A WORLD BANK STUDY

Prospects for Livestock-Based Livelihoods in Africa's Drylands

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Foreword

Drylands—defined here to include arid, semi-arid, and dry sub-humid zones—are at the core of Africa's development challenge. Drylands make up 43 percent of the region's land surface, account for 75 percent of the area used for agriculture, and are home to 50 percent of the population, including a disproportionate share of the poor. Due to complex factors, the economic, social, political, and environmental vulnerability in Africa's drylands is high and rising, jeopardizing the long-term livelihood prospects for hundreds of millions of people. Climate change, which is expected to increase the frequency and severity of extreme weather events, will exacerbate this challenge.

Most of the people living in the drylands depend on natural resource-based livelihood activities, such as herding and farming. The ability of these activities to provide stable and adequate incomes, however, has been eroding. Rapid population growth has put pressure on a deteriorating resource base and created conditions under which extreme weather events, unexpected spikes in global food and fuel prices, or other exogenous shocks can easily precipitate full-blown humanitarian crises and fuel violent social conflicts. Forced to address urgent short-term needs, many households have resorted to an array of unsustainable natural resource management practices, resulting in severe land degradation, water scarcity, and biodiversity loss.

African governments and the larger development community stand ready to tackle the challenges confronting dryland regions. But while political will is not lacking, important questions remain unanswered about how the task should be addressed. Do dryland environments contain sufficient resources to generate the food, employment, and income needed to support sustainable livelihoods for a fast-growing population? If not, can injections of external resources make up the deficit? Or is the carrying capacity of dryland environments so limited that out-migration should be encouraged as part of a comprehensive strategy to enhance resilience? And given the range of policy options, where should investments be focused, considering that there are many competing priorities?

To answer these questions, the World Bank teamed up with a large coalition of partners to prepare a study designed to contribute to the ongoing dialogue about measures to reduce the vulnerability and enhance the resilience of populations living in the drylands. Based on analysis of current and projected

future drivers of vulnerability and resilience, the study identifies promising interventions, quantifies their likely costs and benefits, and describes the policy trade-offs that will need to be addressed when drylands development strategies are devised.

Sustainably developing the drylands and conferring resilience to the people living on them will require addressing a complex web of economic, social, political, and environmental vulnerabilities in Africa's drylands. Good adaptive responses have the potential to generate new and better opportunities for many people, cushion the losses for others, and smooth the transition for all. Implementation of these responses will require effective and visionary leadership at all levels from households to local organizations, national governments, and a coalition of development partners. This book, one of a series of books prepared in support of the main report, is intended to contribute to that effort.

Magda Lovei

Manager, Environment & Natural Resources Global Practice

World Bank Group

Acknowledgments

This book is one of several background works prepared for the study "Confronting Drought in Africa's Drylands: Opportunities for Enhancing Resilience." The study, referred to here as the "Africa Drylands Study," was part of the Regional Studies Program of the World Bank Group Africa Region Vice Presidency and was carried out as a collaborative effort involving contributors from many organizations, working under the guidance of a team made up of staff from the World Bank Group, the United Nations Food and Agriculture Organization (FAO), and the Consultative Group for International Agricultural Research Program on Policies, Institutions, and Markets (CGIAR-PIM). Raffaello Cervigni and Michael Morris (World Bank Group) coordinated the overall study, working under the direction of Magda Lovei (World Bank Group).

This book, entitled *Prospects for Livestock-Based Livelihoods in Africa's Drylands*, was prepared by Cornelis de Haan based on inputs received from a large team of contributors including Tim Robinson and Polly Ericksen (ILRI); Abdrahmane Wane, Ibra Touré, Alexandre Ickowicz, and Matthieu Lesnoff (CIRAD); Frederic Ham and Erwann Fillol (Accion Contre la Faim); Siwa Msangi (IFPRI); Pierre Gerber, Giulia Conchedda, and Anne Mottet (FAO); and Raffaello Cervigni and Michael Morris (World Bank). Substantial inputs were also provided by participants in a consultation workshop held in Dakar in January 2014, hosted by CILSS and attended by about 30 livestock scientists.

Amy Gautam and Elizabeth Oakes Minchew (World Bank Group) copy-edited the manuscript. Vanthana Jayaraj (World Bank Group) assisted with the publication process.

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Cornelis (Cees) de Haan is a retired World Bank Senior Adviser. He has a post graduate degree in Animal Production from the University of Wageningen, the Netherlands. After his graduation, he worked for 10 years in Dutch Technical Assistance Programs in rural development projects in South America, followed by seven years in livestock research at the International Livestock Center for Africa (now ILRI) in Addis Ababa, Ethiopia ultimately as Deputy Director General. He joined the World Bank in 1983, working for 10 years on livestock development in the African and East European regions, and for the same period as Adviser (later Senior Adviser) responsible for the policy development and quality enhancement of the World Bank's animal resource development activities in the Rural Development Department, contributing to World Bank policy and investments in livestock related environmental, health and social issues. Since his retirement in 2001, he has remained active as a consultant in animal production and health for the World Bank and other international organizations. Within the World Bank he contributed to several rural strategy and sector papers. He has published extensively both through World Bank publications and the scientific literature on private and public sector roles in the delivery of animal health and production services (including One Health), livestock and environment, pastoralism, food safety, and livestock value chains.

Jill Barr has worked in international development for more than 30 years. She has a Master of Arts in Teaching (MAT) degree in French. For many years she worked with CIRAD as liaison officer for their Washington office providing coordination, research and editing support to CIRAD input on the African Drylands and other studies. Previously she was with the World Bank for 12 years as an Operations Assistant dealing with education and training projects in the Middle East and Maghreb countries.

Raffaello Cervigni is a lead environmental economist with the Africa Region of the World Bank. He holds a Masters and PhD degrees in Economics (from Oxford University and University College, London) and has some 19 years of professional experience in programs, projects, and research financed by the World Bank, the Global Environment Facility, the European Union, and the Government of Italy in a variety of sectors. He is currently the World Bank's

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Christian Corniaux is an agronomist with a PhD in livestock sciences. During the last 15 years, he has carried out research on dairy value chains in Africa. He is especially involved in West Africa (Senegal, Mali, Mauritania, Burkina Faso, Niger, Benin). The first studies were on dairy production systems. He worked also on dairy processors, strategies in their production and consumption areas. Now, he is working on the dynamics of dairy chain values in different countries all over the world. He works also on livestock trade in West Africa and North Africa. Based in Dakar, he coordinates research projects on those topics.

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Frédéric Ham is an expert in Geographic Information Systems and Disaster Risk Reduction. He holds an MSc in GIS from Lund University and BA degree in environmental engineering from Strasbourg University. With more than 10 years of experience within humanitarian organizations worldwide (ACF, Red Cross, MSF) he has been responsible for the design of various GIS based applications aiming at reducing the impact of natural disasters. Particularly, he has been extensively involved in the development of remote sensing based early warning and surveillance systems covering the Sahelian pastoral regions. The developments led to the production of functional and recognized tools to address food insecurity and vulnerability to drought in these areas.

Alexandre Ickowicz is a veterinarian and a research fellow of CIRAD (International Cooperation Center in Agricultural Research for Development, France) specialized in animal production science in the tropics. He holds Masters and PhD degrees in veterinary, tropical animal production and environmental science in Paris XII University. He has 18 years of professional experience working in dry areas of west and central Africa, collaborating with nation-

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Andrew Mude pursued his undergraduate degree in Gettysburg College, Pennsylvania. In 1999, he graduated summa cum laude with a major in Economics and a minor in Mathematics and French. In 2000, he joined Cornell University in New York in pursuit of his doctoral degree in Economics with a concentration in development economics and applied econometrics. He graduated with his PhD in June, 2006. As part of his dissertation research, he spent six months in the field studying coffee producers and their cooperatives in Murang'a district Kenya. For this effort he won the silver medal at the 2007 Global Development Network. Upon completion of his doctoral degree in Economics from Cornell University, he joined ILRI in August 2006 as an Economist at ILRIs Targeting and Innovations Program. Andrew's current flagship project involves leading the effort the design, develop and implement index-based livestock insurance aimed at protecting pastoralists against drought-related livestock mortality.

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Lance Robinson is a researcher specializing in environmental governance, and social-ecological resilience in pastoralist systems. His PhD research among Kenyan pastoralists focused on the connection between social-ecological resilience and the approaches to participation used by formal sector agencies working with pastoralists. Since completing his PhD, his research work has centered around participatory and community-based approaches to environmental governance. He also has over ten years of experience working with NGOs and as a consultant in Latin America, Africa and Asia.

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Alexandra Shaw graduated as an economist from Cambridge University and began work on animal health and livestock economics in Nigeria in the mid-1970s. She gained her PhD in 1986 from the University of Reading on the economics of trypanosomiasis and continued to work in this field. With a group of colleagues, she developed the concept of "mapping the benefits" to quantify the

potential gains from controlling tsetse and trypanosomiasis in cattle, combining this with maps of disease control costs, to map benefit-cost ratios. She has worked for bilateral and multilateral agencies, on project evaluations, postgraduate education and in over 20 African countries. Her recent focus has been the economics of controlling neglected zoonotic diseases in human and livestock populations in Africa. She now works as an independent consultant, while maintaining links with the University of Edinburgh.

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Executive Summary

This book, which was prepared as an input into the study "Confronting Drought in Africa's Drylands: Opportunities for Enhancing Resilience," reviews the challenges and opportunities facing the livestock sector and the people who depend on livestock in the drylands of Sub-Saharan Africa, with a particular focus on the Sahel Region and the Horn of Africa. The key findings and recommendations have been integrated into the synthesis report emerging from the larger study, but the additional material contained in this book is expected to be of interest as well to a more specialized audience interested in the current state of knowledge about drylands livestock production systems. This book presents a novel way of thinking about pastoral development, grounded in a conceptual framework that focuses on the multiple shocks faced by livestock keepers in the drylands and the ways in which those shocks can be addressed. The conceptual framework draws on a state-of-the-art literature review carried out by scientists from leading research institutes and development organizations, and it integrates the results of an innovative approach to modeling development options for the drylands livestock sector.

In the countries[1] covered by this study, the livestock sector is of major importance to the drylands economy, its people, and their lands. *Economically*, the direct contribution of meat, milk, and fiber ranges from 5 to 10 percent of total GDP and accounts for 15–40 percent of the added value in agriculture. When indirect contributions are factored in, including organic fertilizer, traction services, and insurance and saving functions, the economic contribution of livestock increases by about 50 percent. *Socially*, livestock fully or partially supports the livelihoods of about 110–120 million[2] people, or roughly 70 percent of the rural drylands population of West and East Africa. Of these people, between 25 and 41 million depend exclusively on livestock (pastoralists), while the rest derive a portion of their income from cropping (agro-pastoralists). These numbers take on even greater significance when one considers that pastoralists occupy about one-third of Sub-Saharan African (SSA), including many areas in which no other agricultural activities are currently possible.

Looking to the future, prospects for the drylands livestock sector are mixed. On the positive side, demand projections for red meat are favorable. Driven by population increases and income growth within the region, as well as by expand-

ing demand from global markets, demand for African livestock and livestock products is expected to grow rapidly. Projections made for this paper show that in 2030, demand for red meat of 6–7 million metric tons (MT) per year will surpass supply on average by about 1.7 million MT per year, or about 25 percent of total demand, roughly tripling the current structural deficit. This book argues that the deficit could be halved through increased production, provided appropriate policies and investments are implemented.

On the negative side, a large majority of livestock keepers in dryland regions of SSA are classified as poor.[3] While exact data are not available, analysis carried out for this study shows that about 80 percent of pastoralists (more than 20 million people) have an income (cash and home consumption) below the poverty line.[4] Asset levels also show the pervasiveness of poverty. The figure widely cited in the literature as the absolute minimum number of animals needed to provide a family income above the poverty level and buffer weather and disease shocks is 2.5 Tropical Livestock Units (TLU)[5] per capita among pastoralists (and one-half of that number for agro-pastoralists). This figure seems too low: our modeling results for pastoralists suggest that 3–4 TLU per capita are needed for pastoralists to stay above the poverty line. The available evidence on livestock numbers suggests that these minimum levels are not met: the 25–41 million pastoralists living in drylands hold about 51 million TLU (equivalent to only 1.2–2 TLU per capita), and the estimated 72–94 million agro-pastoral livestock keepers hold an estimated 76 million TLU (equivalent to only 0.75–1 TLU per capita). Once livestock holdings fall below the minimum level needed to remain above the poverty line, a drought or disease outbreak can precipitate an irreversible downward spiral of declining herd or flock sizes. In addition, the literature and the analysis carried out for this study show that livestock ownership in the drylands is highly skewed, with wealthier groups owning the large majority of cattle. Calculations based on data from SHIP (Survey-based Harmonized Indicators Program) show that the wealthiest 1 percent of livestock keepers own between 9 and 28 percent of the stock (expressed in TLU). According to this study's projections, given expected population growth of 3 percent per year for pastoralists and 2.5 percent per year for agro-pastoralists, assuming the same ownership patterns, and based on a "business as usual" scenario characterized by a continuation of current policies, 77 percent of pastoralists and 55 percent of agro-pastoralists will have less than 50 percent of the TLU per capita needed to stay above the poverty line by 2030, suggesting they will feel pressure to exit from the sector or face living indefinitely in poverty.

Compounding the problem of structural poverty is the extreme volatility of the so-called "boom and bust" pastoral economy. People and livestock in the drylands must cope with major shocks related to extreme weather events, civil conflict, fluctuating prices, and outbreaks of animal diseases. Over the past decade, these shocks led to an annual flow of about US$1 billion in humanitarian emergency aid into the drylands and affected an average 5 million people per year. During this period, conflicts in the western Sahel have displaced more than 1 million people, a significant share of whom are livestock keepers.

Box ES.1 Key Messages Emerging from This Book

- Scope exists to expand production of livestock in drylands, thereby increasing the contribution of the drylands to rising regional demand for animal source products. The proposed policy changes and investments, particularly those geared to improving animal health and enhancing market integration, could halve the projected 2030 deficit.
- Feed and animal resources are insufficient to provide over the next decades an adequate livelihood for all livestock-dependent people in the drylands. Under a "business as usual" scenario, projections made for this book show that in 2030, between one-half and three-quarters of livestock keepers will not have sufficient livestock holdings to remain above the poverty line, suggesting they will feel pressure to exit from the sector.
- Development of alternative sources of income, inside or outside drylands, needs to be an integral and major component of any drylands development strategy. The narrow focus of past livestock development policies in drylands on producing milk and meat needs to shift and embrace greater multi-functionality, particularly with incentives to strengthen the environmental stewardship of pastoralists and agro-pastoralists.
- The already highly inequitable distribution of livestock is projected to become even more extreme as a result of the ongoing transformation of the drylands economy, leading to further crowding out of poor pastoralists. Animal health improvement and increased market integration could somewhat increase the share of resilient livestock-keeping households.
- Policies designed to settle pastoralists in arid zones are unlikely to work. Herds and flocks must be mobile if they are to use temporally and geographically distributed feed resources, so restricting mobility will reduce productivity and exacerbate poverty.
- The cost of basic investments in animal health improvement and increased integration with higher-potential areas (which in part would come from the private sector) seems high at about US$500 million per year (or about US$27 per person made resilient), but it is lower than the economic losses caused by drought and lower than the US$2 billion spent per year on humanitarian aid.
- The lack of quantitative data on livestock-keeping livelihoods in drylands seriously constrains informed decision making. National and international research and planning agencies should be encouraged to better cover livestock-keeping households and their livestock in national research and data collection efforts.

Determinants of Resilience—How Can They Be Addressed?

The shocks that most significantly affect household welfare in dryland regions of SSA can be grouped into four main categories: (i) weather-related shocks; (ii) disease-related shocks; (iii) price shocks; and (iv) conflicts. The vulnerability and resilience of livestock-keeping households in the face of these shocks are shaped by three main determinants: (i) exposure to shocks; (ii) sensitivity to shocks; and (iii) coping capacity. The three determinants are described below, as are the measures that can be taken to enhance resilience and reduce vulnerability.

Exposure to Shocks

People living in drylands can avoid being affected by shocks if they can move out of harm's way when the shocks appear. The determinants to be addressed if people are to avoid being hit by a shock when it emerges include:

- *Degree of mobility and access to feed and water resources:* When drought hits, disease strikes, or conflict erupts, households that are mobile can move away to avoid being affected. In the drylands of SSA, mobile livestock systems are more productive than sedentary systems. Modeling analysis carried out for this book shows that over the period 2011–30 with a no drought scenario, in West Africa about 20 percent of the arid zone population (holding 28 million TLU) and in East Africa about 25 percent of the arid zone population (holding 40 million TLU) will not have enough year-round local feed resources and will be forced to move. Mobility is increasingly constrained by agricultural expansion and urban growth, however. Policy reforms are needed to guarantee pastoralists' right to mobility, and investments are needed to demarcate routes and allocate dry season grazing rights in common-use rangelands. In recent years, a number of pastoral laws or "codes" have been introduced defining pastoralists' rights. These laws recognize mobility as a key feature of pastoral systems. Implementation of these laws and codes has often lagged, however, constrained by cumbersome bureaucracies and weak enforcement mechanisms. If these laws and codes are to succeed in safeguarding pastoralists' mobility, policy makers and administrators will have to devote increased attention to ensuring their enforcement.
- More work is needed to identify underutilized areas that can be opened through development of water resources. Modeling analysis carried out for this study shows that increased feed resources (from a highly restrictive scenario of 10 percent access to an optimistic scenario of 40 percent access) would decrease the share of households living in extreme poverty or potentially forced to exit out of the sector from 83 to 51 percent over the 2011–30 period. Where water resource development could still help to make additional feed resources accessible, experience shows that siting of water points must be done at a regional scale and in an inclusive fashion to reduce conflicts.
- *Strengthening early warning and response systems:* Early warning systems (EWSs) became popular in the 1990s and were notably successful in improving the timeliness and quality of information about impending drought crises. Several of the original EWSs are still operating. Lamentably, most EWSs have been used almost exclusively for planning the procurement and distribution of emergency aid, and not to produce information of direct use to pastoralists; only rarely have EWSs been harnessed to minimize losses in livestock-based livelihoods. This is disappointing, because one of the most important early response actions, with a high rate of return, that can be taken to enhance resilience in the drylands livestock sector is to help herders rapidly "destock"; that is, sell off their livestock at the initial onset of drought.

Sensitivity to Shocks

People living in dryland regions who are unable to move out of harm's way when a shock appears will be less affected if their livelihoods are not sensitive to the shock's effects. The following determinants should be addressed to minimize losses when one or several shocks hit pastoral or agro-pastoral households.

- *Disease prevalence:* Throughout most of the drylands, livestock herds are sparsely distributed over vast areas, making large-scale epidemic disease outbreaks relatively infrequent and the losses limited (although the indirect losses because of trade restrictions can be substantial). On the other hand, the mobility of animals facilitates disease transmission and constrains control. Control of highly contagious animal diseases is a public sector task requiring international collaboration, and one that would best be tackled by putting in place a permanent international funding mechanism. Less contagious diseases, such as those caused by parasitism, are highly prevalent in the drylands and kill significant numbers of young stock. The clinical services needed to control the latter category of diseases are generally considered private goods, since they benefit individual herd owners. This means that drylands-adapted approaches using private para-veterinarians, as already successfully introduced in many countries of the region, need to be further developed. In the arid areas, animal health improvement investments must be accompanied by increased feed supply or enhanced mobility.
- *Market integration:* Most of the households that depend on livestock as a principal livelihood source are reasonably well integrated into the market. While this allows them to generate income from the sale of animals and livestock products, it also leaves them heavily exposed to price shocks. Pastoral households, which rely on markets to purchase most of their cereal needs, are particularly vulnerable to extreme fluctuations in livestock/cereal price ratios, such as those typically experienced during times of drought. A reduction of the exposure to weather and price shocks through increased market integration can be achieved by promoting closer integration of extensive production systems found in drylands with more intensive fattening/finishing operations in higher-potential areas (for example, the highlands of East Africa, the savannahs of West Africa) through stratification of livestock systems. While stratification often failed in the past, usually because it was managed by inefficient parastatals, today it looks more promising, because private investors are getting increasingly interested in intensive fattening systems (for example in Ethiopia), and more discerning African consumers are now willing to pay a higher price for the better-quality meat coming from these intensive fattening systems. A package of health improvement and intensive fattening outside the drylands will increase production under a no drought scenario, according to the analysis, by about 750,000 MT per year, reducing the deficit projected in 2030 by approximately one-half, and reducing greenhouse gas (GHG) emissions by 18 percent compared to the baseline. It would also pre-

clude the likely exit of 200,000 pastoral and 3 million ago-pastoral households. For stratification to occur, however, major investments are needed in infrastructure, logistics, and technology. Collaboration between the public and private sectors will also be needed, as well as enhanced food safety (mostly a public sector task) and food quality (mostly a private sector task).

