk supply and demand.
- Raising dairy cattle successfully requires access to reasonably priced animal health and artificial insemination services. Thus, mapping access to veterinary services and artificial insemination services will be very useful for interventions aimed at livestock and dairy development.
- More detailed spatial data on existing milk collection, milk bulking centers including chilling plants (with information on capacity and level of functionality), and spatial mapping of economic variables such as farm gate milk prices could all help to identify locations where additional investment is needed and pinpoint which investments would be most beneficial.

MAP 9 DEVELOPMENT HUBS AND POVERTY RATE BY SUBCOUNTY

Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), economic development hubs (ILRI, 2009), milk surplus (ILRI calculation based on IFPRI, 2002), and poverty density (UBOS and ILRI, 2008).

ations measuring the impacts of the hubs will have to take these poverty differences into consideration. They will also need to look at both the effects on the direct beneficiaries (members of the dairy farmers' groups) and other households in the community not directly participating in the project: How did improved market access affect the local milk supply and local milk prices, and did the effects differ

for subcounties with higher poverty levels? In addition, lessons learned from the hubs with higher poverty rates may be instructive—for example what was the capacity of farmers to contribute equity for chilling plants—for future targeting of dairy interventions in Uganda's poorest subcounties.

Sources: Baltenweck, 2010; Heifer International, 2008; and EADD, 2008.



Livestock Diseases and Poverty

A major constraint to improving productivity in Ugandan livestock is the presence of animal diseases and, linked to this, the provision of animal health services. Livestock diseases impose heavy costs on producers and reduce incentives to invest in higher yielding crossbred or exotic animals that tend to be more vulnerable. Important endemic diseases in Uganda include: foot and mouth disease; contagious bovine and caprine pleuropneumonia; peste des petits ruminants; a host of tick-borne diseases (including babesiosis, anaplasmosis, and theileriosis); helminthosis; tsetse-transmitted trypanosomiasis; contagious ecthyma; Newcastle disease; infectious bursal disease; coccidiosis; salmonellosis; African swine fever; tuberculosis; brucellosis; and anthrax.

The government network for controlling disease and providing animal health services in Uganda deteriorated substantially during periods of political unrest. While clinical health services are no longer provided by government institutions and are now regarded as a private good, central government retains responsibility for policy, regulation, surveillance, and control of notifiable epidemic diseases such as contagious bovine pleuropneumonia, and foot and mouth disease (Silkin and Kasirye, 2002). Current concerns relate to preparedness for outbreaks of highly pathogenic avian influenza.

Trypanosomiasis in Uganda (see Box 7 for more detail) is a significant livestock disease in areas where the tsetse vector occurs. A recent study (Thuranira, 2005), conducted across the border in Kenya's Busia district, estimated that farmers' potential income from cattle was reduced by nearly half due to cattle deaths from endemic diseases, principally trypanosomiasis and tick-borne diseases. As a result of the changes in service provision in Uganda, the control of trypanosomiasis in livestock has been left largely in the hands of farmers, who spend considerable sums on trypanocides to cure or protect their livestock.

There are many ways of dealing with trypanosomiasis, ranging from those that focus on the treatment of the parasite in animals ('private goods') to area-wide removal of the vector ('public goods'). At one end of the spectrum is the application of prophylactic and curative trypanocidal drugs, the benefits of which primarily accrue to individual farmers. Applying insecticides to cattle, in contrast, confers further private benefits through the additional control of ticks and nuisance flies and can achieve the public good

of effective tsetse control if it is implemented as a coordinated effort. The use of traps and insecticide-treated cattle requires a fully coordinated program over a wide area to be at all effective and to provide benefits to farmers over a broad area. Sequential aerial spraying with non-residual insecticides is another way to achieve area-wide control, as is the release of sterile insects to eliminate residual fly populations once the tsetse population of an area has been suppressed using an insecticidal method.

The comparative costs of different tsetse control techniques in Uganda are discussed in detail in Shaw et al. (2007). Deciding which approach is best suited to a particular situation depends on whether the objective is control or eradication, availability and type of funding, logistical factors such as terrain and infrastructure, the ecology of the vector, the epidemiology of the disease, and finally, the production system context.

Trypanosomiasis is a zoonotic disease (i.e., it can be transferred from animals to people) with the human form being known as sleeping sickness. Uganda is unusual in that sleeping sickness is present in both its chronic *gambiense* form, found in West and Central Africa, and in its more acute *rhodesiense* form, which is found in eastern Africa. The *gambiense* form occurs in the northwest of the country, whereas the *rhodesiense* form, historically confined to the southeastern part of the country, has recently expanded northwest, beyond Lake Kyoga (see Box 7). This poses a risk that the two diseases will overlap (Picozzi et al., 2005). In the areas where the *gambiense* form of the disease is found, control of sleeping sickness relies mainly on finding and treating infected individuals (WHO, 2006). However, in cattle-rearing communities with the *rhodesiense* form of the disease, cattle are often the major disease reservoir and need to be treated as well as people (Hide et al., 1996; Fèvre et al., 2005).