Capacity to Cope with Shocks

People living in drylands regions who are unable to move out of harm's way when a shock appears and whose livelihoods are sensitive to the shock are likely to suffer income losses. For these people, the ability to survive will depend mainly on their coping capacity. The factors affecting the capacity of livestock-keeping households to recover rapidly from shocks and over the longer term to become better prepared for the next shock therefore are important. For short-term recovery, the policy and investment options include:

- *Introducing livestock insurance.* Index-based livestock insurance (IBLI) is a mechanism for compensating livestock owners when livestock mortality or forage loss from weather-related events reduces their income below a predefined critical threshold. An index constructed using key climatic variables can provide an objective means of determining when a payout is warranted. IBLI has been piloted successfully in Kenya and scaled up in Ethiopia.
- *Establishment of feed reserves*. On-farm or off-farm growing of forage, including fodder trees, and harvesting of surplus wet season grass that can be accessed in times of crisis could provide an important buffer for agro-pastoral livestock keepers. A viable seed industry and credit are important preconditions for this intervention. Setting aside areas for "deferred grazing" is an option for the pastoral environment but is only possible if the institutional framework for allocating access rights to specific groups is well established.

Over the longer term, the objective of public policy should be to make the majority of the livestock-keeping population independent of external support. The policies that would do so focus on asset distribution and diversification of income sources:

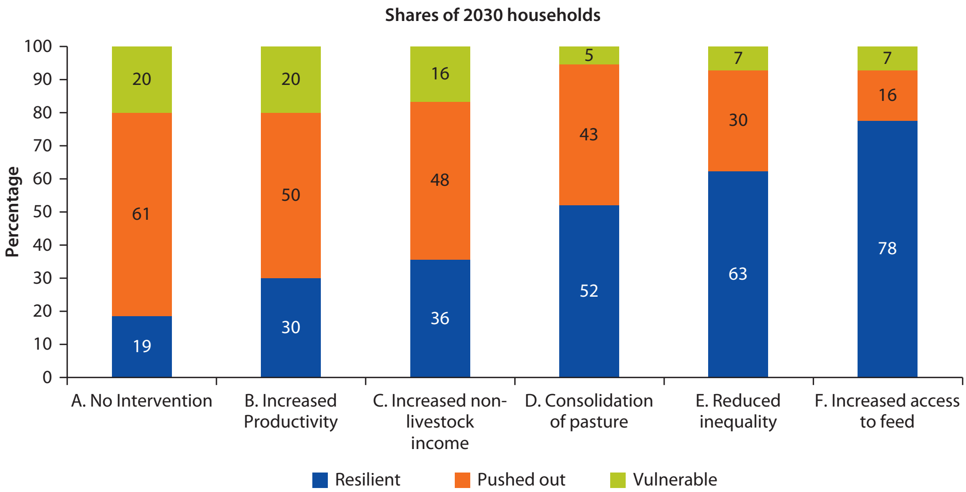
- *Asset distribution*. Given finite physical resources, the highly inequitable distribution of livestock assets (which keeps three-quarters of pastoral households and one-half of the agro-pastoral ones under the critical threshold for exit of 5 TLU or 3.5 TLU per household, respectively) should be addressed to build the essential buffering capacity to cope with shocks. Policy options include:
  - Limiting land ownership to prevent land grabbing by owners of large herds;
  - Enhancing mobility of animals to give vulnerable households easier access to underutilized grazing resources; and
  - Allocating exclusive water use and grazing rights for the wet and dry seasons to groups of smallholder livestock keepers.

According to modeling analysis carried out for this book, land consolidation for households still vulnerable but with moderate livestock resources (that is, between 50 and 100 percent of the TLU needed to pass the poverty line) would increase the share of resilient households from 20 to 47 percent and reduce the share of households that are pushed or drop out from 61 to 53 percent. Further reduction of inequity, such as through progressive taxation, was tested by changing the Gini coefficient: a 20 percent change in the Gini coefficient over the 2010 baseline would reduce the share of households that are pushed or drop out from 61 to 50 percent, and to 41 percent with a 40 percent change in the Gini coefficient.

- *Diversification of income sources:* Large-scale emigration from pastoral areas can be mitigated if additional revenues can be generated within the pastoral sector. Households that are able to rely on multiple sources of income are less sensitive to shocks than households that rely exclusively on a single income source. Within the sector, market differentiation (that is, branding such as for Sahelian beef or Kenyan mutton, product differentiation, and value addition) will increase income and create employment in drylands. Outside the sector, remittances, of critical importance to survive any severe shock, are important, probably in both pastoral and agro-pastoral systems. Other income-generating activities, such as beekeeping, production of charcoal and firewood, and petty trading have some, but only limited, scope in view of the magnitude of the income gap to be bridged. One option for diversifying incomes in drylands, more far-sighted but certainly worth consideration, is the introduction of institutional and financial instruments that offer payment for environmental services (PES) such as carbon sequestration, biodiversity conservation, water cycling, and landscape management. PES has been introduced on a limited basis in SSA for wildlife conservation and in other parts of the world for carbon sequestration. Promoting synergies between livestock and wildlife conservation seems logical, and enhancing the resilience of drylands households through directed cash transfers seems more attractive than continuing streams of food aid.

Introduced individually, none of interventions described above would have a transformational impact on the number of vulnerable households, so the analysis explored the combined impact of all interventions. As shown in figure ES1, the combined interventions could make a big difference: by 2030, the share of vulnerable households could be reduced to 7 percent and the proportion of livestock-keeping households having so few animals that they would feel pressure to exit from the sector reduced to only 16 percent. This does not imply, however, that all of the interventions must necessarily be implemented at the same time; each intervention, implemented individually, will improve livelihoods, although the impact might not be as transformative as desired.

Figure ES1 Impact of Combined Interventions on the Resilience of Livestock-Keeping Households, 2030 (%)



Challenges

Governance. Good governance will be a key factor if the above-mentioned measures are to be implemented successfully. Ensuring good governance will be a challenge, as livestock systems in many drylands areas are already under major stress. Increased competition for grazing land has led to increased incidence of conflicts, which in the absence of effective governance systems can escalate into major instability. Criminality and religious extremism are rising both in the Sahel and in the Horn of Africa. Important measures to address these constraints include: (i) *strengthening an equitable and fully participatory policy dialogue* with pastoralists, especially at the local level (the challenge will be to turn the anti-government attitude now prevailing in many pastoral groups into a cooperative one, where pastoralists, with their unique knowledge of drylands, become the eyes and ears of the public sector and promoters of stability); (ii) *maintaining or even enhancing pastoralists' rights to mobility*; and (iii) *introducing conflict resolution mechanisms,* including participatory consultative processes, facilitated arbitration processes, and equitable grievance redress procedures, that will allow for peaceful resolution of competing claims for common use resources. All these measures will affect multiple groups and encounter conflicting interests. The challenge will be to bring together all of the relevant parties. Positive signs have been observed in recent months of a renewed willingness to engage in constructive dialogue, as reflected in the commitments expressed in the N'djamena and Nouakchott Declarations. Following up on these important documents with concrete actions will be critical for developing a more resilient and stable drylands livestock economy.

Redressing equity: Evidence is accumulating that livestock ownership both in the Sahel and in the Horn of Africa is becoming increasingly concentrated. Ever greater numbers of animals are ending up in the hands of wealthy traders or government officials, who tend to manage their herds with hired labor, in the process crowding out many of the small herders who historically accounted for the largest share of the market. The suggested policies of preferential land allocation to smaller livestock-keeping collectives and progressive grazing fees or taxation policies are likely to engender significant resistance from wealthy livestock owners, but, as shown by the analysis, are needed to keep large numbers of livestock-keeping households from being pushed out.

Towards sustainable provision of services: Most of the "best bet" interventions described in this book (pastoral water development, payments for environmental services, early warning systems, animal health services) require recurrent funding, which, as experience has shown, cannot be assured in many African countries. Addressing this constraint requires concerted action on two policy fronts: (i) creating an incentive framework that can attract private service providers to enter the market as public service providers are gradually phased out; and (ii) recognizing the international public goods character of these investments, and developing mechanisms for long-term or even permanent international funding.

Tradeoffs: The interventions described above are likely to involve a number of tradeoffs, particularly between efficiency and equity. For example:

- *Stratification:* Early offtake of males will favor large herd owners, who can better provide the uniformity and volume of feeder animals, and might further crowd out small livestock keepers.
- *Product differentiation* will benefit larger herd owners, who are better equipped to make the investments to meet the required uniformity in quality required by feedlots.
- *Skills enhancement leading to outmigration* will benefit the poorer parts of society, which depend more on remittances, but it could cause larger producers' labor costs to rise.
- *Payment for environmental services schemes* will particularly benefit agro-pastoral households because of the economies of scale involved in the measurement.
- *Animal health improvement* will, if adequate coverage is ensured and sustained, primarily help the poorer livestock keepers, who have more limited access than wealthier and more powerful ones and who rely more on small ruminants, for which the needs and impacts are greatest.
- *Disseminating the results:* Many of the recommendations made in this book have been made before, but they have not been internalized by African decision makers. The challenge will therefore be to find appropriate channels for conveying the key messages. The message that there are limited income growth opportunities in the dryland livestock sector and there is a need for alternative employment sources needs to be spread by a unified group of

technicians and pastoralists, form part of the investment strategy of the donors, and be reported to as many policy meetings as can be accessed. This will need several preparatory meetings with scientists, pastoralists and donor representatives and high-level presentations to Sub-Saharan African policy makers.

Looking to the Future: Long-Term Vision for Livestock Systems in the Drylands of SSA

The vision that emerges from this background paper is as follows:

In arid and semi-arid zones, a reasonable goal for 2030 is to have land use, training and micro-finance systems established that promote an appropriate balance between human and livestock carrying capacities, featuring mainly *grassland/pastoral systems* that reliably and sustainably satisfy the minimum income needs of herder households, produce at least a significant part of the demand in local markets for animal source food, and provide environmental services for which livestock keepers receive compensation.

In the higher rainfall zones of the semi-arid areas, and in the sub-humid zones, a reasonable goal for 2030 is to have intensified production systems established, featuring mainly *mixed livestock/arable farming or agro-pastoral systems* that are closely linked to nearby grassland/pastoral systems and that consistently generate marketable surpluses of differentiated red meat and livestock products that can compete not only in the expanding domestic market but also in selected regional markets.

Notes

1. Unless otherwise reported, the countries covered are: in the Sahel—Burkina Faso, Chad, Mali, Mauritania, Niger, northern Nigeria, and Senegal; and in the Horn of Africa—Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, South Sudan, Tanzania, and Uganda. Available statistics for the former Sudan do not yet reflect the divide of the country into Sudan and South Sudan, so data are merged. For the livelihood modeling (chapter 5), only Ethiopia, Kenya, and Uganda are included.
2. Different approaches to measuring total numbers and poverty rates are reported (see chapter 2), hence the range of values provided here.
3. In this report, the poverty line is defined as US$1.25 per capita per day.
4. UN figures for all rural dryland areas fluctuate around 60 percent, but the pastoral population might be underrepresented in the sample.
5. Tropical Livestock Unit (TLU) is used to aggregate numbers of animals from different species. It is based mainly on body weight. In this study, camels are assigned a value of 0.7 TLU, cattle 0.6 TLU, and sheep and goats 0.1 TLU.

Abbreviations

ACF	Action Contre la Faim
AFD	Agence Française de Développement
AI	(Global) Aridity Index
ARC	Africa Risk Capacity (group)
ASAL	arid and semi-arid lands
AU	African Union
CAHW	community animal health worker
CBPP	contagious bovine pleuro-pneumonia
CEWARN	Conflict Early Warning and Response Mechanism
CGIAR-PIM	Consultative Group for International Agricultural Research Program on Policies, Institutions, and Markets
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
COMESA	Common Market for Eastern and Southern Africa
DM	Dry Matter
DRR	Disaster Risk Reduction
ETB	Ethiopian Birr
EU	European Union
EWS	early warning and response system
FAO	Food and Agriculture Organization of the United Nations
FMD	foot and mouth disease
FSNAU	Food Security and Nutrition Analysis Unit
GDP	gross domestic product
GHG	greenhouse gas
GLEAM	Global Livestock Environmental Assessment Model
GLW	Gridded Livestock of the World
GTAP	Global Trade Analysis Project
HRM	holistic resource management
IBLI	index-based livestock insurance

IFPRI	International Food Policy Research Institute
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
LEGS	Livestock Emergency Guidelines and Standards
LGP	length of growing period
MT	metric tons
NDVI	Normalized Difference Vegetation Index
NGO	nongovernmental organization
OIE	World Organization for Animal Health
PARIMA	Pastoral Risk Management Project
PES	payment for environmental services
REGLAP	Regional Learning and Advocacy Program
RVF	Rift Valley Fever
SHIP	Survey-based Harmonized Indicators Program
SIPSA	Information System on Pastoralism in the Sahel
SPS	sanitary and phytosanitary (standards)
SSA	Sub-Saharan Africa
TLU	tropical livestock unit
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WAEMU	West African Economic and Monetary Union

CHAPTER 1

Introduction and Conceptual Framework

Cornelis de Haan

People and Livestock in the Drylands of Sub-Saharan Africa

Drylands occupy over 60 percent of the land area in Sub-Saharan Africa (SSA). Because livestock are the main (and often only) land use option in drylands, the livestock sector is the cornerstone of the national economy in many of the countries of West and East Africa, most of which contain significant amounts of drylands. Direct outputs of livestock, such as meat and milk, contribute 5–15 percent of gross domestic product (GDP) and up to 60 percent of agricultural GDP. When indirect benefits such as organic fertilizer and traction services are included, the contribution of livestock increases by an additional 30–50 percent. The livestock sector also tends to be an important source of foreign exchange, as millions of sheep are shipped every year from the Horn of Africa to the countries around the Persian Gulf states, and about one million head of cattle are trekked or trucked from the Sahel region to the West African coastal countries. Moreover, with increasing per capita income in SSA and a high income elasticity of demand for animal source food, consumption of meat and milk is expected to double between now and 2030.

Livestock are the sole source of livelihood for an estimated 25–41 million people and provide a significant share of income for an additional 72–94 million people in the Sahel and the Horn of Africa. Livestock keepers can be classified into two main groups. *Pastoralists* raise livestock as their sole source of income, while *agro-pastoralists* combine livestock keeping with crop farming. In recent years this distinction has started to disappear, however, as pursuit of a purely pastoralist life has become increasingly difficult.

The large majority of livestock keepers in drylands are poor, experiencing poverty of a structural nature: the livestock holdings of about 90 percent of livestock-keeping households are below the minimum level needed to earn an income above the poverty line. And livestock ownership is highly unequal, with

the wealthiest 1 percent of livestock-keeping households owning between 9 and 26 percent of all animals.

The Need for Action

Past Shocks and Impacts

The presence of structural poverty in a marginal production environment makes the livestock-dependent population highly vulnerable to shocks. For example:

- In the Sahel region, the two major droughts that occurred during the 1970s and 1980s led to the deaths of about one-third of all cattle, sheep, and goats (Lesnoff, Corniaux, and Hiernaux 2012). The relatively mild drought that lasted from 2010 to 2012 led to food insecurity for about 12 million people (Oxfam 2012).
- In the Horn of Africa, five major droughts occurring between 1998 and 2011 killed more than 50 percent of the cattle in the most heavily affected areas and decimated the livelihoods of between 3 and 12 million people.
- During the past decade, episodes of violence and civil conflict have broken out in Ethiopia, Kenya, Sudan, South Sudan, Chad, Central African Republic, Niger, Mali, and Nigeria, leading to the displacement of an estimated 1.1 million people in West Africa and extensive losses of property, including livestock. Livestock keepers in many dryland regions are particularly vulnerable to the effects of conflict.
- From 2006 to 2008, outbreaks of Rift Valley Fever (RVF) in East Africa killed and caused spontaneous abortion in significant numbers of animals; more importantly, the outbreaks led to a number of import bans and subsequent major drops in livestock prices.
- Increased criminality linked to the drug and weapons trade, and the rise in religious extremism, is destabilizing parts of the region, displacing a significant share of the population, destroying social infrastructure, and annihilating tourism (de Haan et al. 2014).

Humanitarian Emergency Aid versus Long-Term Resilience

The costs of these shocks are enormous, both in terms of direct losses suffered by the affected economies and in terms of the humanitarian assistance needed for affected populations. The total impact of a series of droughts that affected the Kenyan economy between 2008 and 2011 was estimated to be US$12.1 billion (Venton, Fitzgibbon, and Shitarel 2013). Oxfam (2011) estimated the cost to the Ethiopian economy over the same period at US$1.1 billion per year, while international humanitarian aid for Kenya and Ethiopia over the period 1998–2011 reached US$2.1 billion (Venton, Fitzgibbon, and Shitarel 2013). The large majority of this aid was emergency support, as only a small portion was allocated to building resilience.[1]

Under a business-as-usual scenario, human suffering and economic losses are likely to continue, and projections made for this book suggest that they could get worse. While emergency support will remain essential, shifting the focus from emergency aid to investments designed to build long-term resilience to the different shocks of drylands agriculture is the preferred strategy. Analysis carried out for this book and summarized below suggests that interventions in the livestock sector have the potential to generate highly positive cost-benefit ratios, not only for individual actions but also for comprehensive packages.

Key Question

In this context, this chapter seeks to answer the following question:

What policy reforms, institutional changes, and supporting investments are needed to build a resilient livestock value chain in the drylands—one that by the year 2030 will be able to provide adequate income and employment opportunities for pastoral and agro-pastoral livestock keepers while remaining resilient in the face of shocks, sustaining the natural resource base, and contributing to meeting the rising demand for animal source food?

For present purposes, "resilience" refers to the capacity of vulnerable households, families and systems to face uncertainty and the risk of shocks, to withstand and respond effectively to shocks, as well as to recover and adapt in a sustainable manner. This definition is in line with that used by the AGIR Alliance (OECD 2012).

In the modeling projections discussed below, a household is considered resilient if it is able to maintain an average income above the international poverty line of US$1.25 per capita per day. While this is a major simplification of the AGIR Alliance definition, the results of the analysis show the herd size needed to provide the income that would enable a household to withstand a climate shock and have the capacity to recover.

Conceptual Framework

The conceptual framework used for this book is similar to that used in the other books prepared as background pieces for the larger Africa Drylands study. It features the same drivers of vulnerability and resilience (exposure to shocks, sensitivity to shocks, and capacity to cope) and the same types of shocks (weather, price, conflict and diseases) (table 1.1 and figure 1.1). Table 1.1 gives an overview of the main determinants that affect the impact of shocks, although there is clearly some overlap, as many determinants affect multiple drivers. For example, a household's assets affects not only its exposure to shocks and its sensitivity to shocks, but also its coping capacity after a shock has hit.

Figure 1.1 Determinants of Vulnerability and Resilience

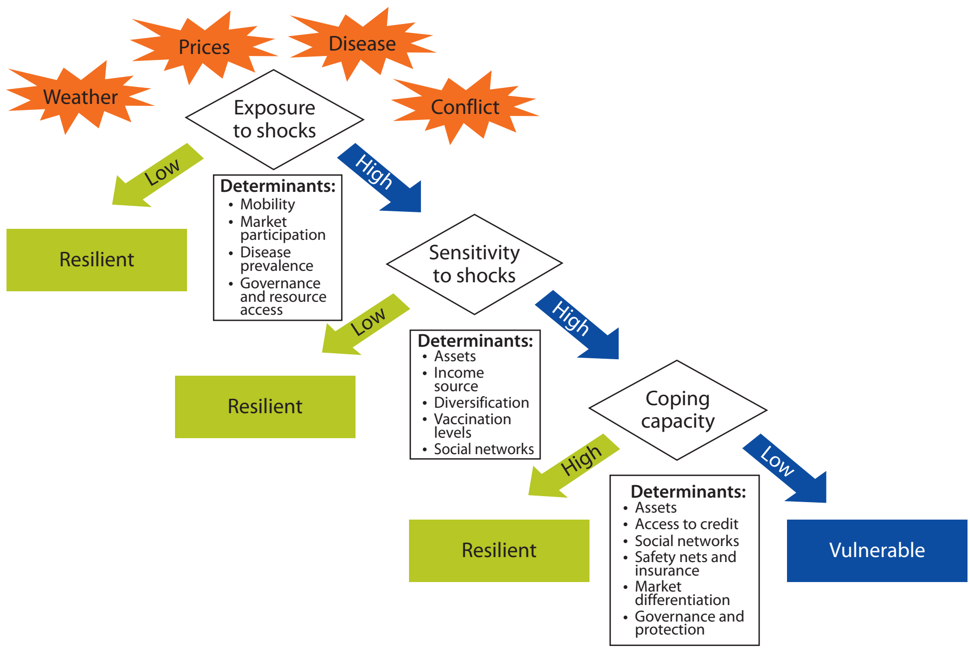


Table 1.1 Factors Affecting the Drivers of Vulnerability of Livestock Keepers to Four Types of Shocks in Dryland Regions of SSA

	Shocks			
Drivers of Vulnerability	*Climate*	*Conflict*	*Price*	*Disease*
Exposure	Mobility	Governance	Cereal/livestock price ratio	Disease prevalence
Sensitivity	Levels of assets	Mobility	Market integration	Vaccination levels
	Income diversification	Social cohesion	Infrastructure	
Capacity to cope	Safety nets and insurance	Level of government protection	Market differentiation	Access to animal health services

Note: SSA = Sub-Saharan Africa.

Objectives of this Chapter

This chapter has four main objectives:

1. Establish the role of livestock in the livelihoods of drylands populations and the national economies of the dryland countries;

2. Analyze the main factors affecting the drivers of vulnerability and resilience for four types of shocks;
3. Assess the impact of likely resilience-enhancing interventions on supply and demand and on the livelihoods of livestock keepers; and
4. Offer guidance to policy makers.

Organization of the Chapter

Following this introductory chapter, chapter 2 describes the macroeconomic aspects of the livestock sector in the drylands, including the main production systems. Chapter 3 provides a detailed analysis of the factors affecting vulnerability to the different types of shocks. Chapter 4 describes possible interventions to reduce the impact of shocks, with emphasis on recent experiences. Chapter 5 reports on an assessment of the impacts of "best bet" interventions on feed balance, the future supply of meat and milk, and the number of vulnerable households that can be lifted from poverty or that need alternative sources of income.

Note

1. Worldwide, only 4.2 percent of total humanitarian aid in 2009 was for disaster prevention and preparedness (Venton, Fitzgibbon, and Shitarel 2013).

CHAPTER 2

Macroeconomic Aspects of Livestock Production Systems in the Drylands of Sub-Saharan Africa

Tim Robinson, Giulia Conchedda, and Cornelis de Haan

Introduction

This chapter highlights the importance of the livestock sector in the national economies of drylands countries located in the Horn of Africa and the Sahel, the focal area for the overall Africa Drylands study.[1] It provides an overview of livestock production systems in these countries, including presenting estimates of the numbers of animals and numbers of people who keep animals.

Role of Livestock in the Economies of Dryland Countries of SSA

Drylands livestock production systems are the socioeconomic cornerstone of Sub-Saharan African (SSA) rural livelihoods. Pastoral systems alone cover an area of 3.66 million square kilometers, distributed across the Sahel, the Horn of Africa, and Southern Africa. In many areas, range-based livestock production is the only possible form of land use.

Contribution to GDP

Table 2.1 shows the direct contribution made by the ruminant livestock sector (in terms of milk, meat, and wool) to total gross domestic product (GDP), agricultural GDP, and employment for the countries where data were available in the GTAP (Global Trade Analysis Project) from Purdue University.[2]

The ruminant livestock sector in the focus countries contributes 5–10 percent to total GDP and 20–40 percent to agricultural GDP, and provides about 30 percent of rural employment. Across all of SSA, the direct contribution of livestock production activities to total agricultural value added is frequently estimated to be in the range of 20–50 percent (ALive 2011). These figures may understate the importance of the sector, however. A recent study by the Intergovernmental Authority on Drought (IGAD) focusing on four drylands countries showed that when value-addition is taken into account, the contribution of livestock to GDP

Table 2.1 Contribution of the Ruminant Livestock Sector to GDP and Agricultural GDP, 2010

	Contribution to GDP (%)	*Contribution to Agricultural GDP (%)*	*Employment in Livestock (number)*	*Employment in Agriculture (number)*
Burkina Faso	9.28	30.13	366,562	1,216,601
Nigeria	6.23	16.18	NA	NA
Senegal	6.39	31.93	211,277	661,689
Rest of West Africa	2.99	12.30	NA	NA
Ethiopia	8.26	19.53	NA	NA
Kenya	5.44	20.78	714,427	3,438,053
Tanzania	7.59	24.55	3,050,304	12,424,863
Uganda	1.49	7.23	316,839	4,382,279
Rest of East Africa	5.39	39.24	NA	NA

Source: GTAP (Global Trade Analysis Project) from Purdue University.
Note: GDP = gross domestic product.

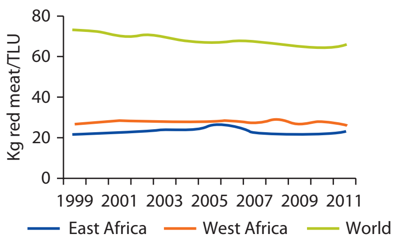
increases by 19–150 percent (IGAD 2013). In addition, livestock GDP figures often do not include the indirect contribution of organic fertilizer (manure) and/or animal traction services. Such indirect contributions can be substantial. For example, Behnke (2010) showed that the contribution of the Ethiopian livestock sector to the agricultural economy would rise by 30 percent if the value of traction and transport services were included. The GTAP database does not cover a number of countries with large livestock sectors, such as: Sudan, which reportedly has a livestock contribution to agricultural GDP of 60 percent (Behnke 2012); Mauritania with 44 percent (World Bank 2012); and Chad, with 16 percent of GDP and 53 percent of agricultural GDP (Hesse et al. 2013). Including those countries would further increase the regional average share of livestock in agricultural GDP.

Using FAOSTAT (2012) data, total production of livestock and livestock products in the drylands countries is estimated at 14.5 million metric tons (MT) of milk (3.3 million MT in West Africa and 11.2 MT in East Africa) and 4.6 million MT of red meat (1.8 million MT in West Africa and 2.8 million MT in East Africa). This is about 67 percent of the total red meat production and 56 percent of the total milk production in all of SSA.

Productivity per animal is still low by global standards, however (figure 2.1). Average production levels of approximately 19 and 22 kilograms meat per tropical livestock unit (TLU) per year in East and West Africa, respectively, compare poorly with the worldwide average of 68 kilograms per TLU in 2012 (FAOSTAT data). Worldwide, the red meat production sector has experienced the same stagnation in productivity as has been observed in SSA.

Demand for milk and meat is expected to rise sharply in SSA (table 2.2). The Global Perspective Studies Unit of the Food and Agriculture Organization of the United Nations (FAO)[3] estimates that over the period 2006–2030, demand for meat will approximately double, and demand for milk will grow by about 90 percent.[4] Satisfying this demand locally will be challenging. Chapter 5 discusses

Figure 2.1 Livestock Productivity, West and East African Dryland Countries versus the World, 1999–2011 (kilogram red meat/TLU/year)



Source: Adapted from FAOSTAT (2012).
Note: TLU = tropical livestock unit.

the impact of some possible interventions and drought scenarios on the supply of livestock and livestock products in the focus countries.

Livestock Production Systems in Dryland Regions of SSA[5]

Introduction

Analysis of livestock systems in the drylands of SSA is challenging, in part because statistics on the numbers and distributions of animals and animal keepers are scarce and sometimes contradictory. This chapter provides updated, previously unpublished information on the importance of livestock systems in African drylands. The information was generated using three major data platforms:

- For SSA as a whole and for the focus countries in West and East Africa in particular, the area under ruminant livestock production systems (either livestock only systems or mixed agro-pastoral systems) in three agro-ecological zones (arid, semi-arid, and dry sub-humid) was estimated based on the Global Aridity Index (AI). The estimates were made using a novel approach to mapping global livestock production systems (Robinson et al. 2011) under which length of growing period (LGP) was replaced by the AI as the key determinant of agro-ecology. These estimates provide credible measures of the distribution of livestock production in the drylands of SSA.
- Livestock numbers and densities across SSA and within the focus countries are presented for the four major groups of ruminants (cattle, camels, sheep, and goats) differentiated by AI zone and production system. The numbers represent updated values of those appearing in Gridded Livestock of the World (Wint and Robinson 2007; Robinson, Franceschini, and Wint 2007), taking advantage of new datasets and refined modeling techniques. The updated numbers confirm the presence of disproportionately high numbers of livestock in the drylands compared to more humid zones, with more than three-quarters of all TLU in SSA located in the focus countries.

Table 2.2 Demand Projections for Meat and Milk (MT) in SSA, 2006, 2020, and 2030

		2006			*2020*			*2030*		
Region	*Commodity (MT)*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*
West Africa	Beef	280,561	564,652	845,212	543,144	879,503	1,422,647	787,402	1,047,698	1,835,100
	Mutton	268,229	437,394	705,623	484,795	611,998	1,096,793	675,924	700,276	1,376,200
	Milk	1,273,563	2,509,037	3,782,600	2,466,318	3,716,873	6,183,192	3,559,579	4,338,321	7,897,900
East Africa	Beef	349,656	1,210,727	1,560,383	708,704	1,586,281	2,294,985	1,027,501	1,792,199	2,819,700
	Mutton	170,879	504,126	675,004	383,367	642,626	1,025,994	558,258	718,442	1,276,700
	Milk	4,019,376	11,342,424	15,361,800	8,288,061	14,000,356	22,288,417	11,707,663	15,528,337	27,236,000
Total	Beef	630,217	1,775,379	2,405,596	1,251,848	2,465,784	3,717,632	1,814,904	2,839,896	4,654,800
	Mutton	439,108	941,520	1,380,628	868,162	1,254,624	2,122,787	1,234,183	1,418,717	2,652,900
	Milk	5,292,939	13,851,461	19,144,400	10,754,379	17,717,229	28,471,608	15,267,242	19,866,658	35,133,900

Source: Robinson and Conchedda (2014).
Note: SSA = Sub-Saharan Africa.

- Estimates of the numbers of rural poor and rural poor livestock keepers are presented for the AI-derived production systems in each of the focus countries. These figures were estimated following the methodology described in Thornton et al. (2002) and updated in Robinson et al. (2011). The estimates on the vulnerable population in rural areas show that there is a major concentration of vulnerable people in drylands areas.

"Drylands" are defined here on the basis of the AI (Trabucco and Zomer 2009; UNEP 1997). Under this approach, drylands are defined as regions having an AI of 0.65 or less, with subdivisions into four types: hyper-arid (AI < 0.03); arid (0.031 < AI < 0.2); semi-arid (0.21< AI < 0.5); and dry sub-humid 0.51 < AI < 0.65). As can be seen in appendix B, this classification corresponds closely to the widely adopted classification scheme based on LGP, whereby AI = 0.03 = 10 growing days; AI = 0.2 = 65 growing days; AI = 0.5 = 150 growing days; and AI = 0.65 = 185 growing days.

Geography of Livestock Production Systems

To ensure consistency with the use of the AI to define drylands, the ruminant production system classification described in Robinson et al. (2011) was recreated for SSA, integrating new information on crop cover and differentiating between rainfed and irrigated crops.

Maps 2.1 and 2.2 show the AI-derived livestock systems classification in detail for the focus countries in West and East Africa, respectively.

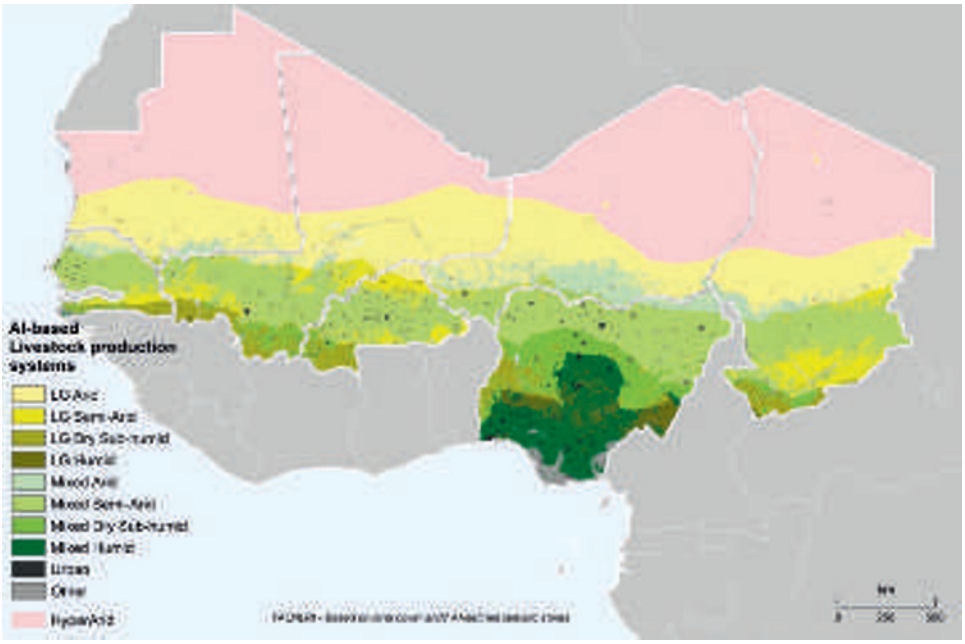
Essentially all habitable land in Burkina Faso, Chad, Mali, Mauritania, and Senegal falls under drylands (map 2.1). Northern Nigeria is largely drylands, while southern Nigeria is humid and has mostly mixed farming. The aridity gradient in West Africa is pronounced, ranging from arid at the northern latitudes to dry sub-humid at the more southerly latitudes. Mixed farming is concentrated at the more southerly latitudes.

The situation in East Africa is considerably more complex, with topography and heterogeneous weather and climate patterns playing a far greater role in shaping the agro-ecological landscape (map 2.2). Sudan shows a similar pattern to West Africa, but in South Sudan and the rest of the Horn of Africa, the drylands tend to occur at more northerly latitudes and at lower altitudes. Livestock-dominated drylands are prevalent in Djibouti, Eritrea, Kenya, Somalia, and Sudan, with mixed farming dominant in Ethiopia, South Sudan, Tanzania, and Uganda.

Distribution of Livestock in the Drylands of SSA

The global livestock distribution maps available in Gridded Livestock of the World (GLW) (Robinson et al. 2007; Wint and Robinson 2007) were produced in 2007. Since then, significant improvements have been made in subnational livestock statistics for Africa. The improvements were used in generating the updated maps presented in this book. In addition, a new set of 1 kilometer pre-

Map 2.1 Livestock Production Systems Defined Using the AI as a Measure of Agro-ecology and Land Cover, West Africa



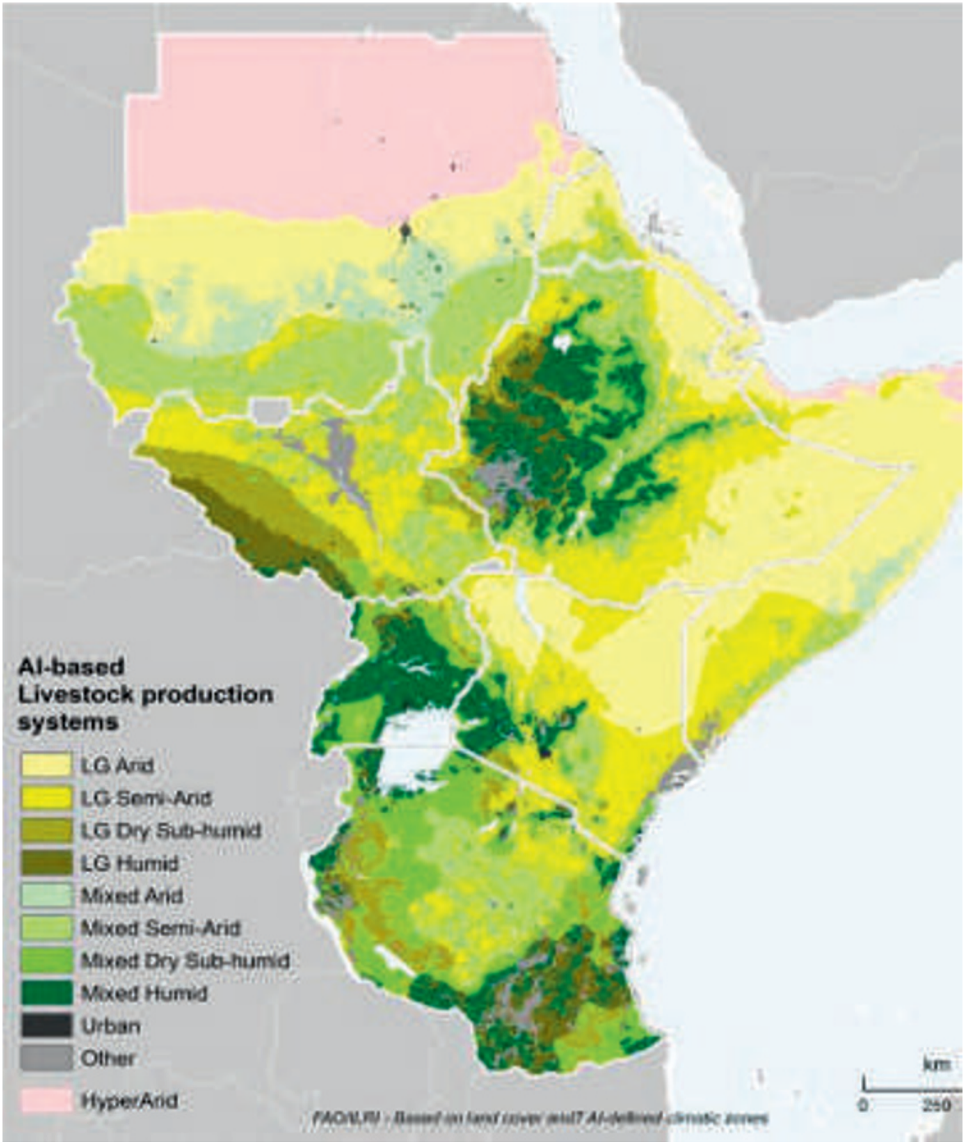
Source: Robinson and Conchedda (2014). Used with the permission of Tim Robinson (ILRI). Further permission required for reuse.
Note: AI = Aridity Index.

dictor variables has been compiled, and modifications made to the modeling approach. This resulted in updated distribution maps for the four major ruminant species in Africa with the reference year of 2006 (map 2.3).

Map 2.3 shows that ruminant livestock are raised across most of Africa where environmental conditions allow. For example, the heavily forested areas of Africa and the deserts have very low densities of livestock. Cattle, sheep, and goats are the most widespread, while camels are restricted to drier areas, particularly in the Horn of Africa and the more arid parts of West Africa.

The role of livestock in SSA varies greatly depending on the production systems to which they contribute. In the more sparsely populated arid and semi-arid areas, where the potential for crop growth is limited by moisture availability, cattle, camels, sheep, and goats are raised in pastoral systems in which mobile stock can take advantage of seasonal, patchy vegetation growth. In these areas, raising livestock is the only viable form of agriculture. In the more densely populated humid, sub-humid, and tropical highland zones, cattle and small ruminants frequently are kept in mixed crop-livestock farming systems, where they perform many roles and can increase crop production by providing draft power and manure, while at the same time converting organic material not suitable for human consumption into high-value food and non-food products.

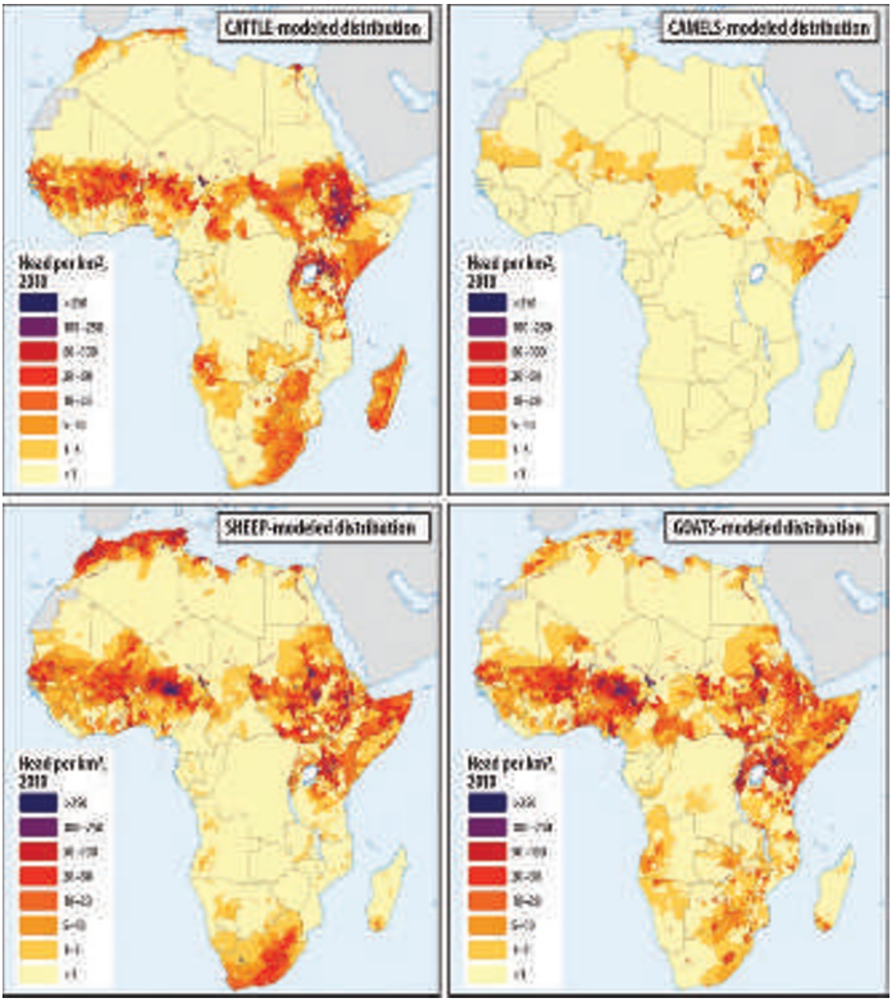
Map 2.2 Livestock Production Systems Defined Using the AI as a Measure of Agro-ecology and Land Cover, East Africa



Source: Robinson and Conchedda (2014). Used with the permission of Tim Robinson (ILRI). Further permission required for reuse.
Note: AI = Aridity Index.