Faced with this situation, a lively debate is ongoing among animal and human health experts as to the best ways to control trypanosomiasis in livestock and people, focusing on issues of scale, sustainability, and cost. All of these have important implications for the choice of technique.

Whichever methodology, or combination of technologies, is ultimately used to intervene, there is a clear need to target interventions appropriately. A spatial targeting approach was adopted in Uganda some years ago by

Box 7 TRYPANOSOMIASIS

Trypanosomiasis is a parasitic disease caused by different species of a one-celled microorganism (i.e., trypanosomes) and affects animals and humans. In Africa, it is transmitted by the tsetse fly, which can acquire its infection from animals or humans harboring the parasites. Only certain tsetse species transmit the disease, each with different habitat preferences, such as wooded savannah or woodlands along rivers and lakes.

Animal Trypanosomiasis

African animal trypanosomiasis occurs in many wild and domestic animals. Trypanosomes can infect all domesticated animals, but in many parts of Africa, cattle are the main species affected because of the feeding preferences of tsetse flies. In cattle, the disease is called Nagana, a Zulu word meaning “to be depressed.”

While acute cases of the disease, which are fatal within a week, occur, most cases of trypanosomiasis are chronic, affecting animals over a longer time period. Intermittent fever, anemia, weight loss, decreased milk yield, premature births, and perinatal losses are among the main clinical signs of the disease. Many untreated cases are fatal. Deaths are common among chronically infected animals, particularly when combined with poor nutrition.

The effects of the disease vary with the breed of the animal, as well as the strain and dose of the infecting parasite. Some African livestock breeds are genetically resistant to trypanosomiasis. The roles of different trypanosome species on disease severity in different livestock species and breeds are incompletely understood.

Human Trypanosomiasis

Human African trypanosomiasis, also known as sleeping sickness, is transmitted through the bite of an infected tsetse fly. At first, trypanosomes multiply in the bloodstream (often without any major symptoms) and eventually infect the central nervous system. This process can develop rapidly or take years, depending on the parasite involved. Once the central nervous system is affected, symptoms such as confusion, poor coordination, and sleep disturbance (the latter gives the disease its name) occur. Without treatment, sleeping sickness is fatal. Diagnosis must be made as early as possible to avoid difficult and risky treatment.

In Africa, sleeping sickness occurs only where there are tsetse flies that can transmit the disease, but not all areas with tsetse flies necessarily have cases of sleeping sickness. Rural populations dependent on agriculture, fishing, animal husbandry, or hunting that are the most exposed to tsetse fly bites have the highest risk for the disease. Remote rural areas, weak health care systems, displaced populations, war, and poverty, are all important factors that lead to increased transmission. The disease can develop in small areas, such as a few villages, but also affect a large geographic region. Exhaustive screening of the population at risk is necessary to identify patients at an early stage and reduce transmission; this requires major human and financial resources.

Trypanosomiasis in Uganda

A 2005 study (Picozzi et al., 2005) found that, since the mid-1980s, the area of Uganda affected by the *rhodesiense* parasite and the more acute form of sleeping sickness has increased two and half times (from 13,820 to 34,843 square kilometers), doubling the human population at risk. Before 1985, this form of sleeping sickness was

restricted to districts in eastern Uganda clustered around the north shore of Lake Victoria and the source of the Nile. Cattle restocking activities and unsuccessful control efforts contributed to the northwestward spread of the epidemic area, with the disease becoming established in Soroti, Kaberamaido, and Lira Districts. More recent information in 2009 indicates a further spread of sleeping sickness, with the media reporting 120 human cases in Dokolo District, including 11 deaths.

During the same time, civil instability on the Sudanese border resulted in human and livestock movements in northwest Uganda. This contributed to the southeastward expansion of the *gambiense* parasite and the more chronic form of sleeping sickness.

The 2005 study found that the *rhodesiense* and *gambiense* forms of the disease were occurring only about 150 kilometers apart. Without preventive action targeting the parasites within the livestock population, it is expected that the two diseases will converge, requiring a major revision of diagnostic and treatment protocols.

The study recommended real time monitoring of the two diseases (both in livestock and human patients) and treating the animal reservoir for the *rhodesiense* form. In their economic analysis, the authors also indicated that the financial benefits of treating this reservoir (increased livestock income and lower treatment costs for humans) would more than cover the treatment costs and confer large benefits on the poorest and most disenfranchised rural communities with the least access to health care.

Sources: Okino, 2009; CFSPH and IICAB, 2009; WHO, 2006; Picozzi et al., 2005; and Welburn et al. 2001.