Because of these different roles of livestock, it is important to consider livestock in relation to the production systems to which they contribute. Table B.1 in appendix B summarizes this information for the individual focus countries; an overview by species and regions is provided here in tables 2.3 and 2.4.

Map 2.3 Livestock Densities for Cattle, Camels, Sheep, and Goats, SSA, 2006



Source: World Bank based on data from Robinson and Conchedda (2014).
Note: SSA = Sub-Saharan Africa.

In the focus countries, about three-quarters of all livestock (77 percent of all TLU) are found in the drylands: 70 percent of cattle; 81 percent of camels; 76 percent of sheep; and 76 percent of goats. Within the drylands, semi-arid drylands with mixed systems predominate. The small percentages falling within the "urban" and "other" (forested) categories reflect the existence of some livestock in these areas, but could also reflect mapping inaccuracies both in the land cover maps contributing to the systems classification used and in the livestock distribution maps. The higher proportion in East Africa reflects the high livestock concentration in the highlands. Small numbers of livestock also appear in the hyper-arid class, reflecting the AI cut-off used and technical issues associated with modeling livestock densities in arid areas. The relative distribution of the species

Table 2.3 Livestock Numbers by AI-Derived Livestock Production System, Focus Countries

		Livestock Only Systems			*Mixed Systems*				
Livestock Type	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Others (Humid, Urban and Forest)*	*Total*
Cattle	3,240,651	18,968,913	19,116,580	5,678,496	12,825,785	51,594,303	17,731,255	50,447,140	179,603,122
	2%	11%	11%	3%	7%	29%	10%	28%	100%
Camels	2,901,679	8,513,392	3,015,262	66,687	1,449,209	2,752,309	26,350	722,567	19,447,454
	15%	44%	16%	0%	7%	14%	0%	4%	100%
Sheep	13,830,308	33,528,615	17,212,907	3,471,569	16,391,945	57,215,991	8,767,690	28,702,441	179,121,466
	8%	19%	10%	2%	9%	32%	5%	16%	100%
Goats	10,956,815	36,214,624	18,756,868	5,241,252	18,951,701	66,307,354	15,940,741	40,267,532	212,636,888
	5%	17%	9%	2%	9%	31%	7%	19%	100%
TLU	6,454,278	24,315,046	17,177,608	4,325,060	12,244,282	45,235,533	13,128,041	37,671,078	160,550,927
	4%	15%	11%	3%	8%	28%	8%	23%	100%

Source: Robinson and Conchedda (2014).
Note: TLU = tropical livestock unit; AI = Aridity Index.

Table 2.4 TLU by AI-Derived Livestock Production System in the Focus Countries, by Region

		Livestock Only Systems			*Mixed Systems*				
TLU	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Others (Humid and Urban)*	*Total*
West Africa	3,384,613	8,123,728	3,149,742	1,551,792	6,721,409	20,287,750	3,587,335	5,758,773	51,378,246
	7%	16%	6%	3%	13%	39%	7%	9%	100%
East Africa	3,069,665	16,191,318	14,027,866	2,773,268	5,522,873	24,947,783	9,540,706	54,936,466	109,172,681
	3%	15%	13%	3%	5%	23%	9%	30%	100%

Source: Robinson and Conchedda (2014).
Note: TLU = tropical livestock unit; AI = Aridity Index.

makes sense, however, reflecting their adaptation to living in arid environments, with a relatively large proportion (15 percent) of camels reported in hyper-arid areas, significant numbers of sheep (8 percent) and goats (5 percent), but very few cattle (2 percent). These patterns are also reflected at the other end of the aridity spectrum, with 20 percent of cattle occurring in humid areas, about 10 percent of small ruminants, and only 1 percent of camels.

Focusing on the drylands, camels are predominant in the livestock-only systems, while cattle especially but also small ruminants are more prevalent in mixed systems. About one-third of all cattle, sheep, and goats occur in mixed semi-arid systems.

Table B.3 in appendix B provides a more detailed breakdown of livestock numbers by species and AI-derived livestock production system for each of the focus countries. The data in appendix B table B.4 reflect not only the livestock distributions but also the agro-ecology of each country; arid countries such as Mauritania and Somalia, for example, have much higher proportions of livestock occurring in the drier agro-ecologies.

While the ruminant production system maps based on AI[6] appear to be good proxies for system maps based on empirical data, at least in East Africa, there is a need to extend the empirical approach to livestock production system mapping to areas for which survey data are available. This will enable better characterization of production systems based on agro-ecology and a better understanding of the roles and importance of livestock to people's livelihoods within the different systems.

Rural Population in Dryland Regions of SSA

Numbers of Livestock Keepers

Two approaches were followed to estimate the total number of livestock-dependent people living in the drylands. The first approach, used by the International Livestock Research Institute (ILRI) (Thornton et al. 2002; 2003), provides estimates by country and production system by combining livestock production system maps with poverty and population maps. The livestock production systems were assigned livestock ownership rates, and the poverty maps applied to the human population, resulting in sequential estimation of the: (i) rural population; (ii) rural livestock keepers; (iii) rural poor; and (iv) rural poor livestock keepers. Using earlier poverty statistics from UNDP and livestock ownership patterns from LID (1999), and the number of poor people from Thornton et al. (2000), the proportion of rural people who are livestock keepers (that is, who keep any type of ruminant livestock) was estimated at 76 percent for livestock-only systems, 68 percent for mixed rainfed systems, and 26 percent for the mixed irrigated and all other systems. For want of better estimates, these proportions were adopted directly by Robinson et al. (2011).

Based on these ownership patterns, table 2.5 presents regional and overall totals (see appendix B for detailed estimates per country). According to this approach, there are 41 million "pure" pastoralists (livestock only), of which 12.5

million are in West Africa and 28.6 million are in East Africa. There are 72 million agro-pastoralists, 36.2 million in West Africa and 35.8 million in East Africa. These figures are roughly in line with the findings of de Leeuw et al. (in press), who estimated 47 million pastoral people inhabiting this system in SSA, with a total livestock population of 33 million TLU.

The country details show, not surprisingly, that Nigeria in West Africa and Ethiopia in East Africa host the highest numbers, with over 40 million livestock keepers in each country. In Nigeria, only 39 percent (16 million) of livestock keepers are in the drylands systems whilst in the other West African countries almost all of them are, illustrating their total dependence on drylands systems for ruminant meat. In East Africa, the picture is much more varied. Djibouti, Eritrea, Somalia, Sudan, and South Sudan are all highly dependent on drylands systems, with almost all livestock keepers in these systems, but in Ethiopia, Kenya, Uganda, and Tanzania many livestock keepers live in the humid areas. Just over half of the livestock keepers in these East African countries live in the drylands.

The second approach used to estimate the total number of livestock-dependent people living in the drylands, developed specifically for this book, is based on 2013 UN World Population Prospect data for 35 selected African countries, which International Food Policy Research Institute (IFPRI) gridded in the Global Rural-Urban Mapping Project, Version One,[7] and then disaggregated across administrative areas, AIs (clustering them in four drylands zones—hyper-arid, arid, semi-arid, and dry-sub-humid), and livestock systems. World Bank data adjusted with SHIP (Survey-based Harmonized Indicators Program) survey data were used to estimate agricultural employment within the overall labor force. As a next step, the number of pure crop farmers (that is, those without livestock) was determined for countries with SHIP surveys. For other predominantly drylands countries, a proportion of 15 percent was assumed. By overlaying the gridded IFPRI population map with the FAO livestock production systems map, the size of the pastoral population was determined, with the crop/livestock mixed farmers (the agro-pastoralists) comprising the rest. This gives the following population numbers (table 2.6).

The estimated total numbers of livestock-keeping people are reasonably similar (113 million using the ILRI approach and 119 million using this book's approach), but major differences are apparent in the relative importance of individual subsystems. This is probably due to the fuzziness of the boundaries between livestock-only and mixed systems, as even "pure" pastoralists take up some opportunistic cropping, which is often not captured in the estimation methods.

Numbers of Poor Livestock Keepers

A similar approach was used to approximate the number of poor livestock keepers in the drylands. First, ILRI and FAO reevaluated the number of poor livestock keepers per AI-derived livestock production system in Africa. The same estimates for population and poverty rates used by Robinson et al. (2011)

Table 2.5 Livestock Keepers in AI-Derived Production Systems, by Region, 2006 (IFPRI Methodology)

		Livestock Only Systems				*Mixed Systems*				
Region	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Total*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Total*	*Grand Total*
West Africa	149,561	5,137,468	3,798,155	3,468,744	12,553,928	5,222,219	22,460,093	8,515,112	36,197,424	48,751,352
East Africa	559,968	11,654,880	11,232,249	5,216,622	28,663,719	3,460,038	11,074,572	21,254,609	35,789,219	64,452,938
Total	709,529	16,792,348	15,030,404	8,685,366	41,217,647	8,682,257	33,534,665	29,769,721	71,986,643	113,204,290

Source: Robinson and Conchedda (2014).
Note: IFPRI = International Food Policy Research Institute; AI = Aridity Index.

Table 2.6 Livestock Keepers in AI-Derived Production Systems, by Region, 2011[8] (Revised Methodology)

		Livestock Only Systems				*Mixed Systems*				
Region	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Total*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Total*	*Grand Total*
West Africa	422,620	5,020,022	3,952,155	2,990,042.	12,384,839	4,643,716	49,444,560	11,340,966	65,429,242	77,814,081
East Africa		3,649,023	5,598,881	3,688,963	12,936,867	3,158,003	10,632,067	15,096,661	28,886,731	41,823,598
Total	422,620	8,669,045	9,551,036	6,679,005	25,321,706	7,801,719	60,076,620	26,437,627	94,315,966	119,637,672

Source: UN World Population Data/IFPRI–GRUMP version 1.
Note: IFPRI = International Food Policy Research Institute; AI = Aridity Index.

were adopted, and the proportions of poor livestock keepers in different systems adapted from LID (1999) were translated to the AI-derived livestock production systems as described above. To facilitate comparison of different estimates of the poverty rate, the numbers of poor livestock keepers by system were estimated using each of the poverty measures used in Robinson (2011): (i) national rural poverty lines; (ii) international poverty lines for the poor (<US$2.00 per capita per day); and (iii) international poverty lines for the very poor (<US$1.25 per capita per day).

The results summarized in table 2.7 show that: (i) for pastoral systems, the total number of poor (below US$1.25 per capita per day) amounts to 21.7 million out of a total population of 25.3 million, indicating a poverty rate among pastoralists of 85 percent; and (ii) for agro-pastoral systems, using the same US$1.25 per capita per day poverty line, there are 54.5 million poor out of a total population of 71 million, indicating a poverty rate of 77 percent.

The individual country data reported in appendix B show that estimates based on national poverty lines tend to be similar to those based on the US$1.25 per capita per day poverty line. Notable exceptions are Mauritania, Djibouti, and Kenya, for which the national poverty line estimates suggest considerably more poor people than does the US$1.25 per capita per day international poverty line; and Nigeria, Tanzania, and (to a lesser extent) Uganda, for which the national poverty line estimates considerably fewer poor people than does the international poverty line. This highlights the importance of standardizing by using international poverty lines in such analyses.

As a second approximation, and in particular for this book subregional poverty data (2010) were obtained from the Africa Risk Capacity (ARC) group (adjusted to coincide with national poverty rates reported by the World Bank), as presented in table 2.8. These estimated poverty figures, ranging between 40 and 50 percent, reflect the more conventional opinion on poverty rates of drylands livestock keepers.

One difference between these figures is that the ARC data also include income from non-livestock-related activities, whereas the ILRI data focus on livestock-related income only. However, as shown in chapter 3 with field data and in chapter 5 with SHIP data and simple herd models, the ILRI data seem to better reflect the income and resulting poverty rates from livestock, and hence will be used in future modeling efforts.

Maps 2.4 and 2.5 show the distribution of poor livestock keepers (those living on less than US$1.25 per day) in detail for the focus countries of West and East Africa, respectively.

While rangeland systems contain relatively small numbers of people, most of those people depend on livestock for their livelihoods, and as a rule poverty rates

Table 2.7 Rural Poor Livestock Keepers in AI-Derived Production Systems, by Region (ILRI/FAO Approach)

			Livestock Only Systems			*Total Livestock Only*	*Mixed Systems*				
Region	*Poverty Measure*	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*		*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Total Mixed*	*Grand Total*
West Africa	Rural Nat. Pov. Rate	218,421	3,067,097	2,111,199	1,733,619	7,130,336	3,240,945	16,310,406	3,534,030	23,085,381	30,215,717
	Int. Rate US$1.25	101,716	2,583,269	2,149,797	1,991,360	6,826,142	3,279,743	20,893,127	5,288,336	29,461,206	36,287,348
	Int. Rate US$2.00	181,740	3,669,991	3,040,788	2,776,674	9,669,193	4,361,818	28,581,305	7,054,361	39,997,484	49,666,677
East Africa	Rural Nat. Pov. Rate	1,096,545	5,524,588	5,620,612	2,267,038	14,508,783	2,416,887	10,478,315	9,186,934	22,082,136	36,590,919
	Int. Rate US$1.25	1,058,188	4,869,984	5,760,304	3,273,044	14,961,520	2,318,282	11,300,384	11,417,311	25,035,977	39,997,497
	Int. Rate US$2.00	1,489,416	7,622,607	8,587,864	4,359,546	22,059,433	3,275,874	16,764,159	16,715,698	36,755,731	58,815,164
Total	Rural Nat. Pov. Rate	1,314,966	8,591,686	7,731,811	4,000,657	21,639,120	5,657,832	26,788,721	12,720,963	45,167,516	66,806,636
	Int. Rate US$1.25	1,159,904	7,453,253	7,910,101	5,264,404	21,787,662	5,598,025	32,193,511	16,705,647	54,497,183	76,284,845
	Int. Rate US$2.00	1,671,156	11,292,599	11,628,652	7,136,220	31,728,627	7,637,692	45,345,464	23,770,059	76,753,215	108,481,842

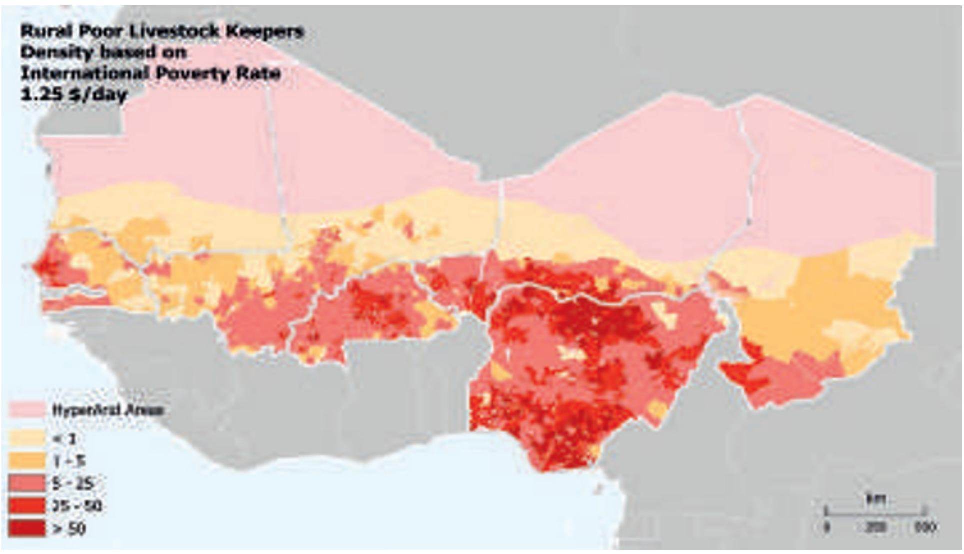
Source: ILRI/FAO.
Note: ILRI = International Livestock Research Institute; FAO = Food and Agriculture Organization of the United Nations; AI = Aridity Index.

Table 2.8 Incidence of Poverty among Pastoralists and Agro-pastoralists, West Africa and East Africa (Based on the ARC Methodology Adapted for This Study)

	Pastoralists	*Poor Pastoralists*	*Agro-pastoralists*	*Poor Agro-pastoralists*
East Africa	12,742,367	4,907,020	34,332,282	13,827,013
West Africa	12,384,841	5,610,490	65,429,244	37,410,250
Total	25,127,208	10,517,510	99,761,526	51,237,262

Source: ARC adapted for this study.
Note: ARC = Africa Risk Capacity.

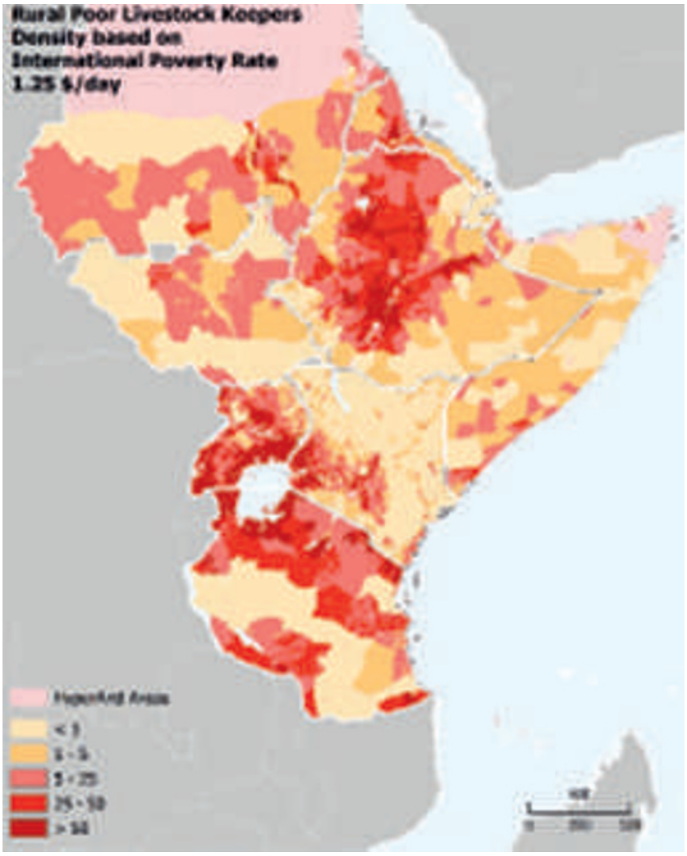
Map 2.4 Incidence of Livestock Keepers Living in Extreme Poverty, West Africa



Source: ILRI/FAO. Used with the permission of Tim Robinson (ILRI). Further permission required for reuse.
Note: ILRI = International Livestock Research Institute; FAO = Food and Agriculture Organization of the United Nations.

are high. The maps in maps 2.4 and 2.5 show a common feature of poverty maps: the highest densities of poor livestock keepers are not necessarily found in the poorest areas, but rather in the areas of highest population density.

Map 2.5 Incidence of Livestock Keepers Living in Extreme Poverty, East Africa



Source: ILRI/FAO. Used with the permission of Tim Robinson (ILRI). Further permission required for reuse.
Note: ILRI = International Livestock Research Institute; FAO = Food and Agriculture Organization of the United Nations.

Notes

1. Unless otherwise reported, the countries covered include: in the Sahel—Burkina Faso, Chad, Mali, Mauritania, Niger, Northern Nigeria, and Senegal; in the Horn of Africa—Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, South Sudan, Tanzania, and Uganda. Available statistics for the former Sudan do not yet reflect the divide of the country into Sudan and South Sudan, so data are merged.
2. The focus of this study is exclusively on ruminants (cattle, camels, sheep, and goats), so data will only cover this ruminant livestock subsector.
3. Using a methodology described by Alexandratos (1995), on the basis of food demand functions (Engel curves) and assumptions about changes in population, urbanization rates, and per capita gross domestic product (GDP).

4. FAO (2011), based on supply and demand estimates from the FAO Global Perspective Studies Unit, produced demand maps by spatially disaggregating the estimated production based on maps of the relevant livestock species, and expected growth rates till 2030. The resulting maps and tables of change in supply and demand from 2000 to 2030 are available on the Gridded Livestock of the World website (www.fao.org/ag/againfo/resources/en/glw/home.html).
5. The information presented here has been extracted from a separate paper. For a detailed description of the methodology, as well as additional information and maps, see Conchedda and Robinson (2014).
6. Although the separate paper argues that the LGP-derived production systems correspond more closely to livelihood-derived classes available for East Africa.
7. GRUMPv1, see http://sedac.ciesin.columbia.edu/data/collection/grump-v1/about-us.
8. Excludes Eritrea, Sudan, South Sudan, and Somalia.

CHAPTER 3

Trends and Drivers of Vulnerability in SSA Drylands

Cornelis de Haan with Polly Ericksen, Mohammed Said, Lance Robinson, Fiona Flintan, Alexandra Shaw, Shem Kifugo, Abdrahmane Wane, Ibra Touré, Alexandre Ickowicz, Christian Corniaux, Jill Barr, and Cecile Martignac

This chapter first presents an overview of the main trends in human and livestock population dynamics and livelihoods (poverty, food security, education, and health) at the level of drylands livestock-dependent households. It then describes the drivers of households' vulnerability to the four categories of shocks—climate, disease, prices, and conflict.

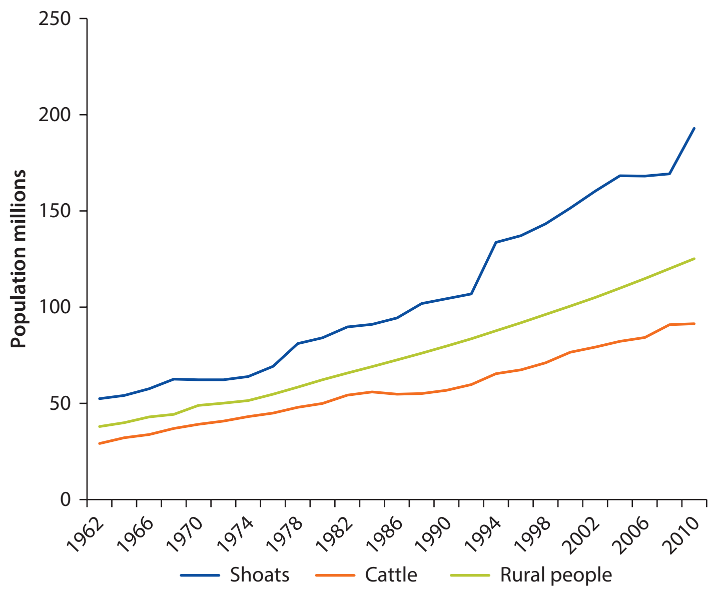
General Features

Human and Livestock Population Dynamics

The population living in drylands zones of the focus countries[1] is estimated to include between 25 and 41 million pastoralists and 71 and 94 million agro-pastoralists. Overall, strong population growth has occurred in dryland regions of Sub-Saharan Africa (SSA). Touré et al. (2012) found an increase in the overall rural population of the West African drylands of 2.4 percent per year over the period 2005–2010. Over the period 1960–2010, the human population increased 3.6-fold, leading to the emergence of urban centers and a rise in the sale of meat, milk, leather, and hides. Rural populations are still very young, with high dependency ratios caused by the outmigration of more active men.

Data are scarce on the growth of pastoral and agro-pastoral populations/arable farmers and their differential birth rates. The conventional wisdom is that nomadic pastoralist populations have lower natural population growth rates than sedentary farming populations. Some hard data come from a study of two villages in Niger, where Swift (1977) reported that the nomadic Fulani and Touareg had an annual growth rate of 11 per 1,000 people, whereas the semi-

Figure 3.1 Livestock and Rural Human Population Trends, East Africa, 1960–2011

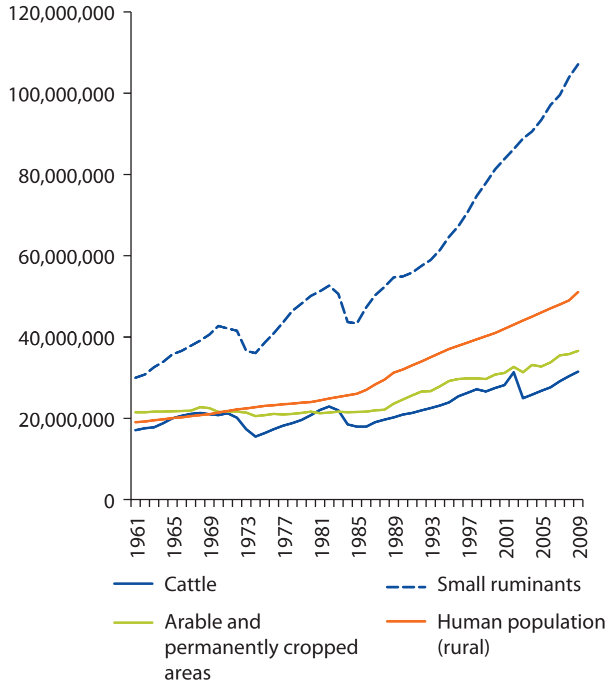


Source: FAOSTAT (2012).
Note: Data for Ethiopia are not included.

and fully sedentary groups and all rural people together had an annual growth rate of 23–25 per 1,000 people, although some of these data have been challenged in part because of their limited sample size (Randall 2012). This book (chapters 2 and 5) projects an increase of 3 percent per year in the pastoral population and 2.5 percent per year in the agro-pastoral population, taking into account outmigration and absorption in other sectors resulting from gross domestic product (GDP) growth.

Figures 3.1 and 3.2 illustrate the rapid increase over the past four decades in total livestock numbers, and in particular the rapid increase in small ruminant numbers. It is interesting to note that with an annual growth of between 3.1 and 4.4 percent between 1980 and 2010,[2] the livestock population increased faster than the human population (1–2.5 percent growth per year), but this rate is in line with the future projections. This means that on average, the herd/flock size per household and per pastoralist has gone up. However, as discussed below, livestock holdings of the poor are going down due to changes in livestock ownership patterns. Moreover, the overall averages conceal important regional and species differences. For example, the USAID-funded Pastoral Risk Management Project (PARIMA) (Desta and Coppock 2004; also reported in Headey, Taffesse, and You 2012) found a clearly declining herd size in cattle, probably the result

Figure 3.2 Livestock and Rural Human Population Trends, Sahel Region, 1961–2009



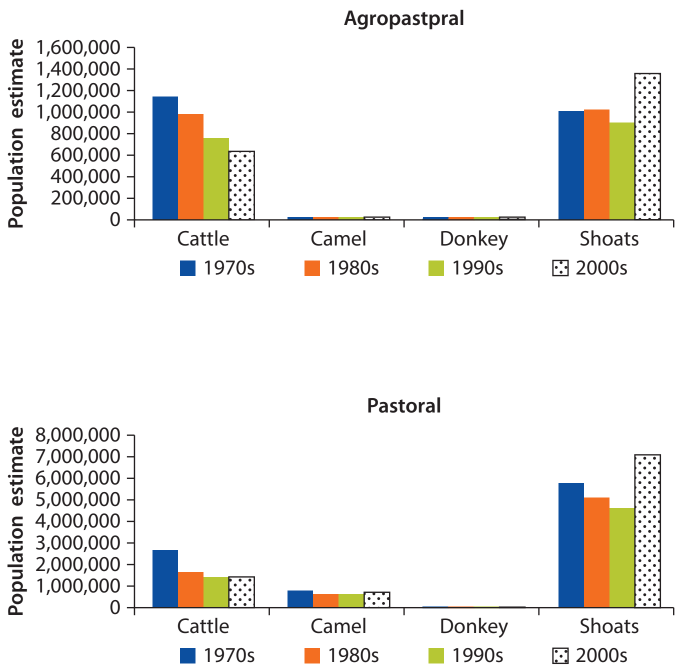
Source: FAOSTAT (2012) and adapted from SIPSA atlas.

of consecutive droughts and herd sizes falling below the minimum level for recuperating from weather shocks.

Figure 3.3 shows the trends in livestock population in agro-pastoral and pastoral systems in Kenya from the 1970s to 2000s. Both systems reflect the same decline in cattle and an increase in small stock, the latter notably in the past decade. Camel populations have remained more or less constant in pastoral areas over this same period in Kenya, although aerial census data suggest the population is moving southward. The camel population has reportedly significantly increased in Ethiopia (Ethiopia LMP, in press).

In the Sahel, the livestock population increased from 14,499,000 TLU[3] in 1950 to 26,243,000 TLU in 1983 and 39,759,000 TLU in 2003, and as shown in chapter 2, to 52,565,000 TLU (including Nigeria) in 2006. However, TLU per capita declined as the human population increased: it was 0.98 in 1950, 0.83 in 1983, and 0.68 in 2003. In almost all Sahelian countries, small ruminants and especially goats showed a higher growth rate, reflecting their short reproductive cycle, their capacity to adapt to degraded rangelands, and their strategic role in the household economy as highly liquid assets (Dicko, Djitèye, and Sangaré 2006).

Figure 3.3 Livestock Numbers, Agro-pastoral and Pastoral Systems, Kenya, 1970s to 2000s

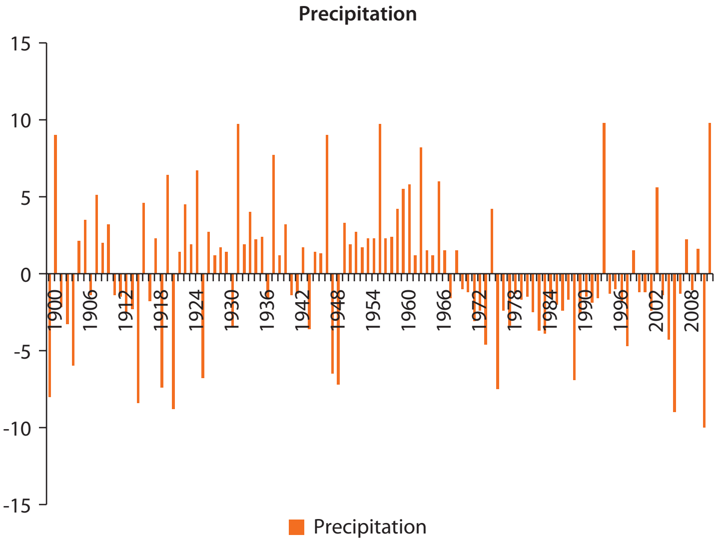


Source: Kenya Department of Resource Surveys and Remote Sensing (DRSRS).

Climate

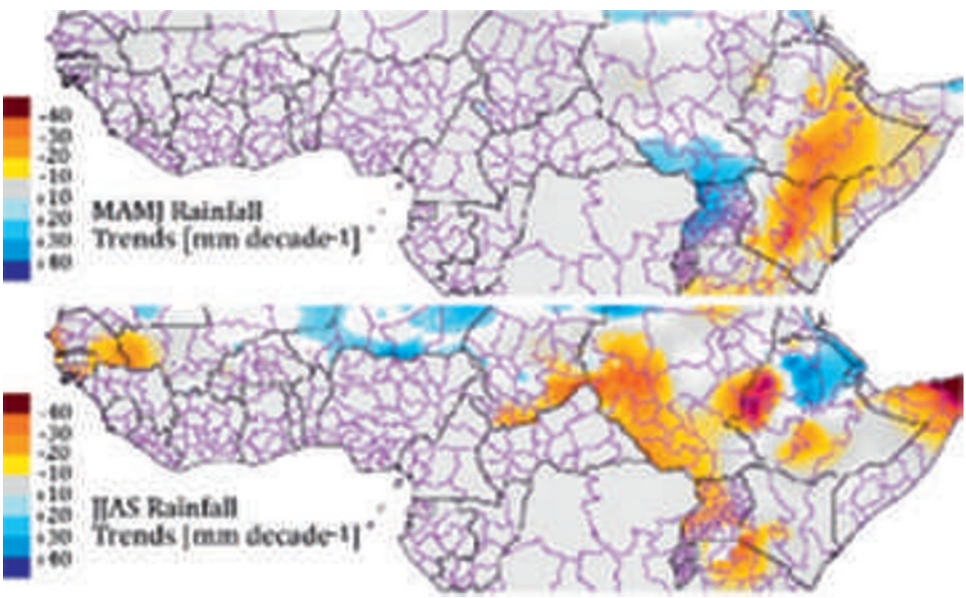
Figure 3.4 and map 3.1 show rainfall trends for the Sahel and East Africa from 1960 to 2009. There are marked differences, with a bi-modal rainfall distribution in most of East Africa, with short rains occurring from October to December and long rains from March to May. Further north (much of Ethiopia, Sudan, and Eritrea) a mono-modal cycle occurs, with the primary rainy season falling during June to September (Giannini et al. 2008). In the Sahel, rainfall is also mono-modal, with most precipitation occurring from June to September. Climate variability is one of the major characteristics of the drylands areas, with a coefficient of variation of rainfall[4] of 30 percent for the Sahelian areas and 44–65 percent in East Africa. This variability can be observed over time and space. Together with high temporal variability, the other main feature is rainfall's high spatial variability, given the storms that occur during the monsoon. As a consequence, rainfall can be very heterogeneous on a single day over a 10-km distance, and also highly variable over a year within a 20–30 kilometer range.

Figure 3.4 Annual Variation in Rainfall Index, Sahel, 1900–2010



Source: University of Washington Global Historical Climate Network Data.

Map 3.1 Rainfall Trends, East and West Africa Drylands



Source: International Livestock Research Institute (ILRI). Used with the permission of Polly Ericksen (ILRI). Further permission required for reuse.

Regarding past trends in the Sahel, the period 1900–1950 was marked by a fairly regular alternating pattern in which three to four humid years were often followed by one to two dry years. From 1951 to 1969, a long series of humid years occurred, followed from 1970 to 1993 by a long series of dry years. However, the period 1994 to 2011 was marked by alternation of one humid year followed by three to four dry years. Over the longer term, a picture of "re-greening" of the Sahel emerges, with, according to remote sensing indicators and ground observations, increased production on sandy or clay soils that dominate in pastoral sceneries, although on shallow soils there is a continued regression (Mortimore 2014). West Niger appears to be an exception to the regional trend to re-greening (Dardel et al. 2012; ECliS 2012).

For East Africa, the data show a definite increase in temperature over the last 50 years. Precipitation trends are much more difficult to assess, but the data indicate a decrease in March–June rains in much of East Africa, and a decline in June to September in some key parts of Ethiopia, Somalia, and Sudan. Figure 3.4 also shows a clear downward trend for the June to September rains and a highly variable trend for Kenya and Ethiopia for the March to June rains. However Washington et al. (2011) find disagreement among multiple data sets for 1961 to 2000, with either a drying trend or none at all.

For future trends, there is a large variability in the prediction of climate models, but there seems to be some consensus that a "significant decline in precipitation" will occur in the western Sahel (OECD 2010a), with no clear trend in the Central Sahel. For East Africa, the predictions are for increased precipitation (IPCC 2013), although the region has experienced at least five major droughts since the beginning of the century. Analysis of four global climate model outputs suggests that large areas of East Africa will experience greater rainfall intensity (Ericksen et al. 2013).

Natural Resources

Pastoralism has been defined as a finely-honed symbiotic relationship between local ecology, domesticated livestock, and people in resource-scarce, climatically marginal, and often highly variable conditions. It represents a complex form of natural resource management, involving the direct interaction between three systems in which pastoral people operate: the natural resource system, the resource users system, and the larger geopolitical system (Pratt, LeGall, and de Haan 1997).

Pastoralism is based on the grazing of natural vegetation, whose nutritional value and spatio-temporal distribution depends on the variability and intensity of annual precipitation. Access to grazing, crop residues, and water for livestock in the dry season is of critical importance. The highly variable rainfall is a primary driver of vegetation growth, which closely follows rainfall amount, frequency, and duration (Vetter 2005; Ellis and Galvin 1994). For example, the relationship between aboveground biomass and rainfall is about 8 kg Dry Matter (DM)/ha for every mm of rainfall over 20 mm in East Africa (Deshmukh 1984).

In the arid zones, mobile forms of livestock production are the only large-scale agricultural option. For West Africa, this normally involves a north (rainy season) to south (dry season) cyclic movement, with a growing tendency for movement deeper into southern regions in recent years. In East Africa, the movement of herds is less regular. Crop production may be practiced opportunistically in the arid zones, with highly variable results. In the semi-arid areas, agro-pastoralism combines grazing livestock with crop production, with varying degrees of intensity and integration between the two activities. Cropping can range from very opportunistic planting of some small plots in wetter areas or years, basically as "coping" strategy to complement livestock production, to a major settled economic activity providing an income diversification strategy to livestock production. Because cropping is becoming more common in all areas, the traditional distinction between pastoralists and agro-pastoralists is fading and might disappear. Data from Maasai communities in southern Kenya and northern Tanzania compiled by Homewood, Trench, and Kristjanson (2009) indicate that anywhere from one-half to more than 88 percent of these households cultivated crops in 2004, despite poor returns relative to other income sources and high risk of harvest failure. Traditionally, the majority of agriculture in drylands has been rainfed, but a notable increase in irrigation is attracting major interest (Sandford 2013; Mortimore 2014); this might affect critical dry season grazing and thus undermine the viability of the entire pastoral system. It might, however, be an interesting option for alternative sources of income to address the structural poverty of pastoral and agro-pastoral populations, as discussed in more detail below and in chapter 4.

For the Sahel, based on the analysis of the estimated average rainfall for the 2000–2010 period, Garba et al. (2013) provide the following zonal distribution:

- The Sahel-Saharan zone, with under 150 mm annual rainfall (that is, AI 1 = 0.00–0.05), is suitable for short-cycle plants and sparse perennial grasses that are grazed by herds (mainly camels and goats) managed by nomadic herders during their movements between available watering places;
- The northern Sahelian subzone, with 150–300 millimeters annual rainfall (that is, AI 2 = 0.06–0.20), almost no woody plant cover, and biomass production of up to 400 kg DM/ha (Boudet 1977), is mainly used by nomadic and transhumant herders;
- The typical Sahelian subzone, with 300–450 millimeters annual rainfall (that is, AI 3 = 0.21–0.50), characterized by a broad range of diverse vegetation types according to the main geomorphological units, is used for agro-pastoral production side by side with pure pastoralism. On sandy soil, there is barely 5 percent woody plant cover. Average annual grassy biomass production ranges from 500 to 2000 kilograms DM per hectare over a north-south gradient;
- The southern Sahelian subzone, with higher rainfall (450–600 millimeters) (that is, AI 4 = 0.51–0.65) and woody plant cover ranging from 5 to 30 percent over the north-south gradient, is mostly used for agro-pastoralism.

In all areas, the spatial distribution of forage resources is highly variable depending on soil type and land use. The quantity and quality of forages also vary widely over time, seasons, and total rainfall. For example, the feeding value quality of natural vegetation in the low rainfall, northern parts of the Sahel is much higher than in the sub-humid zones. Herd management strategies are defined by strong seasonal contrasts between highly digestible green fodder from two to three months of rainy season in the Sahel and straws and low digestible litter in the long, dry season, part of which is lost by livestock trampling, fire, and insects. As shown in chapter 5, forage resources meet the needs of the livestock population in certain areas and are chronically insufficient in others (Miehe et al. 2010).

While the Sahel has been often been associated with land and vegetation degradation (for example, Dregne (1986) and early NOAA (National Oceanic and Atmospheric Administration) studies by Tucker, Dregne, and Newcomb (1991)) highlighted the resilience of the vegetation and spoke of an "expanding and contracting vegetation." This resilience is demonstrated in photo 3.1.

Herd accumulation, often mentioned as one of the main driving forces of land degradation in the drylands, is a sensible strategy for the individual live-

Photo 3.1 Changes in Vegetation Demonstrate the Resilience of Sahelian Ecosystems

Source: Hiernaux et al. (2016).

Note: The photos on the left of the Hombori Hondo site (in April 1985 and September 2008) show the regeneration of the herbaceous layer with herbaceous annuals and development of a pioneer shrub population (*Leptadenia pyrotechnica*). The photos on the right of the Kelma Seno site (in September 1986 and September 2007) show the regeneration of the herbaceous layer with annuals and the collapse of the old population of the same pioneer shrub. These illustrate the strong resilience to drought of the herbaceous annuals and the more complex dynamics of the woody population.

stock keeper, considering his or her current social, institutional, and incentive frameworks. In particular:

- Lack of attractive alternative investments for the pastoralist, as livestock asset investments earn a much better rate of return given the lack of formal credit or other savings mechanisms available to pastoralists;
- Lack of alternatives to reduce drought or disease risks, leading individual pastoralists to increase the number of animals to spread those risks; and
- Open access grazing, which means that incremental costs of keeping additional animals are practically zero, leading to the very rational decision to keep more animals even if they gain very little weight.

It is therefore not surprising that Lybbert et al. (2004) and McPeak, Little, and Doss (2011) did not find any evidence that overstocking by other herders has an impact on individual herder behavior.

In West Africa, a clear change has occurred in the relationship between pastoralists and arable farmers/agro-pastoralists. In the past this interaction was quite peaceful, with a strong symbiotic relationship. Pastoralists benefitted from the grazing of crop residues such as millet straw, and arable farmers benefitted from the manure droppings that maintained the fertility of their cropland. These interchanges were based on pure commercial principles, with pastoralists paying for the grazing of crop residues in areas with a high livestock but low arable farmer density, and arable farmers paying for pastoralists to night corral their animals in areas with a low livestock but high cropping density (McCown, Haaland, and de Haan 1979). Further interaction included a lively barter of milk for grain, as well as exchanges of services, as livestock-keeping arable farmers gave their stock to pastoralists for herding ("*gardiennage*") and pastoralists provided animals for traction to arable farmers.