PATTEC—the Pan African Tsetse and Trypanosomiasis Eradication Campaign—to prioritize areas for trypanosomiasis control. The method is described in detail in Gerber et al. (2008) and summarized in Wint and Robinson (2007). In essence, a GIS-based modeling approach (weighted linear combination) was used to combine relevant spatial data to identify priority areas for animal trypanosomiasis control. Five criteria were chosen and weighted in terms of their relative importance for prioritizing areas for trypanosomiasis control by stakeholders in the livestock sector in Uganda. The criteria were: (1) density of rural poor, derived from the 1992 poverty maps (UBOS and ILRI, 2004); (2) probability of presence of tsetse (Wint, 2001); (3) length of growing period as a measure of agricultural potential (Jones and Thornton, 2005); (4) cattle density, to measure current level of livestock investment (Wint and Robinson, 2007); and (5) percentage crop cover, to gauge current levels of cropping (UBOS, 2004). Based on that analysis, areas of high priority were selected as the zone where the initial activities under the PATTEC program would be implemented.

In recent years, new data have become available to evaluate the problem of trypanosomiasis in Uganda. The following sections take the reader through an analysis in which livestock and poverty data—using the latest available poverty maps—are explored in the context of tsetse distributions, and the importance of livestock production systems is acknowledged in assessing the number of cattle and people at risk from animal trypanosomiasis. There is no scope here to include an analysis of human sleeping sickness, other than to emphasize the important additional benefits that would result from effective tsetse and trypanosomiasis control where the *rhodesiense* form occurs, mainly in the southeast of Uganda.

TRYPANOSOMIASIS RISK AND LIVESTOCK

It is estimated that some 70 percent of Uganda is infested with 11 species of tsetse, each of which occupies a different ecological niche. By far the most important species, however, are *Glossina pallidipes*, *G. morsitans submorsitans* and *G. fuscipes fuscipes*, which together stretch across the country in a belt from northwest to southeast, with the populations apparently more fragmented and less dense in the central area around Lake Kyoga. Map 10 shows the aggregate distribution of these three tsetse species, derived from predicted distributions of the three most important species based on multivariate models that combine environmental data with known distributions (Wint, 2001). The methodologies for predicting tsetse and other disease vector distributions are well established and are described, for example, in Robinson et al. (1997); Rogers and Robinson (2004); and Pfeiffer et al. (2008).

When considering trypanosomiasis, as with the majority of livestock diseases, it is important to take a systems perspective. This is because the disease is likely to present

itself differently in different production systems based on livestock species and breeds, stocking rates, and management practices. Moreover, the impact of the disease on the livestock, and more importantly on the keepers of those livestock, is likely to be different because the role of livestock in peoples' livelihoods varies among production systems. Furthermore, provision of animal health services is likely to differ across systems and the optimal choice of control approach will vary; for example, using insecticide-treated cattle for tsetse control is highly dependent on cattle numbers and stocking rates (Hargrove et al., 2003).