Over the past two decades, this finely woven fabric of resource use and resource users has frayed, as these symbiotic relationships have changed quite radically. Arable farmers have increasingly invested in livestock, whereas pastoralists have been forced to take up cropping because their herd sizes fall below the minimum size needed to sustain their households. The reciprocal incentives for cooperation are therefore disappearing and, indeed, are changing into a competitive relationship for access to dry season grazing and water, leading to crop damage along transhumant routes (de Haan et al. 2014). In Niger, in particular at Djougou, the largely resident livestock feed needs plus the spread of fires and reduced access because of rangeland fragmentation, earlier drying of ponds, and competition for other water points all generate temporary and localized deficits (ECliS 2012).[5]

Production and Trade

Production

While the livestock population has increased both in the Sahel and in the Horn of Africa, *productivity per head* (TLU) has remained generally flat (although fol-

lowing recent droughts, a small decline has been observed in East Africa; see chapter 2). The lack of productivity growth is often blamed on herd accumulation.

Table 3.1 provides an overview of key technical parameters that determine productivity in livestock systems, as estimated for this book through an extensive literature review and consultations with experts. They form the basis for the livestock modeling reported in chapter 5. More detailed data, including on small ruminants, are provided in appendix A.

Herd offtake figures for cattle in pastoralist systems are lower than in commercial ranching. For example, an 8–13 percent offtake is found when FAOSTAT data for cattle numbers and number slaughtered are analyzed for Ethiopia, Mali, and Niger. Even lower percentages are reported (3.3 percent) for the Borana in Ethiopia (Desta and Coppock 2004) through recall methods over the period 1980–1997. For purposes of this book, mortality losses from drought were assumed to be 15 times higher than in a normal season, which would point to a lack of market access or willingness to sell of the pastoralists. These Borana figures led a recent study by International Food Policy Research Institute (IFPRI) (Headey, Taffesse, and You 2012) to argue for a major transformation through modernization. However, as argued in chapter 4, there might be some underreporting of sales, overreporting of deaths, and a shift from cattle to sheep, goats, and camels. On the other hand, as reported on page 35, the productivity per hectare of traditional pastoral systems is still the same or superior to the production in commercial ranches under similar climates in Australia and the United States.

Table 3.1 Technical Parameters Used to Estimate Productivity in Cattle, by Production Systems, East Africa and West Africa

	*West Africa**		*East Africa***	
	Pastoral	*Agro-pastoral*	*Pastoral*	*Agro-pastoral*
Cattle fertility (%)	51	51	55	53
Calf mortality (%)	24	19	22.5	19
Adult mortality (%)				
Age 1–4	7	3	7.5	7
Age >4	6	2	6	5
Cow milk offtake (liters/year)	457		300	285
Cattle live weight at slaughter (kilograms)				
Male	297		300	
Female	227		250	
Offtake (%)	12	12	10	9.5

Notes: *Based on meta-analysis carried out under this study by CIRAD, and expert consultation in Dakar; **Based on expert opinion and literature review by International Livestock Research Institute (ILRI) in particular from Shaw et al. (2006) and Shaw et al. (in press).

Trade

Pastoral production systems have long relied on trade, and the income earned from livestock sales is important to food security and income generation (Hesse and Cavanna 2010). For both regions, domestic trade is the most important subsector. Little (2013) estimates that for East Africa, more than 90 percent of livestock and meat trade is domestic. Considering the increased demand for meat from growing urban populations, it can be expected that the importance of the domestic market will increase even further.

But international trade is important as well, especially as governments often promote exporting. In East Africa, the Common Market for Eastern and Southern Africa (COMESA 2009) estimates the annual value of trade across five border areas (Ethiopia/Somaliland, southern Somalia/northeastern Kenya, southern Ethiopia/northern Kenya, western Ethiopia/eastern Sudan, and northern Tanzania/southern Kenya) to have a value of US$61 million annually. Much of this trade passes through unofficial channels and is therefore difficult to measure. The same COMESA brief estimates that intraregional trade has a value more than 10 times that of extra-regional trade. Export trade is significant for Somalia, Somaliland, and Ethiopia. In spite of the long running civil war, FEWS NET (Famine Early Warning Systems Network) and FSNAU (Food Security and Nutrition Analysis Unit) data estimate that 2.5–3 million animals are exported from the Berbera and Bosaso ports in Somaliland and Somalia, respectively, with about for example in the port of Berbera 60–70 percent of animals originating from Ethiopia. In 2012, Somalia and Somaliland together exported over 4.8 million animals to the Middle East (*Financial Times* Nov 25, 2013, based on data from the FAO FSNAU). Ethiopia's total exports of livestock and livestock products are valued at US$300–455 million, of which between US$150–300 million passes through informal channels (Gebremariam et al. 2013).

Significant differences exist between East and West Africa's national and regional policies with respect to the importance and potential for domestic and international (export) trade (for example, Moritz et al. 2010; Hesse and Cavanna 2010). In West Africa, North-South regional trade networks and the proximity of large urban centers to pastoral and agro-pastoral areas have allowed domestic and regional livestock markets to flourish (Turner and Williams 2002; Moritz et al. 2010).

In East Africa, public support for pastoral livestock markets has been less substantial, even though livestock production contributes a significant percentage to national GDPs (Hesse and Cavanna 2010). Exports to the Middle East remain important (Scoones and Woolmer 2006), and donors continue to invest in export schemes (Aklilu and Catley 2009). Verbeke et al. (2009) attributed a stronger market orientation among pastoralists in Kenya compared to Tanzania and Uganda to an institutional environment that is more conducive to the market participation of traditional cattle keepers. In general, richer pastoralists benefit more from market participation than do poorer ones (Turner and Williams 2002; Aklilu and Catley 2009). This is a function of several factors, including the

minimum herd sizes needed before market-oriented production is deemed viable, cash available to buy herds, social capital and information needed to negotiate good prices, access to credit, and transport infrastructure. More wealthy livestock keepers also have the capital to invest in fattening animals, as well as the means to obtain health certificates for export, licenses, and letters of credit.

Trade in milk is largely informal, although a more formal camel milk trade is slowly growing in Kenya. It should also be noted that trade in camels to the countries around the Persian Gulf is an emerging new opportunity, as Ethiopia, Kenya, and Somalia have a combined camel population of over 10 million and prices are good (Mahmoud 2013).

In West Africa, also almost all livestock trade is in live animals, inasmuch as current policies have been unfavorable to the development of animal product processing. The value of trade in live cattle increased in real terms from US$13 million in 1970 to US$150 million in 2000 (Williams, Spycher, and Okike 2004). Livestock trade from Sahelian countries to the coastal countries passes through three main corridors. In the West, the important flows are to Senegal, which imports more than 300,000 head per year from Mali and Mauritania. In the center, Côte d'Ivoire imports hundreds of thousands of animals per year from Mali and Burkina Faso. During the 2000s, trade with Côte d'Ivoire suffered significantly from political and military conflicts. Finally, the heavyweight of the subregion remains Nigeria, which dominates the transactions in the eastern corridor. Nigeria imports about 500,000 head per year, primarily from Chad, Cameroon, Niger, and Burkina Faso (with animals transiting through Togo and Benin).

Transaction costs in live animal trade are high. Transportation and handling costs can represent 40–60 percent of all cross-border trade costs involving live cattle, excluding the purchase price of the animals. This is in part because of illegal taxes levied by veterinary and custom control posts along the road by different institutions,[6] although the West African Economic and Monetary Union (WAEMU), which includes all Sahelian countries, has made a major effort to harmonize sanitary and custom standards.[7]

The West African drylands are a net importer of dairy products. Intensive dairy farms with imported dairy breeds are developing around urban centers, and increased use of crop byproducts has enabled agro-pastoralists to increase milk production as well. However, this is not enough supply to meet the growing demand. For example, the four west Sahelian countries, all members of WAEMU,[8] imported a total of 434 million liters in 2010, or about 15 percent of their total consumption. Despite commanding a higher price than imported milk powder, locally produced milk is attracting growing interest from local dairies, because it can be used to produce products with higher added value (Duteurtre and Corniaux 2013).

Few data exist on the competiveness of current production, but the general opinion is that the drylands red meat sector can compete with imported meat in the lower end of domestic markets. Local dairy production can compete in the fresh produce market, but not with imported milk powder.

Vulnerability and Poverty

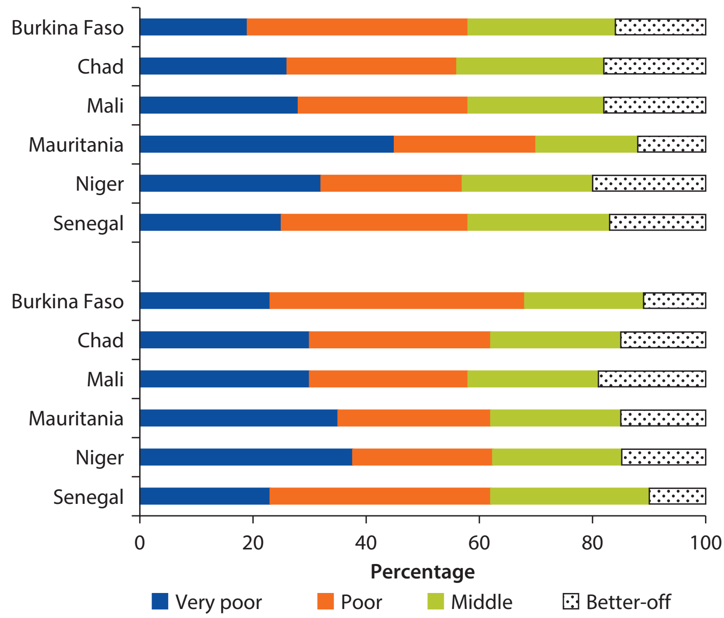
Asset (Livestock) Ownership

In many drylands regions of SSA, livestock systems are increasingly coming under pressure. Pastoral and agro-pastoral people alike have become highly vulnerable, and live perpetually in poverty or on the brink of it (figure 3.5). First, according to International Livestock Research Institute (ILRI) data (chapter 2), approximately 85 percent of pastoralists and 77 percent of agro-pastoralists live below the poverty line of US$1.25 per capita per day. Second, the basis of their livelihood is extremely narrow, as their livestock ownership is below the minimum required to meet their basic needs, avoid livestock inbreeding, and recover from drought. The minimum values cited in the literature range from 2.5 to 4.0 TLU per capita for pure pastoral households and about half that for typical agro-pastoralist households as they can supplement their livestock income with income from cropping activities (Sandford 2013).[9] A longitudinal study for East Africa carried out under PARIMA and summarized by Lybbert et al. (2004) estimated 15 TLU per household. A summary prepared by Food and Agriculture Organization of the United Nations (FAO) provides a range of 3.1–14 per AAME (African Adult Male Equivalent), or 15–70 TLU per household (Rass 2006).[10]

Most drylands households currently do not have anywhere near that many livestock: using ILRI data, the estimated 25–41 million pastoralist livestock keepers hold about 52 million TLU (equivalent to less than 1.7 TLU per capita), and the estimated 72–91 million agro-pastoral livestock keepers hold an estimated 71 million TLU (less than 1 TLU per capita). While official sources of livestock population data are often criticized for lack of precision, the data of Niger–which recently (2007)[11] carried out a comprehensive census and therefore has better-quality livestock data–confirm the Sahel-wide data. According to the FAOSTAT (2011) Niger data, which incorporate the results of the census, the country has 6 million and 2.7 million TLU in pastoral and agro-pastoral systems, respectively, owned by 3.2 million pastoralists and 4.6 million agro-pastoralists, or 1.9 and 0.6 TLU per capita, respectively. Given these and the prevailing low levels of production, these households have no possibility of earning a decent livelihood or recuperating from weather-related shocks.

These region-wide figures are confirmed by area-specific findings. For example, de Leeuw et al. (forthcoming) find that in most of the Kenyan arid and semi-arid land (ASAL) districts, livestock holding per capita has dropped to below 1 TLU. Osano et al. (2013) found 46 percent of households in 2008 and 80 percent of households in 2009 in southern Kenyan sites with livestock holdings below the threshold. This is of concern given the evidence of growing inequity in pastoral systems (Aklilu and Catley 2009; Homewood, Trench, and Kristjanson 2009). Households below this level find it difficult to move out of poverty even in good periods, while those households with higher levels of livestock can reproduce herds after droughts, but also use their animals for the critical social networks on which they rely (Little et al. 2008).

Figure 3.5 Incidence of Poverty in Pastoral and Agro-pastoral Populations, Sahel Region



Source: Household Economy Approach (HEA) Sahel profiles, 2008 to 2013 (http://www.hea-sahel.org/).

From the same survey, Little et al. (2008) reported that 70 percent of households had livestock holdings below 4.5 TLU per capita, whereas McPeak and Little (2014) highlighted the inequality, with a Gini coefficient for livestock ownership of 0.64, whereby the upper 10 percent of households control 42 percent of the livestock wealth. A similar picture is given by Homewood, Trench, and Kristjanson (2009), who show that in southern Kenya and northern Tanzania, the wealthiest 20–25 percent of households own 45–66 percent of all animals across their five study sites. At the same time, herds are being consolidated in the hands of so-called "traders" in East Africa (Catley, Lind, and Scoones 2013) and by government officials and traders in West Africa. Also Lybbert et al. (2004) show a long-term trend of declining herd size, at a rate of about 1.7 TLU/household/year, indicating a lack of resilience to fully recuperate from a drought shock. Shifting species composition (from cattle to small ruminants and camels) might be another cause.

The SHIP data from five focus countries[12] represented in chapter 5 provide a similar disquieting picture, with between 70 and 95 percent of pastoral households owning less than 15 TLU, although as argued in chapter 5, some underreporting of livestock holdings might have occurred in this survey.

In practical terms, this is shown by a survey carried out in Niger in 2009 (Save the Children UK 2009), which showed that approximately 57 percent of Katsinawa agro-pastoralists and 63 percent of Bororo pastoralists are below the threshold of 3 TLU per adult, with Katsinawa agro-pastoralists owning 1–5

cattle, 10–25 small ruminants, 2–4 donkeys, and 3–7 poultry and borrowing 0–2 cows, 1 goat, and 0–1 sheep; Bororo pastoralists own 3–6 cattle, 10–15 small ruminants, 2–3 donkeys, and no poultry. Given the productivity levels reported above, it is obvious (and confirmed by other field surveys and the modeling work herein) that no decent living can be expected from such meager resources.

Income and Expenditure

The major differences observed among drylands livestock keepers with respect to wealth are also reflected in their income sources and degree of diversification (Little et al. 2008; Homewood, Trench, and Kristjanson 2009; McPeak, Little, and Doss 2011). An in-depth analysis of data gathered from March to June 2002 in northern Kenya and southern Ethiopia as part of PARIMA, covering a drought and an early recovery (McPeak and Little, 2014), shows that even with a herd size of 26 TLU per household (4.4 TLU per capita), total income (for example, with home consumption of milk and meat from their own herd) amounted to only US$0.46 per day. Households with, on average, 7.3 TLU (0.9 per capita) earned a total income of only US$0.20–0.27 per capita per day. At least 40 percent of income from the small herd-owning households and 50 percent from the larger ones was from milk sales and home consumption. The calculations in chapter 5 confirm these low income levels.

If income derived from livestock is as modest as these examples suggest, clearly additional income sources will be needed, particularly for the poorer households. Surveys carried out in the Sahel show that outside employment can be a major source of income for poor households, whereas for wealthier households, the major sources of income include sale of cereals, livestock, and livestock products. As one author put it, “Wealthier households live by their production, but poorer households live by their work” (Holt 2011). A similar picture emerges from the report produced by Save the Children UK (2009) and partners using a Household Economy Approach (HEA) (see below): in Niger, the “better-off” and “middle” agro-pastoralists and pastoralists get almost 65 percent from livestock, while the “very poor” make only 10 percent from livestock. In terms of consumption, food purchase (cereals and other foods) is the main expenditure category, accounting for 75 percent of annual income of $US48 per person year cash income for the poorest agro-pastoralists and only 20 percent of the wealthiest group (US$134 per person per year cash income).

Remittances are an important source of income for inhabitants of the Sahelian drylands, including pastoralists. For example, it has been estimated[13] that 82 percent of households in four Nigerien departments[14] receive remittances; from 45 to 87 percent of these revenues are used for food purchases. The drop in remittances due to the war in Libya ranges from 51 to 75 percent.

The degree of food diversification at the household level depends very much on income level (the wealthiest households consume a larger share of milk than the poorest households, for example). On average, the “better-off” and “middle”

households spend two to three times more to access basic services such as education, health, etc. The handful of small ruminants owned by poor households are often sold or exchanged for food during the lean season. Rarely can small ruminants be used to get out of the poverty trap; poor households consume practically no animal products and have to buy most of their cereal food.

Poverty

The low asset base and modest level of income results in widespread poverty among drylands livestock keepers. In the four arid lands districts of Turkana, Marsabit, Wajir and Mandera in Kenya in 2005–2006, 74–97 percent of ASAL residents were counted as poor (Government of Kenya 2009), versus 46 percent of the general population. In Ethiopia, poverty levels of 36.1 percent and 32.8 percent are reported in ASAL areas such as Afar and Somali region, respectively, relative to a national level of 38.7 percent (MFED 2013). The lower level in Ethiopia might have been caused by different definitions of the poverty level. A more dramatic picture emerges from household surveys for four consecutive dry seasons (McPeak and Little 2004) in the pastoral areas of southern Ethiopia and northern Kenya. There, 49 percent of households wholly or partially dependent on pastoralism were below an income poverty line, which was set at a value equivalent to *half* the level of the UN extreme poverty line (US$1 of 1993 purchasing power parity) per person per day.[15] Data from northern Kenya show poverty incidences (which include income, assets, and food contributions of livestock) ranging from a high of 73 percent to a low of 13 percent, and a low correlation with market access (Little et al. 2008).

It has often been mentioned that income figures for pastoralists frequently omit nonstandard measures of income, since conventional estimates derived from household income alone omit the asset value of livestock (Little et al. 2008; Aklilu and Catley 2009) and fail to recognize that livestock are also a source of insurance, prestige, and other sociocultural values, providing a better livelihood than would appear considering income alone. While this argument might be valid for the wealthier and older parts of the population, for the poor and younger groups, the prospect of a decent income in the future will probably be critical, and household income is considered a critical indicator to assess the livelihood conditions of these livestock-keeping populations.

Food Insecurity

Similar to income level, the level of food insecurity among livestock-keeping groups is difficult to assess. Milk has traditionally been at the center of pastoral diets, but considerable variation exists among wealth groups. Seasonal and interannual variability also exists in terms of households' reliance on milk versus other sources of protein and calories (Sadler et al. 2010). In East Africa, the trend of purchasing more grains is increasing, and grains provide more calories than milk. Poorer households have less milk for either animal or human consumption, and

they often trade the milk they have for grains. More pressure on the little milk they have, however, also means that there is less milk for young animals, which increases calf mortality (Sadler et al. 2010). These same authors suggest that the role of milk in pastoral diets may decrease as pastoralists keep fewer cattle and more small stock. Meanwhile, milk markets are developing with the increases in urban populations. Sedentarization (settlement) can have a negative effect on household food security, as settled groups have less year-round access to milk, especially during the dry season when animals move (Fratkin, Roth, and Nathan 2004). These authors also found that human morbidity and poverty were higher in settled communities, leading to more food insecurity and disease prevalence. Deveraux (2006) notes a real paradox for some pastoralists, based on analysis of data from the Somali region of Ethiopia. Somali pastoralists have greater wealth relative to highland farmers, but are intensely vulnerable to livelihood shocks, particularly drought and conflict.

The close market integration of pastoralists and agro-pastoralists (Wane et al. 2010) can have a negative impact on food security. Milk that was once available for household consumption—and a particularly important food for children—may either be sold or left for consumption by young animals to promote their growth and improved production of meat for sale. Especially for poorer households with small herds, the effect of increased market involvement on milk availability and child nutrition is a concern (Sadler et al. 2010). On the positive side, the efficiency of extensive milk production systems has been demonstrated, for example, in Mali. This finding considers the positive role of extensive livestock systems in harsh environments, beyond food production alone (Vigne et al. 2013).

Chronic food insecurity clearly prevails in some pastoral areas and may have increased over the past decade, with repeated droughts triggering food insecurity. Reliable long-term data on child malnutrition are hard to find, and often the main evidence used is the number of people requiring food aid after a drought. The repeated triggering of such drought-related crises increases vulnerability, causing widespread malnutrition. In mid-2011 at the height of the last drought-related crisis, the Food Security and Nutrition Working Group reported global acute malnutrition rates of 38.3 percent across 18 areas in Somalia, 37 percent in Turkana, 24–27 percent in 11 northern Kenyan districts, and 25 percent in Bale province of southeast Ethiopia (FSNWG 2011).

The Result: Food Aid Dependency

Pastoralists and agro-pastoralists are highly dependent on emergency aid, as shown in table 3.2. They often live on the brink of poverty as their asset bases are too small when they are hit by conflict, insecurity, or drought. In East Africa alone, major droughts have occurred in 1998–2001, 2003/04, 2006, 2008, and 2009, with 42 million people displaced (of which a large proportion are likely pastoralists and agro-pastoralists).

Table 3.2 Impact of Drought Events, Ethiopia and Kenya

Major Drought Events	*Country*	*Humanitarian Aid Received (US$ millions)**	*People Affected (millions)*
2011	Kenya	427.4	3.75
2011	Ethiopia	823	4.5
2009	Kenya	432.5	3.79
2008	Ethiopia	1,078	6.4
2006	Kenya	197	2.97
2005	Ethiopia	545	2.6
2003/04	Kenya	219.1	2.23
2003	Ethiopia	496	12.6
1998–2001	Kenya	287.5	3.2

Source: Venton et al. (2013).
Note: *For Kenya, Government of Kenya and international humanitarian aid, for Ethiopia, international humanitarian aid only.

Education and Health

Indicators of educational participation and achievement have long been lower in mobile pastoral communities compared to national averages. Morton and Kerven (2013) cite data from Carr-Hill and Peart (2005) comparing gross enrollment ratios from 1999 to 2001; in Kenya, these rates were 12.9 percent in mobile communities versus 87.6 percent nationally, while in Ethiopia the discrepancy was 10.6 percent versus 57.4 percent. There is dearth of data about education in Sahelian nomadic areas. Despite this, Swift et al. (2010) cited information provided by national agencies in Chad estimating that only 2 percent of children were enrolled in primary education in community schools in nomadic areas. It should be noted, however, awareness is growing about the importance and benefits of education for mobile pastoralists (Little et al. 2008; Kratli 2000; Swift et al. 2010), with recent recognition that education is important for diversification.

Similarly, access to good health services is constrained by distance from urban areas, low population densities, and political marginalization. In Kenya, only 33 percent of people in the drylands areas have been vaccinated against measles, compared with 72 percent nationally; in Ethiopia, it is 28 percent versus 66 percent (Morton and Kerven 2013 citing Ali and Hobson 2009). They also have constrained access to clinics and other preventative services (Cohen 2005).

Exposure to Shocks

The exposure to shocks of livestock keepers is, to a large degree, determined by herd mobility, disease prevalence, market integration, and governance structures. Each is detailed below.

Mobility

The degree to which livestock-keeping households are exposed to shocks is greatly influenced by their mobility. When drought hits, disease strikes, or con-

Table 3.3 Comparative Productivity of Commercial Ranching and Open-Range Pastoral Production Under Comparable Ecological Conditions (Ranching = 100%)

Country	*Pastoral vs. Settled Ranch Productivity (%)*	*Unit of Measure*
Botswana	188	kg protein per hectare per year
Ethiopia (Borana)	157 (relative to Kenya)	MJ (Mega Joule) per hectare per year of gross energy edible by humans
Kenya (Maasai)	185 (relative to East Africa)	kg protein per hectare per year
Mali	80–1,066 (relative to United States) 100–800 (relative to Australia)	kg protein production per hectare per year
Uganda	667	Uganda shillings per hectare per year
Zimbabwe	150	Zimbabwe dollars per hectare per year

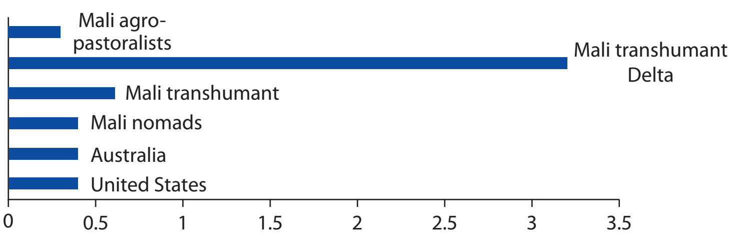
Source: Behnke and Abel (1996); Ocaido, Muwazi, and Opuda-Asibo (2009).

flict erupts, mobile households can move away to avoid being affected. Pastoral households are the most mobile, making them arguably less exposed to these types of shocks. Agro-pastoral households often have the ability to move their animals as well, but generally over shorter distances, leaving them more exposed to shocks. Quite a body of evidence now shows the superiority of mobile systems over sedentary ranching systems in terms of risk mitigation (table 3.3).

The comparison of mobile pastoralist systems with semi-mobile agro-pastoralist systems gives mixed results. On one hand, the review of livestock performance indicators (10) shows slightly higher mortality figures in the mobile, pure pastoral systems. On the other hand, earlier research on the Baggara in Sudan (Wilson and Clarke 1976) and in Niger (de Verdiere 1995) shows better performance for the mobile systems. The above-mentioned research in Mali (Breman and de Wit 1983) illustrated in figure 3.6 also shows the superiority in production of protein per ha of transhumant systems to ranching systems under similar climates in Australia and the United States.

Governments have had an ambivalent attitude towards mobility, and policy and legislation often offer mixed support for securing mobility. The need for stricter administrative control and the possibility of better service delivery in

Figure 3.6 Protein Yields in Extensive Systems in Mali, United States, and Australia (kilograms per hectare)



Source: Adapted from Breman and de Wit (1983).

health and education have often been used as arguments by public authorities to justify the promotion of sedentarization. Moreover, over the past two decades, mobility has become more restricted for reasons such as conflict, land expropriation, and changes in land tenure that favor privatization. This is still generally the case in East Africa, where there are no integrated or comprehensive national or local land use plans. The situation in Sudan offers an example of the way in which insecure land tenure undermines pastoralism. Pressures on pastoralist groups and their relations with other groups (farmers) over access to natural resources are a main underlying cause of conflict in Sudan (Young and Osman 2006). In other parts of East Africa, such as southern Ethiopia and southern Kenya, large livestock owners are adopting individual tenure and enclosing rangelands because individual titles offer improved security of ownership (Mwangi 2007; Tache 2013). Excision of key resource areas further undermines the ability of rangeland ecosystems to support livestock production. The fragmentation of range and forestland into small plots can lead to degradation and reduce livestock output (Hobbs et al. 2008). For example, the Thornton et al. (2006) model results show that in Kajiado, Kenya, subdivision of group ranches into small plots reduces the total number of livestock that can be sustained overall by more than 50 percent. Households then have to sell more animals for cash to buy food, so overall herd sizes continue to decline. The consolidation of larger private landholdings can exclude poorer pastoralists. Ironically and erroneously, in southern Ethiopia, managing drought risk is cited as one reason for the increase in enclosures, along with the rise of crop-based agriculture and private fodder production for animals on their way to markets (Tache 2013). In another estimate of the impact of expropriation of communal lands for irrigated agriculture, Behnke and Kerven (2013) estimate that denying herd animals access to bottom lands in the Awash valley of northeastern Ethiopia has a direct and significant effect on their productivity, resulting in almost total loss of GDP from such activities. Only very recently has the need for mobility been acknowledged in Uganda and Tanzania (chapter 4).

In West Africa, pastoral rights, including the right of mobility, are better defined. Several Sahelian countries have passed pastoral laws or codes that define the rights of pastoralists, including Mauritania (2000), Mali (2001), Burkina Faso (2003), and Niger (2010). Thébaud and Hesse (2008) provide a balanced review of these codes' contribution to pastoralism. On the positive side they: (i) give herders rights over the common use of rangelands and priority—albeit not exclusive—rights over resources in their "home areas," as well as rights to compensation in the event of loss of their lands to public interest needs; (ii) provide greater recognition of customary tenure arrangements, including the principle of decentralized natural resource management, and multiple and sequential use of resources by different groups at different times of the year (for example, herders' access to harvested fields); and (iii) reduce the need to manage conflict at the local level. Niger's pastoral code is the most recent (2010) and probably the most advanced, as it very explicitly recognizes that "mobility is a fundamental right of

herders and transhumant pastoralists." Implementation is still incipient in part due to lack of funds, but conflicts have practically disappeared in the regions where transhumance corridors have been marked.

Some of the earlier "codes" adopt a more technocratic and development-oriented approach in support of pastoralism. For example, Burkina Faso's pastoral code still provides for the establishment of special grazing reserves (*zones pastorales aménagées*), seeking to replace customary systems of resource access (driven by what is perceived by outsiders to be rather "messy" processes of social and political bargaining between actors) with a more orderly and technical system. It is erroneously believed that this would make pastoral production in the Sahel more secure. More recently, as exemplified by the recent Nouakchott Declaration, a general consensus seems to have developed exclusively recognizing "pastoralism as an effective practice and lifestyle suited to the Sahelo-Saharan conditions" as well as the right to mobility (Nouakchott Declaration 2013). Thebaud and Hesse (2008) made the point that "water rights are crucial to pastoralists to manage grazing lands sustainably and endow pastoral communities with assets that can be negotiated to access distant resources in times of crisis," but in the codes a functional link between access to water and access to grazing is often missing. The role of management committees is limited to surveillance of the water infrastructure, excluding the use of grazing resources or control over the number of livestock using the well.

More recent evaluations in West Africa confirm the above assessment. A recent review by the ECliS project (2012) notes that despite recent advances in legislation dealing with the pastoral economy, especially in Sahelian countries, and in regional regulations (UEMOA), pastoral mobility is increasingly hampered by the expansion of crops, but also by land policy and local governance. Rights on pastoral lands generally remain precarious and are not recognized by institutions (HLPE 2011), especially in the strategic areas of lowlands, riverbanks, wet valleys, forests, and pastoral reserves (Ickowicz et al. 2012b).

Disease Prevalence

Throughout most of the drylands, livestock are distributed sparsely over vast areas, making herd-to-herd transmission and therefore large-scale epidemic disease outbreaks relatively infrequent. Rinderpest, which some decades ago killed millions of animals, is officially eradicated. Regarding other contagious diseases, according to the World Organization for Animal Health OIE-WAHID[16] database, which is based on official national reports, the incidence of contagious bovine pleuro-pneumonia (CBPP) is sporadic in the Sahelian countries and most East African countries, with a somewhat higher prevalence in Ethiopia. *Peste de petits ruminants*, a contagious disease of sheep and goats, has a higher but still limited prevalence. Underreporting might be an issue here. However, parasites and nutritional deficits cause high levels of mortality and major production losses of livestock in the drylands especially for young animals, where environmental, feed, and sanitary factors combine to result in high mortality rates of

around 20–25 percent in East and West Africa (Ezanno, Ickowicz, and Lancelot 2005; Ickowicz et al. 2012a).

Sudden emerging livestock diseases and related sanitary bans put livestock keepers at a high risk of exposure. For example, Little, Teka, and Azeze (2001) illustrate how disease outbreaks linked to extreme weather (floods), especially Rift Valley Fever (RVF), are difficult for pastoralists to manage as they are infrequent and their impacts are poorly understood. The 12-month ban imposed by Saudi Arabia in 1996 on the import of all live animals reduced annual incomes of pastoralists in Somaliland by more than US$20 million and regional state revenues by about 45 percent. Nin Pratt et al. (2005) studied the effect of a further sanitary export ban from 2000 to 2003 imposed by Saudi Arabia and the Gulf States for RVF in Kenya. They showed that almost the entire population on the Somali-Ethiopia border was exposed to the price shock resulting from the ban. Not only did GDP drop by US$91 million (25 percent) in nominal terms, but pastoralists' livelihoods were also severely affected by the ban: pastoral income dropped by about 25–30 percent; the herd composition changed from cattle to goats and camels; and the number of animals per herd fell. In particular, the poorest pastoralists changed their consumption patterns, decreasing their purchases of food and grain. Marketing agents such as traders, brokers, transporters, and even clothing retailers experienced negative effects on income and the volume of business, while grain producers and retailers slightly improved their income.

Market Integration

Contrary to common belief, most households that depend on livestock as a principal livelihood source are reasonably well integrated into the market, both for livestock and for grains. This has obvious advantages, but it also leaves them exposed to price shocks (Ickowicz et al. 2012a; Aklilu et al. 2013). For example, Desta and Coppock (2004) found that over the 1980–1997 period, more than 90 percent of livestock keepers in northern Kenya and southern Ethiopia had been involved in livestock marketing. Regarding grain, falling per capita herd wealth encourages the exchange of protein for calories, that is, the sale of high-priced animal products to purchase cheaper grain (Ensminger 1996; Bollig 2006). Increased market integration can be both a boon and a hazard for pastoralists. On the positive side, Little et al. (2008) stress that the "caloric" terms of trade usually favor pastoralists who sell a few animals to purchase cereals and finance other needs. However, particularly in times of drought, livestock prices generally decline, but grain prices rise, and the greater reliance on cereals increases the exposure to price shocks. For example, Ickowicz et al. (2012b) found in a market survey in three Malian villages that the goat/cereal price ratio in good years was about double that of a bad year. They found also that greater market integration and related price volatility at the international level, such as the grain price spike in 2008, were transmitted to the cereal/livestock price ratio in the rural areas of the Sahel, and affected the more intensive livestock farms through higher feed prices. During the feed and food price spike, there were exceptional sales of small ruminants because farmers were forced to sell

more to cover their expenses (food consumption and water). The structure of sales of adult cattle could also change, with more beef offered on the markets as well as cows with calves instead of the culled cows usually sold, illustrating the weakening of the pastoral micro-economic model (Wane et al. 2010). Similar effects to those in response to drought are described in Gitz and Meybeck (2012).

Governance Structures

Conflict and insecurity are prevalent features of life for many pastoralists in arid and semi-arid zones and represent a significant obstacle to long-term development. Often localized in their immediate manifestations, they are also linked to longer-term and higher-level factors, including contested borders, failures of policing, and divisive politics, combined with long-term economic marginalization (Pavanello and Scott-Villiers 2013). Localized conflicts can lead to more widespread, even cross-border, instability. de Haan et al. (2014) distinguished four different causes of instability and conflict: (i) religious extremism, such as Al Qaeda in the Islamic Maghreb (AQIM) and Al Shabaab in Kenya and Somalia; (ii) rebellion and irredentism (that is, pan-nationalism based on ethnicity, such as in the case of the Tuareg and Toubou in West Africa); (iii) criminal activities (drugs, smuggling, kidnapping, and money laundering); and (iv) localized conflict between arable farmers and pastoralists over crop damage from livestock, access to water, and dry season grazing.

Regarding the latter, population growth combined with steady increases in animal numbers have led to increased competition for grazing land, particularly for the higher-potential dry season grazing areas, and water. For example, in the Sahel, cropland has increased 2.5-fold to the detriment of critical grazing areas, which have decreased by 13 percent. In parallel, the livestock population (expressed in TLU) increased 2.5-fold between 1961 and 2009 (SIPSA 2012). Various mining resources are also being tapped in previously grazed areas to meet urban and industrial needs. The changing relationship between pastoralists and arable farmers described above has further increased tensions.

This, in turn, has led to greater incidence of conflicts, which in the absence of effective governance systems sometimes escalate to major instability (OECD 2010b). The proliferation of small arms has increased the violence of cattle raids. Unclear governance arrangements (particularly devolution of power without budget, lack of participatory skills at the local administrative level, unclear and overlapping mandates of traditional and formal administrative systems, and governance structures that do not honor traditional institutions and arrangements) can exacerbate resource conflicts. Pastoralists have also lost trust in national and local administrations (Beeler 2006; de Haan et al. 2014).

Sensitivity to Shocks

The sensitivity to shocks of livestock keepers is to a large degree defined by their assets, their livestock vaccination coverage, and the number and diversity of their income sources. These factors are discussed below.

Assets

The size and composition of livestock ownership significantly affect households' sensitivity to climate-related shocks and disease shocks. Households with larger holdings, consisting of different species, can better spread climatic risks as they can divide their herds and deploy them to different locations. In contrast, households with smaller herds, consisting of the same species, are more sensitive to climatic risks and disease outbreaks, not only because their animals tend to be physically located in one place, but also because their lack of political and economic influence means their animals often get crowded out from critical dry season grazing areas. And as indicated before, livestock ownership is increasingly dominated by wealthy traders and civil servants.

Vaccination Coverage

Livestock vaccination clearly reduces households' sensitivity to contagious diseases. As indicated above, according to the official OIE database, the incidence of the major contagious diseases in drylands is limited, although the real prevalence might be masked because of underreporting. Further reduction and eventually eradication might be difficult, however. The highly mobile, low-density livestock population, spread over vast areas, results in high transport costs for already underfunded animal health service delivery systems, and means that effective vaccination coverage is generally very low (for example, it is only 20 percent in Senegal).

Number and Diversity of Income Sources

Households with multiple sources of income are less sensitive to shocks affecting a given income source than households that rely exclusively on a single income source. Remittances, of critical importance to survive any of these shocks, are increasing, probably for both pastoral and agro-pastoral systems. For example, the above-mentioned household survey in West Africa (Holt 2011) shows the importance of: (i) income from casual labor[17] and remittances, in particular for the poor; (ii) diversification in species composition of the herd (small ruminants, camels); and (iii) diversification of outputs, with the sale of milk of critical importance for women. Ridgewell and Flintan (2007) highlighted the importance of the collection of other range and forest byproducts, such as gum arabic, fuel wood, and medicinal plants. However, as shown by Devereux (2006), these other activities are less financially attractive than livestock or crop farming: livestock and crop production yielded a monthly income of Ethiopian Birr (ETB) 210 and ETB 216, respectively, while charcoal production and firewood collection resulted in income of only ETB 88–100 per month.

Ability to Cope with Shocks

The coping capacity of livestock keepers is influenced by their access to assets (particularly the amount and distribution of physical and financial assets), social

capital, safety nets, and technology services. The first three are detailed below, technology services are described in chapter 4. As described in box 3.1 and box 3.2, livestock systems in the Sahel and the Horn of Africa feature similarities but also differences when it comes to coping strategies.

Assets

After a shock has hit, a household's ability to cope with the effects and rapidly rebuild its livelihood depends in large part on its assets and the degree to which they can be liquidated and re-procured. Savings accounts held in financial institutions are perhaps the most liquid, but pastoralists generally distrust them. Only a small proportion of pastoralists hold some wealth in bank accounts; most use informal savings and credit mechanisms through shopkeepers (Morton 2007).

Social Capital

Households that have experienced shocks may be able to rely on social capital to help them cope. Following cultural traditions, relatives of distressed households frequently contribute resources to help distressed households get through periods of crisis. However, the social cohesion of pastoral people is deteriorating, both at the household level and at the clan level, as described for the Turkana in East Africa (Galvin et al. 2008) and the Fulani of Niger (Niamir-Fuller 1998), although the rate at which this social "glue" is disappearing varies according to ethnic group. The rebellion of many youth against traditional hierarchical authority structures and increasing levels of conflict are at least partially caused by competition for resources and the financial attraction of criminal activities. One potentially positive trend is the growing number of pastoral organizations (for example, the Pastoral Forum in Ethiopia; and the RBM/*Réseau Bilital Maroobé* and the APESS/*Association pour la Promotion de l'Elevage au Sahel et en Savane* in the Sahel). Kenya's former Ministry for Northern Kenya and Other Arid Lands, although now disbanded, made some key strides in getting recognition for the importance of pastoral rights and economic activities (Elmi and Birch 2013).

Safety Nets

Safety nets, including various types of emergency relief programs, can play an important role in helping rural households cope in times of crisis. However, because of their marginalization, pastoralists are often discriminated against or even excluded from safety net coverage. If poorly delivered—for example, if the aid ends up on the black market or benefits the wealthy—it can cause discontent and contribute to rebellion. Reasons for the lack of a timely and effective response in affected pastoral zones include: lack of available information; refusal to declare an emergency; the greater complexity of intervention in pastoral areas; security constraints for international staff; and lower priority given to pastoral zones by donors and governments (Sahel Working Group 2011).

Box 3.1 Vulnerability and Resilience in the Sahel: Senegal Case Study

Introduction

Almost 68 percent of Senegalese households own livestock. Senegal's livestock system remains dominated by traditional activities (for example, those that cannot be measured exclusively in quantitative or monetary terms). Livestock activities occupied 30 percent of the active workforce and contributed about 4 percent of gross domestic product (GDP) in 2006–2009. The system has significant nonmarket drivers that may be as or more important than market drivers.

Senegal has three main livestock subsystems:

- The *pastoral system* in northern Senegal (the Ferlo), which occupies 64,000 square kilometers, 31 percent of the national territory, with density between 2 and 10.6 TLU per kilometers;
- The *agro-pastoral system* in southern and eastern Senegal, mainly based on mobility and use of natural grazing and crop residues. Sales are mainly driven by financial emergencies, scarcity of pastoral resources, increasing land competition, bushfires, water access, weakness of animal byproduct markets, and structural lack of basic infrastructure (IDELE-CIRAD-CA17 2012); and
- The *intensive system* in urban and suburban areas (the Niayes), with animal disease (trypanosomiasis) in the so-called risk areas. These areas have high calf mortality, short length of lactation and milk production, low live-weight, and commercial disincentives to production (38 percent lower sales in risk areas) (Wane 2012).