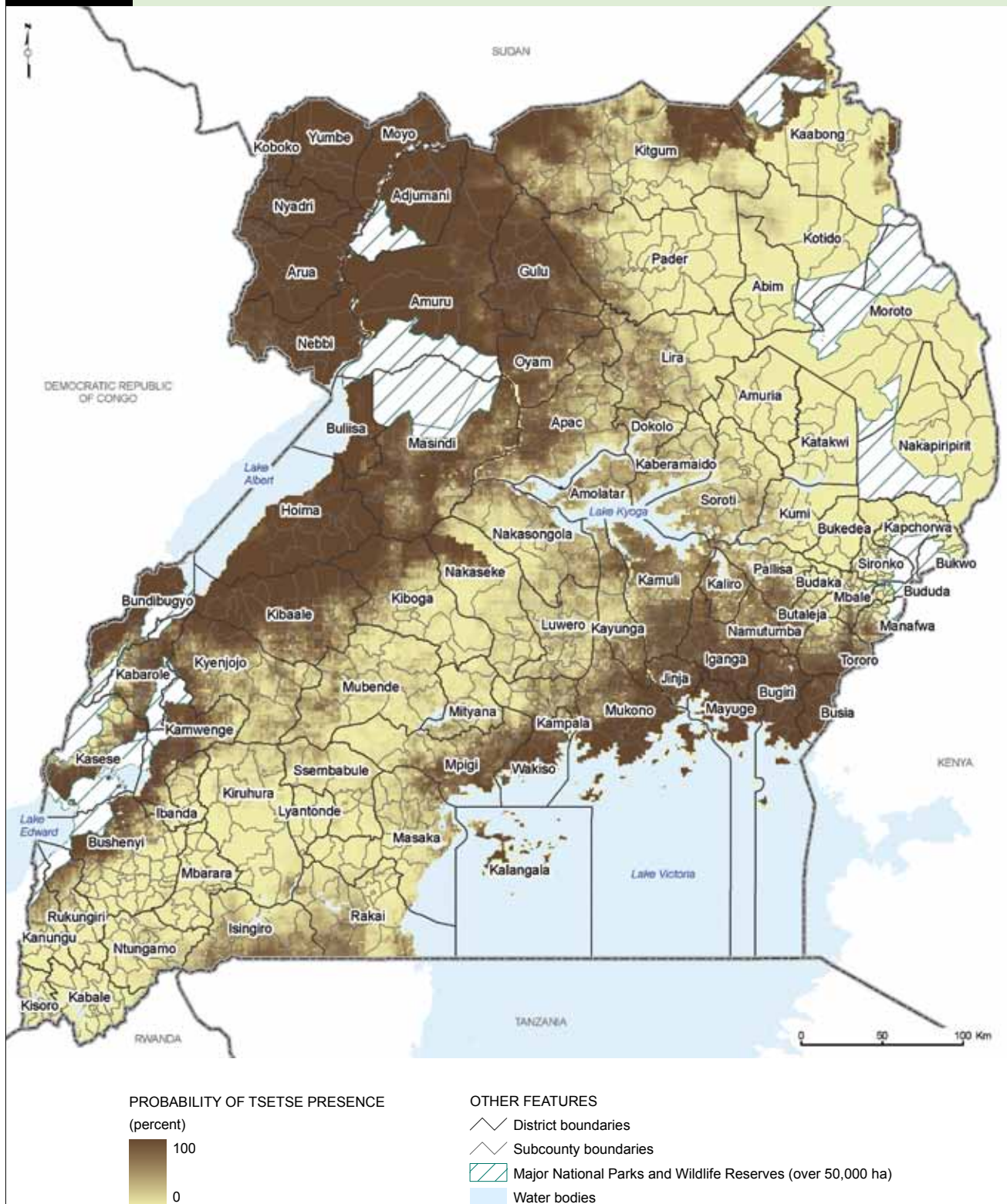
Table 2, derived from combining maps of livestock production systems, livestock density, and tsetse distribution, shows the numbers and densities of cattle in the various livestock production systems of Uganda, inside and outside the areas where tsetse occurs, using modeled 2002 census data (see Box 3 for more detail). Overall, it is estimated that about a third of Uganda's cattle population, about 1.9 million head, were at risk from trypanosomiasis in 2002. By far the largest number of cattle (4.6 million head) is found in mixed rainfed crop-livestock systems. Of these, a higher proportion (36 percent), compared to rangeland-based livestock-only systems (19 percent), is at risk from trypanosomiasis.

Trypanosomiasis is likely to be most prevalent in the humid and sub-humid zones, where length of growing period exceeds 180 days, largely reflecting the habitat preferences of the tsetse fly. It is therefore no surprise that production systems in the humid and sub-humid zone account for the highest share of cattle at risk from trypanosomiasis of Uganda's two major production systems: About 56 percent of the cattle in the mixed rainfed crop-livestock system (1.3 million head) and 59 percent of the cattle in the rangeland-based livestock-only system (93,000 head).

To have the greatest impact on cattle trypanosomiasis, planners targeting these two areas with intervention strategies need to balance absolute and relative livestock numbers, but also take the geographic extent of the target area into consideration (since it is a major cost factor). Examining average stocking rates in different production systems, inside and outside the tsetse areas, can help in prioritizing the most promising locations.

In each of the seven livestock production systems shown in Table 2, stocking rates are higher outside the tsetse area and, in some cases, dramatically so. The greatest differentials in stocking rates are in the rangeland-based livestock-only systems. There are nearly six times as many head per square kilometer outside the tsetse distribution in the temperate areas, though these include only relatively small numbers of animals. In the arid and semiarid areas, which do account for large numbers of cattle, there are over five times as many head per square kilometer outside the tsetse distribution. If, as a result of tsetse removal, the stocking rates currently seen outside the tsetse area in each production system could be achieved throughout that system,

Map 10

TSETSE DISTRIBUTIONS: COMBINED MAP OF THE DISTRIBUTIONS OF *GLOSSINA FUSCIPES FUSCIPES*, *G. PALLIDIPES*, AND *G. MORSITANS SUBMORSITANS*


Sources: International boundaries (NIMA, 1997), district administrative boundaries (UBOS, 2006a), subcounty administrative boundaries (UBOS, 2002a), water bodies (NFA, 1996; NIMA, 1997; Brakenridge et al., 2006), and tsetse distribution (Wint, 2001).

TABLE 2 TRYPANOSOMIASIS RISK IN UGANDA: LAND AND LIVESTOCK PROFILE, 2002

		PRODUCTION SYSTEM AREA	TRYPANOSOMIASIS AREA	
		Total Area (square kilometer)	Total Area (square kilometer)	Share of Total Area in Production System (percent)
PRODUCTION SYSTEM	Rangeland-Based Livestock-Only Systems			
	Arid and Semi-arid	18,913	3,845	20.3
	Humid and Sub-humid	17,355	12,756	73.5
	Temperate and Tropical Highlands	1,208	321	26.6
Total Rangeland-Based Livestock-Only Systems		37,476	16,923	45.2
Mixed Rainfed Crop-Livestock Systems	Arid and Semi-arid	36,428	7,674	21.1
	Humid and Sub-humid	96,615	58,936	61.0
	Temperate and Tropical Highlands	15,941	3,609	22.6
	Total Mixed Rainfed Crop-Livestock Systems	148,984	70,219	47.1
Other Livestock Systems		15,588	9,153	58.7
TOTAL		202,048	96,295	47.7

then increases in cattle numbers to the tune of 0.8 million head may result. Such figures can be considered indicative only—there may be other factors that cause the observed differentials in stocking rates—but it is clear that higher stocking rates are achieved outside the tsetse distribution.

TRYPANOSOMIASIS RISK AND POVERTY

Looking at trypanosomiasis risk in terms of numbers of livestock at risk is important, but what decision-makers really need to understand to prioritize their interventions is how the disease affects the owners of those livestock—in terms of livelihoods, welfare, and food security. Table 3 provides a breakdown of demographic and welfare statistics in the context of livestock production systems and the distribution of tsetse in Uganda.

It comes as no surprise that the vast majority of rural Ugandans live in the widespread mixed rainfed crop-livestock system in the humid and sub-humid zone: 12.8 million people are supported by this system, and 40 percent of these—some 5.1 million people—live in areas infested by tsetse. Of these 5.1 million, some 1.9 million live below the poverty line. This system supports by far the greatest number of poor people living under tsetse threat compared to the other systems, though the rangeland-based livestock-only system in the humid and sub-humid zone also has large numbers of poor in the tsetse areas—about 0.2 million—as do the so-called ‘other’ systems, with some 0.17 million.

It is also interesting to compare poverty rates inside and outside the tsetse areas in the various systems. The greatest numbers of poor live in the three systems within tsetse areas—mixed rainfed crop-livestock system in the humid and sub-humid zone (with 1.9 million poor); rangeland-based livestock-only system in the humid and sub-humid zone (with about 0.2 million poor); and ‘other’ systems (with about 0.17 million poor). In these three systems greater poverty rates are also seen inside the tsetse area compared with outside: 25 percent versus 15 percent; 45 percent versus 16 percent; and 16 percent versus 12 percent, respectively. The other systems all have higher rates of poverty outside the tsetse area compared to inside. In terms of the density of poor people, it is the humid and sub-humid systems (whether mixed rainfed crop-livestock or rangeland-based livestock-only) that have higher densities of poor people within the tsetse areas compared to outside—for example twice the density of poor people in the mixed rainfed crop-livestock system in the humid and sub-humid zone occurs inside the tsetse areas (32 per square kilometer) compared with outside the tsetse areas (16 per square kilometer).

DISCUSSION AND FUTURE ANALYSIS

Much can be learned from overlaying maps showing livestock disease risk on top of maps of livestock distribution, livestock production systems, population, and poverty. The analysis above highlights that, in Uganda, the benefits of trypanosomiasis control are likely to be greatest

CATTLE NUMBERS			CATTLE DENSITY		
Total Cattle Population in Production System (number)	Within Trypanosomiasis Area		Average Cattle Density (number of cattle per square kilometer)		
	Total Cattle Population (number)	Share of Total Cattle Population in Production System (percent)	Within Production System	Within Trypanosomiasis Area	Outside Trypanosomiasis Area
412,821	18,934	4.6	21.9	5.0	26.2
157,479	93,139	59.1	9.1	7.3	14.0
38,076	2,248	5.9	31.7	7.1	40.6
608,376	114,321	18.8	16.3	6.8	24.1
1,505,110	181,143	12.0	41.4	23.8	46.1
2,405,160	1,344,260	55.9	24.9	22.8	28.2
722,366	145,113	20.1	45.4	40.4	46.9
4,632,636	1,670,516	36.1	31.1	23.8	37.6
281,514	117,891	41.9	18.1	12.9	25.5
5,522,526	1,902,728	34.5	27.4	19.8	34.3

Source: Authors' calculation. The data are derived from combining the tsetse distribution (Map 10), taking a threshold for the probability of presence of greater than 30 percent to indicate presence of tsetse and therefore trypanosomiasis, with maps of cattle densities (Map 3a) and livestock production systems (Map 1), using GIS overlay functions.

in the mixed humid and sub-humid systems: these areas have the largest absolute numbers of cattle, the greatest numbers of poor people, and the greatest densities of poor people. Moreover, control of cattle trypanosomiasis in mixed rainfed crop-livestock areas will have additional benefits from the associated crops, for example increases in manure, the potential for draft power, and better use of crop residues. But these systems cover large areas of Uganda—about half of the total land area. More focused targeting can be achieved in some other farming systems where the absolute numbers may not be quite so dramatic, but where the impact of trypanosomiasis may be even greater, albeit over smaller areas. The rangeland-based livestock-only systems in the humid and sub-humid zone, in particular, have the highest proportion of cattle in tsetse areas, have stocking rates inside the tsetse area of only half those outside, and have large differentials in poverty rates and densities inside and outside the tsetse areas.

Without systematic survey data it is not possible to say to what extent poor people in tsetse-infested areas depend on cattle for their livelihoods. To answer that would require survey data, representative at the level of the production system, that explicitly links: (1) household welfare (e.g., income, food security); (2) the role of cattle (e.g., ownership, income); and (3) the importance of trypanosomiasis in those cattle (e.g., mortality, morbidity).

Some indication of cattle ownership can be taken from Ellis and Bahiigwa (2003) who report on surveys conducted in three districts of Uganda in 2001: In Mbale District,

which is mostly mixed humid and sub-humid, with some mixed temperate and tropical highlands (on the slopes of Mount Elgon) and a small area under 'other' systems, 37 percent of households own cattle. In Kamuli District, which is entirely mixed humid and sub-humid, 24 percent of households own cattle. In Mubende District, which is mostly mixed humid and sub-humid, with some mixed arid and semi-arid areas, 22 percent of surveyed households held cattle. On average they found about 30 percent of households to be engaged in cattle rearing.

Data from the new National Livestock Census (MAAIF and UBOS, to be published) reveal similar shares of cattle-owning households for Mbale, Kamuli, and Mubende Districts (31, 35, and 21 percent, respectively) for 2008 (see Map 2b). In fact, analysts working with the Ministry of Agriculture, Animal Industry and Fisheries and with national and local planning efforts can use these recent livestock data to establish more accurate estimates of cattle ownership by production system and, in turn, use these estimates to model the economic costs and benefits of different intervention strategies.

Such an economic model to estimate the benefits that would accrue from controlling the tsetse fly has been constructed for a regional priority setting study in the Horn of Africa, building on an approach developed for West Africa (Shaw et al., 2006). In a collaborative effort between the Intergovernmental Authority on Development's Livestock Policy Initiative and the Programme Against African Trypanosomiasis, livestock production systems have been

TABLE 3 UGANDA TRYPANOSOMIASIS RISK IN UGANDA: PEOPLE AND POVERTY PROFILE, 2005

Production System		HUMAN POPULATION			NUMBER OF POOR		
		Total Human Population in All Rural Subcounties in Production System (number)	Within Trypanosomiasis Area		Total Number of Poor in All Rural Subcounties in Production System (number)	Within Trypanosomiasis Area	
			Total Human Population (number)	Share of Total Human Population in Production System (percent)		Total Number of Poor (number)	Share of Total Number of Poor in Production System (percent)
Rangeland-Based Livestock-Only Systems	Arid and Semi-arid	652,986	25,071	3.8	476,304	12,350	2.6
	Humid and Sub-humid	726,849	371,140	51.1	411,765	203,520	49.4
	Temperate and Tropical Highlands	75,497	3,611	4.8	42,671	2,410	5.6
Total Rangeland-Based Livestock-Only Systems		1,455,331	399,822	27.5	929,401	155,689	16.8
Mixed Rainfed Crop-Livestock Systems	Arid and Semi-arid	2,822,061	152,645	5.4	1,093,965	49,136	4.5
	Humid and Sub-humid	12,759,447	5,128,704	40.2	4,651,206	1,869,793	40.1
	Temperate and Tropical Highlands	3,489,997	143,684	4.1	836,089	35,069	4.2
Total Mixed Rainfed Crop-Livestock Systems		19,071,504	5,425,034	28.4	6,577,530	1,627,595	24.7
Other Livestock Systems		2,554,436	666,428	26.1	687,760	168,533	24.5
TOTAL		23,081,272	6,491,284	28.1	8,191,229	1,946,222	23.8



defined and mapped according to the ratio of livestock-to crop-derived income, using information collected for livelihood analysis. This map has formed the basis for economic herd models analyzing the impact of trypanosomiasis in pastoralist, agropastoralist, and mixed farming systems.

Based on cattle population data, expert opinion, livelihoods surveys, and documented information, the mixed farming systems have been further subdivided into those with high and low use of draft animals and those dominated by dairy production. In essence, the herd model is parameterized separately to account for each of the production systems identified. Within each system, different parameters are also established for areas with and without tsetse fly and trypanosomiasis (e.g., different mortality rates, birth rates, yields). The herd models will then be run for a 20-year period, and outputs—milk, livestock sales, manure, draft power—will be monetarized. In this way, the financial benefits that would accrue over a 20-year period through removal of the tsetse vector will be modeled and mapped. It is expected that the results from this regional analysis will reinforce what is shown in the analysis above: that it will tend to be the systems where cattle and crop production are closely intertwined, often on the fringes of the tsetse distribution, which will see the highest potential benefits from controlling trypanosomiasis in livestock.

POVERTY RATE (percent)			POVERTY DENSITY (number of poor per square kilometer)		
Average Poverty Rate for All Rural Subcounties in Production System	Average Poverty Rate		Average Poverty Density for All Rural Subcounties in Production System	Average Poverty Density	
	Within Trypanosomiasis Area	Outside Trypanosomiasis Area		Within Trypanosomiasis Area	Outside Trypanosomiasis Area
75.8	13.4	62.4	25.2	3.2	22.0
60.9	45.2	15.8	23.7	16.0	7.8
78.4	22.0	56.3	35.3	7.5	27.8
69.0	28.3	40.7	24.8	9.2	15.6
50.5	8.8	41.7	30.0	6.4	23.6
40.1	24.8	15.3	48.1	31.7	16.4
28.4	6.2	22.2	52.4	9.7	42.7
41.4	18.7	22.3	44.1	23.2	21.0
28.4	16.5	11.8	44.1	18.4	25.7
45.6	20.4	25.1	40.5	20.2	20.3

Source: Authors' calculation. The data are derived from combining the tsetse distribution (Map 10), taking a threshold for the probability of presence of greater than 30 percent to indicate presence of tsetse and therefore trypanosomiasis, with maps of poverty density (Map 5), population density, and livestock production systems (Map 1), using GIS overlay functions.



Moving Forward:

Conclusions and Recommendations

Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda illustrates how poverty maps can be combined with livestock-related maps to create new indicators and information that can guide future investments to reduce poverty and strengthen the livestock sector. The examples demonstrate how to classify and map livestock systems by type of livestock, market accessibility, livestock disease risk, and poverty profile, and how the analysis can in turn help to identify priority regions or communities for pro-poor livestock management interventions.

By integrating and conducting spatial analyses on livestock and poverty data, Ugandan analysts can strengthen livestock investments and poverty reduction efforts. Similarly, given that analysts already have the data available to conduct such work, Ugandan decision-makers can demand additional analytical returns for their data investments, such as agricultural census data collection or geographic referencing of livestock markets. The examples presented here demonstrate how examination of spatial relationships between poverty, livestock systems, location of livestock services such as dairy cooling plants, and livestock disease 'hotspots' can provide new information to help craft more effective—and more evidence-based—investments and poverty reduction efforts.

CONCLUSIONS

The process of compiling the data, producing the maps, and analyzing the map overlays has shown that:

- Analysts working with the Uganda Bureau of Statistics, the Ministry of Agriculture, Animal Industry and Fisheries, and other collaborators can combine poverty maps with maps of livestock systems and distributions, milk surplus and deficit areas, and areas of high disease risk to highlight relationships that might not otherwise be obvious.
- From these map overlays, analysts can create new indicators and maps juxtaposing levels of poverty and the type and levels of livestock production.

- Analysts can use these indicators and maps to select geographic areas with specific poverty and livestock profiles for pro-poor targeting.
- Decision-makers can use these new indicators and maps to make more informed and transparent choices when prioritizing investments in the livestock sector and to communicate these priorities to the public.
- These new indicators and maps can help bring together and inform decision-makers from different sectors (e.g., livestock and human health) on complex problems such as diseases that affect both people and livestock (such as sleeping sickness).

While the maps and analyses in this report are primarily designed to demonstrate the value to decision-makers of combining social and livestock-related information, they also support the following conclusions:

Maps showing milk surplus and deficit areas can highlight geographic differences in market opportunities for poor dairy farmers. This information can help policymakers, dairy researchers, and development agencies to better target knowledge dissemination, market infrastructure investments, and service delivery to dairy farmers.

- ***Milk surplus areas*** – About 3.5 million poor people live in subcounties identified as producing more milk than their residents consume (based on maps in this report). Development strategies in these subcounties could aim to improve market infrastructure and reduce market transaction costs.
- ***Milk deficit areas*** – Approximately 0.8 million poor people live in areas where the demand for milk is greater than the supply (based on maps in this report). Interventions that target increasing production (e.g., capacity building efforts, improved service delivery) could be beneficial in these areas.

Maps showing animal (and human) disease risk by livestock system at the subcounty level can help inform the choice of the most appropriate control approach.

- The impact of disease on livestock, and more importantly on the keepers of those livestock, differs geographically because the role of livestock in peoples' livelihoods varies among production systems. Provision of animal health services varies across systems, thus the optimal choice of disease control approach will need to vary.
- The benefits of trypanosomiasis control are likely to be greatest in the mixed humid and sub-humid systems: these areas have the largest absolute numbers of cattle, the greatest numbers of poor people, and the greatest densities of poor people.

Mapping poverty, livestock systems, and distribution of disease vectors such as tsetse fly can pinpoint poverty patterns within disease risk areas. This can help to increase understanding of how a disease affects the owners of livestock in terms of livelihoods, welfare, and food security.

- Some 1.9 million poor live in humid and sub-humid mixed crop-livestock farming areas infested by tsetse fly, compared to around 0.4 million poor living in the other livestock systems. However, the percentage of poor is much higher in these other systems, such as pastoral systems.

RECOMMENDATIONS

The primary objective of this publication is to demonstrate with examples how census and poverty maps can be combined with dairy market and livestock disease information to produce new indicators and maps. The publication also seeks to catalyze the production of new and improved analyses and greater use of the resulting information in decision-making. Central and local government agencies can increase the likelihood of more evidence-based decision-making by intervening on the supply side to make more and better information available, and on the demand side to increase the use of these maps and analyses in government planning.

Strengthening the supply of high-quality spatial data and analytical capacity will provide broad returns for future planning and prioritization of livestock sector and poverty reduction efforts. Priority actions to achieve this include:

- **Fill important livestock data gaps, regularly update data, and continue supplying poverty data for small administrative areas.**
Future planning could be improved with more precise livestock data from the Ministry of Agriculture, Animal

Industry and Fisheries (such as the 2008 National Livestock Census) and other important livestock production indicators such as the location of livestock markets and service providers, especially if they are available for small administrative areas and are updated regularly. Regular updates of detailed poverty maps for small administrative areas is essential for tracking progress of poverty reduction efforts and to support pro-poor targeting of resources, both for central and local government institutions.

- **Strengthen data integration, mapping, and analysis.**
Compared to the financial resources spent on data collection, fewer resources have been earmarked to analyze and communicate the data from the various sources explored in this publication. To create a fuller picture of the human-livestock relationship, it is important that different data relative to livestock, disease, and other socioeconomic data are made compatible and can be analyzed together. The in-house technical and analytical capacity within the Ministry of Agriculture, Animal Industry and Fisheries and other government institutions to extract, map, interpret, and communicate these data requires strengthening through regular and focused training. Such training needs to foster a more integrated approach that promotes understanding of the whole livestock production system and how the components of this system interact and relate to each other.

Promoting the demand for such indicators and spatial analyses will require leadership from several government agencies. Actions in the following three areas carry the promise of linking the supply of new maps and analyses with specific decision-making opportunities:

- **Incorporate poverty information in livestock-related interventions and in regular performance reporting for the livestock sector.**
 - This publication provides examples of how poverty maps can enrich analyses for the livestock sector and lead to more precise geographic targeting. Follow-up analyses by the Animal Resources Directorate in the Ministry of Agriculture, Animal Industry and Fisheries can build on these examples and include other variables that are relevant to prioritizing livestock-related interventions (e.g., costs, efficiency, equity).
 - There is a wide range of institutions in the livestock sector (National Agricultural Research Organization, National Agricultural Advisory Services, Dairy Development Authority, and others) that can work more closely with the Uganda Bureau of Statistics and the Ministry of Finance, Planning and Economic Development to discuss the pros and cons of different livestock investment prioritization criteria for national and local planners and local community representatives.

- Future performance reporting for the livestock sector could include a poverty profile identifying the benefits that low-income families have received from livestock investments. For example, communities that report a growth in livestock assets and greater access to livestock-related services could break out how these benefits have been distributed by income level.

■ ***Incorporate livestock sector information into poverty reduction efforts.***

- Improved access to livestock, markets, and livestock services will affect well-being, livelihoods, and economic development. Therefore, strategic investments to improve livestock infrastructure and service delivery could provide broad benefits reaching far beyond the livestock sector. The Ministry of Finance, Planning and Economic Development could collaborate with the institutions in the livestock sector to identify communities that are near a critical threshold where additional investment could bring widespread benefits at the community level. Such a threshold could be defined by the community's current livestock assets and other community indicators reflecting well-being. Based on such an assessment, district and local communi-

ties could then work with the Central Government to lobby for changes in recurrent and development budgets (both from the Central Government and District Local Government). These new funds could be used to design geographically targeted campaigns to boost livestock service delivery and improve livestock production and marketing performance in priority communities.

■ ***Incorporate poverty maps and maps of livestock systems, disease risk, etc. into local decision-making.***

- The underlying data and maps discussed in this publication are in most cases detailed enough to be useful in local decision-making. However, many local decision-makers still have difficulty accessing these data, conducting such analyses, and applying the findings to planning efforts. Initially, the Ministry of Agriculture, Animal Industry and Fisheries and the GIS unit at the Uganda Bureau of Statistics could provide technical and analytical support to a few pilot districts to incorporate poverty information into the design of livestock interventions. Later, such support could be given to all districts through ongoing and planned local government capacity-building programs.



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