Alternatively, it is possible to distinguish between: (i) the intensive commercial sector, which deals with disease and input price fluctuation at the production level; and (ii) the extensive pastoralist system, which traditionally faces climate and socio-anthropogenic changes including ineffectiveness of decentralization policies and weakness of local organizations (Dia, Becerra, and Gangneron 2012).

Exposure to shocks

In the *Ferlo* pastoral area, climate shocks have considerable impacts on resources and pastoral herd performance. In a drought situation, feed largely constitutes of imported inputs (Harder and Jung 2008) affected by increasing prices (Assani et al. 2012) that make pastoralists' livelihoods more fragile. Their vulnerability specifically raises the lack of consideration given to the economic role and function of pastoralists. In the south and east agro-pastoral areas, the main shocks other than climate change are structural and governance related. Conflicts originate from the competition for resource access and the erosion of traditional management systems, heightened by political and/or ethnic tensions. Conflict breakouts lead to less accessible roads and marketing corridors and weak productivity, and to pastoralists hurriedly selling their stock. Thus, herd size drops below viability thresholds. In the *Niayes*, more intensive disease-risk areas, the main shocks remain climate change (extreme temperatures, droughts, flooding, etc.) and rapid population growth. This modifies the host-vector contacts, particularly for African animal trypanosomiases (Pagabeleguem et al. 2012). With

box continues next page

Box 3.1 Vulnerability and Resilience in the Sahel: Senegal Case Study *(continued)*

rapid population growth, land use competition between crops and livestock results in fragmented areas, and by extension, in changing disease patterns, with increasing pressure in low disease-risk areas from greater host-parasite-vector interactions (Van den Bossche et al. 2010) and reemergence of other diseases or strains.

Sensitivity to shocks

Climate and natural resources: Climate shocks remain a major issue with important impacts: simulations in semi-controlled areas show a significant decrease in plant biomass in 2011 (0.85±0.48 tons per hectare) compared to 1964 (1.71±0.64 tons per hectare) and the number of species declined from 168 in 1964 to 92 in 2011 (ECliS 2012). At the same time, over the past 40 years, the national herd has roughly doubled in size. Since the late 1980s, animal numbers have increased rapidly, on the order of 2–3 percent per year according to Senegal's National Livestock Services. In contrast, the previous two decades were marked by relative stagnation due to two severe droughts that affected the entire subregion. The relative share of cattle decreased significantly from 1970 to 2010 in favor of small ruminants. However, in terms of TLU, the cattle herd was and remains largely dominant.

Vaccination coverage: With a coverage of 20 percent, Senegal is far from achieving the OIE standards for immunization (80 percent) due to asymmetric distribution of veterinary services in livestock areas. The national immunization program sometimes does not account for some (re)emerging or parasitic diseases, and is challenged by insufficient and inadequate domestic production of vaccines and volatile international vaccine prices. In addition, counterfeit drugs, estimated at 50 percent of drugs sold in the country, are not controlled. The increased incidence and pathogenicity of disease strongly constrain economic and sociocultural activities, thus increasing livestock keepers' sensitivity to the loss of livestock productivity and diminishing small producers' food security.

Number and diversity of income sources: Sales of live animals provide over 97 percent of livestock keepers' total income. Agricultural products are used essentially as a means of subsistence and contribute only marginally to household income (2 percent). Farm activities are organized between livestock production mostly for the market (with limits imposed by food security constraints particularly for dairy products) and food crops for home consumption. Bovine sales are mainly of cattle, with cows having relatively less commercial value due to their provision of milk and calves. More male sheep (67–80 percent) are sold than females (33–20 percent). Animal sales are unevenly distributed (Gini index = 52.8) and closely follow ecological disparities between the very driest north (>50 percent) and the more watered south (<50 percent) (Wane, Ancey, and Touré 2009). With the development of wage labor (25 percent in the Ferlo), the poorest households obtain income for rebuilding the livestock population, particularly after crises.

Ability to cope with shocks

By staying pastoralist-focused, traditional actors continue even today to respond to production shocks with many strategies: mobility, forced sales, herd splitting, herd diversification, flexible social organization, seasonal labor, use of wage labor, transfer of fertility with crop

box continues next page

Box 3.1 Vulnerability and Resilience in the Sahel: Senegal Case Study *(continued)*

systems, etc. Whilst international and domestic price fluctuations and sudden climatic events (for example, the cold rain events of 2002) remain risky at the production level, the shocks seem to be much greater at the enabling environment level. The inability or delay in responding to shocks probably poses the major risks (loss of access to lands, instability and inadequacy of policy and regulatory measures, failure to establish and operate quick and effective veterinary response plans). Some problems (shrinking space, decreasing forage production, decreasing biodiversity, falling incomes) or constraints (low productivity, water scarcity) could become future risks or shocks to pastoral production systems and pastoralists' way of life (sedenterization, population growth, expanding agriculture) if responses at the local, national, and international levels are not better organized.

Public actions for the livestock sector to address climatic shocks now focus particularly on safeguarding a permanent supply chain for feed. In 2012, 21,000 MT of animal feed worth around US$7.5 million were mobilized and made available to farmers at a 50 percent discount. This exceptional measure assumed that livestock keepers would manage (and bank) the revenue surplus provided by the sales of feed animals through this program for use in case of crises. There is also a potentially positive trend in the growing number of regional and national pastoral organizations, which facilitate dialogue between actors and prevent eventual conflicts.

Source: Abdrahmane Wane (personal communication).

Box 3.2 Coping in Marsabit County, Northern Kenya

Marsabit County in north-central Kenya is one of the most arid and most sparsely populated parts of the country. The lowlands that make up the majority of the land area include deserts, grassland, and rugged lava plains. Annual precipitation in the lowlands is around 300 millimeters, so agriculture and horticulture are not practiced except for very modest efforts to grow forage in gardens adjacent to permanent springs at the edge of the Chalbi Desert. However, three highland areas rise up from the lowlands—Mt. Marsabit, Mt. Kulal, and Hurri Hills—where precipitation is higher (around 600 millimeters per year for Hurri Hills and 800 millimeters per year for Mt. Marsabit and Mt. Kulal). These three highland areas serve important functions in the hydrology of the greater area, being the main source of both surface water and groundwater for many kilometers. The portion of the lowlands that lies in the center of these three highland areas—Chalbi—is an enclosed basin. The desert at the center of the Chalbi basin is actually a salt flat lakebed, which often has standing water for short periods each year.

The region is one of the most remote parts of Kenya, although it is gradually being incorporated into national road and mobile phone networks. In the lowlands, livelihoods are dominated by pastoralism; only a small percentage of the population has any livelihood source

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Box 3.2 Coping in Marsabit County, Northern Kenya *(continued)*

other than livestock and occasional food aid. While a trend toward households establishing permanent homes in one of the settlements has been going on for the past two or three decades, a significant portion of the population is still genuinely nomadic. Even for those who have settled, much of their herd remains mobile, part of the household—often the young men—moving with it. In the highland areas, especially Mt. Marsabit, agriculture is more common, although even here livestock are still a critical part of most people's livelihood mix.

Aside from drought, the main shocks to people's livelihoods are loss of livestock to disease, conflict, and theft. Patterns of livelihood diversity play a central role in sensitivity to all three of these kinds of shocks, although in two contradictory ways. On one hand, sensitivity is exacerbated by the overwhelming reliance on livestock. On the other, other forms of diversity at household, community, and clan levels help to compensate for the lack of diversity in the main livelihood activity. For example, there is diversity across space pasture and forage resources and of herd movement. Different herders, even if they have very similar herd compositions, may take their livestock to different places based on social connections and on personal knowledge of the territory. While this does not result in diversity within the livelihood of a household, it does result in diversity within the community, thereby spreading risk. Related to this is the practice of herd splitting, which can serve a number of functions at once: it allows each species of livestock to be taken to areas best suited for it; it helps to spread risk, especially risk of losses due to theft; and it helps to reduce concentration of grazing pressure. Another form of diversity is the livestock species mix kept by each household.

Central to the strategies that Marsabit pastoralists use to cope with drought is the role that livestock play as an asset buffer, the strategy being to increase livestock holdings as much as possible whenever conditions allow. The ability to cope is, in part, a function of herd size, and fluctuation in herd size according to the cycle of droughts is accepted as part of life.

Of course, water resources for livestock are also critically important. In the lowlands, water sources tend to be ephemeral, except for a few scattered boreholes and reliable groundwater located around the periphery of the Chalbi Desert. However, what is important for coping with drought is not water resources themselves, but the spatial relationship between water and pasture resources. Gabra pastoralists often remark that where there is water there is no pasture, and where there is pasture there is no water. This distribution of water and pasture results in a mobility pattern for some Gabra and Rendille pastoralists that is, in some sense, opposite to that of other pastoralists: for many households, livestock are moved to the driest part of the territory (near the Chalbi Desert) not during the rainy season but during the dry season; during the rainy season, livestock are moved away from the desert toward parts of the territory where pasture resources are better but where only temporary water sources can be found. Once those water sources have run out, it is time to move back toward permanent water. For those who follow this pattern, the challenge during a drought is not to find water—the oasis springs and shallow wells around the desert are permanent. However, during a drought the availability of forage around the Chalbi Desert goes from bad to worse. The challenge, therefore, is to find places where water and grazing resources are sufficiently close to

box continues next page

each other. One of the interventions of development partners aimed at this aspect of coping with drought has been to make water available in what have heretofore been only rainy season grazing areas via emergency water tankering during droughts into areas with good pasture, construction of pans and rock catchments, and, in a few places with good pasture such as in the plains east of Hurri Hills, boreholes.

While some aspects of coping with drought have deteriorated over time, coping capacity in Marsabit County generally remains strong, although a distinction needs to be made between capacity for short-term coping and for long-term adaptation. Here too, the situation is complex. Social and institutional networks are an important dimension of adaptive capacity. Among the Gabra, social capital, embodied in practical ways in a variety of traditional stock sharing and restocking mechanisms, can be very strong. Institutional linkages within Gabra society can also be quite strong. On the other hand, institutional linkages that extend beyond Gabra communities to the district level and higher are few and weak. Robinson and Berkes (2011) argue that the weakness of these linkages places a stark limitation on the adaptive capacity of Gabra communities and households, which is only partly compensated by well-connected formal sector actors such as nongovernmental organizations (NGOs) and government agencies.

Source: Cornelis de Haan (personal communication).

Notes

1. Djibouti, Ethiopia, Eritrea, Kenya, Somalia, Sudan and South Sudan (combined), and Tanzania for East Africa and Burkina Faso, Chad, Mali, Mauritania, Niger, northern Nigeria, and Senegal for West Africa.
2. FAOSTAT data 2011.
3. TLU is a unit to aggregate different livestock species based on 250 kilograms live weight. Here, based on the West African standard, 1 TLU is equivalent to 1.0 camel, 0.7 cattle, 0.1 sheep or goat, and 0.01 chickens. In East Africa, the factors are 0.7 for camels and 0.6 for cattle; the others remain the same. These factors are also used in chapter 2.
4. Standard deviation/average annual rainfall.
5. ECliS was a research project (2009–2012) aimed at assessing livestock husbandry's contribution to the interactions between society vulnerability/adaptability and agro-ecosystem vulnerability/resilience in West Sub-Saharan Africa (SSA) (Senegal, Mali, Niger, Benin). The CIRAD team and its partners conducted this project.
6. http://www.oecd.org/swac/publications/38768799.pdf
7. http://www.standardsfacility.org/Files/Publications/STDF_Regional_SPS_Stategies_in_Africa_EN.pdf
8. Burkina Faso, Senegal, Mali, and Niger.
9. http://www.future-agricultures.org/pdf%20files/Sandford_thesis.pdf.
10. http://www.fao.org/ag/againfo/programmes/en/pplpi/docarc/wp37.pdf

11. This Niger census in 2007 revealed that the number of cattle was largely underestimated, as technical service estimate population (and report in FAOSTAT) on the basis of constant annual growth rates and overlook external events that may have a marked impact on herd dynamics and production (droughts, epizootic diseases, etc.) (SIPSA 2012). This is a problem affecting all Sahelian countries.
12. Burkina, Niger, and Nigeria in West Africa and Ethiopia and Kenya in East Africa.
13. Inter-Réseaux Développement Rural and SOS Faim Belgium, 2012.
14. Loga, Tahoua, Tanout, and Gouré.
15. Quoted by Sandford in http://www.future-agricultures.org/e-debate/pastoralism-in-crisis/7646-too-many-people-too-few-livestock
16. http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail
17. Wane et al. (2010) also highlighted that with the emergence of wage labor, the poorest pastoralists are increasingly providing labor to the wealthiest pastoralists.

CHAPTER 4

Opportunities for Reducing Vulnerability and Enhancing the Sustainability of Livestock Systems

Cornelis de Haan with Polly Ericksen, Fiona Flintan, Andrew Mude, Alexandre Ickowicz, Abdrahamane Wane, and Ibra Touré

Overall Strategy and Vision

Building on the analysis presented in chapter 3, this chapter provides a summary of the technology and policy options used to address the three determinants of vulnerability and resilience: exposure, sensitivity, and ability to cope. Thus, this chapter seeks to cast the most appropriate interventions in the framework of the overall study, with the long-term goal of reducing livestock owners' vulnerability and emergency aid dependency and enhancing their resilience. While not meant to provide an exhaustive and comprehensive description of all options available (which anyway is not possible given the large variation in conditions across study countries), this chapter covers the proven and more promising interventions and presents good practices for each.[1]

The vision for the future is that in pure grassland areas (Aridity Index, AI = 0.05–0.20), priority attention is on reducing vulnerability by rebalancing the ratio of land/livestock/people and maintaining productivity at levels that will not lead to degradation of the natural resource base on which these systems depend. This means focusing particular attention on ensuring diverse and alternative income sources and on more policy and institutional support to enhance pastoral systems' sustainability.

In the semi-arid and dry sub-humid regions (mostly mixed farming with AI = 0.20–0.65), the focus is on sustainable intensification, productivity enhancement through improving technical practices, and policies and institutions.

An overview of the main interventions, the shock(s) they address, and the main expected outcome(s) is given in table 4.1. The rest of this chapter is devoted to elaborating each of these.

Table 4.1 Interventions to Enhance Resilience in Livestock Systems, SSA Drylands

Priority Intervention	*Main Shock(s) Addressed*	*Main Determinant(s) of Resilience Addressed*	*Main Impact (Equity, Environment, Economic Growth)*	*Preconditions for Scaling Up*
Early offtake	Drought	Sensitivity	Environment Economic growth	Price Market
Animal health services	Sanitary Drought	Exposure, Sensitivity	Economic growth	Capacity building
Protect/ensure mobility for pastoralists	Drought Economic Social (Sanitary)	Exposure Sensitivity Capacity to cope	Environment Equity Economic growth	Methodology control Multi-stakeholder approach Recognition of land rights
Index based livestock insurance	Drought Sanitary (Social)	Sensitivity Capacity to cope	Equity Economic growth	

Note: SSA = Sub-Saharan Africa.

Reducing Exposure to Shocks

Grassland and Pastoral Systems

Enhancing Mobility through Water Resource Development

Water resource development can play an important role in facilitating mobility as it enhances the feed balance of drylands in three aspects. First, development of water resources—mainly by constructing shallow wells and drilling boreholes—can open up these areas for grazing, and thereby improve the overall amount of feed resources available, providing additional flexibility during times of drought. Second, water resource development reduces the range that livestock have to trek to a water point, thereby increasing the efficiency of feed utilization. In addition, better-quality water reduces livestock diseases associated with bad-quality drinking water. A positive impact on animal health and livestock keepers' livelihoods has been noted in many projects (Bonnet et al. 2004; Ickowicz et al. 2010; Krätli et al. 2013). Finally, as water resource development is one of the most demanded interventions by pastoralists, well-implemented water points can be a major step towards (re)gaining pastoralists' trust.

Although development of water resources has often been cited as a primary cause of range degradation, this view is now being challenged. Several long-term studies carried out in Senegal show no major vegetation changes after 30 years of major investments in pastoral watering points (Diouf et al. 2005; Miehe et al. 2010). The Chad pastoral water program supported by *Agence Française de Développement* (AFD), which has established 1,100 pastoral water structures in the last 20 years, is less definitive in its recent environmental assessment: in spite of extensive ecological monitoring, the project could not confirm or refute whether the structures had helped regenerate plant cover or avoid its degradation (Krätli et al. 2013; Mtisi and Nicol 2013). There also seems to be a growing,

although not confirmed, consensus that comprehensive coverage of water points over a large area prevents excessive concentration of livestock pressure and causes less environmental damage (or is neutral) than *ad hoc* uncoordinated, piecemeal establishment of single water points (Ickowicz et al. 2010; Krätli et al. 2013).

Designing the appropriate institutional framework supporting water development for livestock in drylands areas is critical. Previous government-directed and donor-funded programs have often failed, as infrastructure was not adequately maintained and broke down after external finance stopped. Inadequate definition of users' rights often led to a permanent water supply, which in turn attracted permanent settlers, disrupting the established equilibrium between wet and dry season grazing, sometimes even leading to pastoralists being excluded from the water point (Pratt, LeGall, and de Haan 1997). Such poorly designed interventions can lead to environmental degradation and increased conflict and instability. On the other hand, a well-designed project integrating traditional local users' rights and state legislation, allowing grazing control by these users in line with the actual carrying capacity of the surrounding areas, can be a useful tool in sustainable range management, and can diminish local conflicts (as seen in Chad, as described above).

In summary, critical requirements in the design of pastoralist water infrastructure to facilitate mobility include: (i) a participatory approach during establishment, seeking agreement of all actors on issues such as siting, users' rights, and cost sharing; and (ii) mechanisms for making access to water dependent on the surrounding rangeland ecology and production.

Enhancing Mobility through Land Use Planning

Integrated and participatory land use planning is essential, ensuring: (i) the possibility that pastoralists can move in uninterrupted fashion from wet to dry-season grazing areas, particularly Sahelian transhumant pastoralists; and (ii) access to critical dry season grazing and watering areas for all groups. These critical requirements to enable mobility should be embedded in national legislation. The diagram in box 4.1 illustrates the complexity of this, given the overlapping pastoral land use systems and the many actors involved.

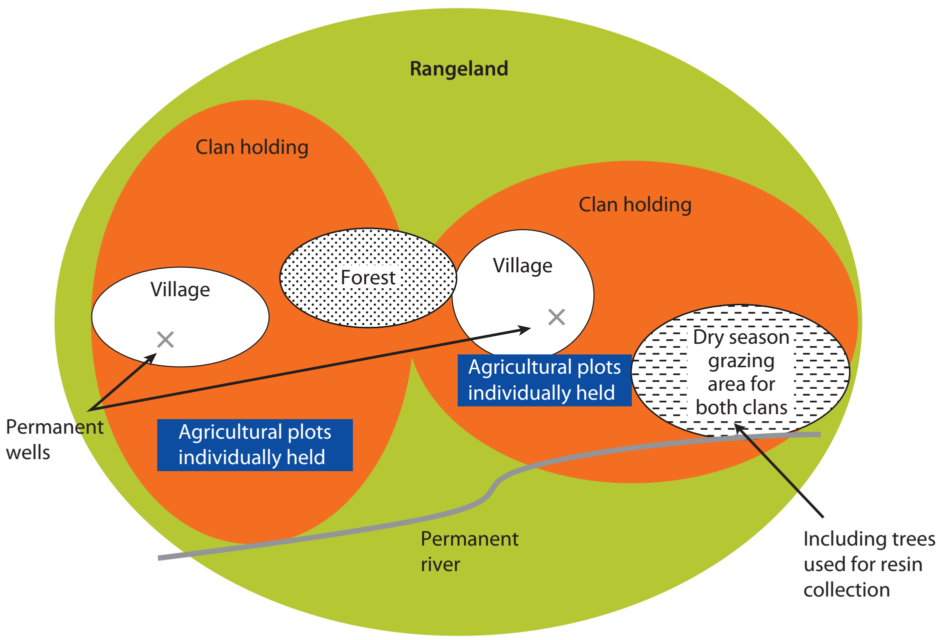
Transhumant corridors, enabling pastoralists' herds to move between wet season and dry season higher-potential areas (valley bottoms, and/or sub-humid savannahs) are an important traditional feature of West African land use. However, arable and agro-pastoral farmers have often encroached on these corridors. Any integrated pastoral development effort should therefore include, through a participatory approach involving all actors, the (re)definition of the exact course of the corridors, and they should be well marked.

Dry season grazing and livestock watering access is critical for sustaining mobility and reducing conflicts. Closing these resources is generally thought to undermine the entire pastoral production system and has been a major cause of conflicts, for example, in the Senegal River valley in 1989–91, and in localized disputes throughout the region (Touré and Wane 2010). For example, about 90 percent of conflicts in Niger are due to dry season crop residue grazing and access

Box 4.1 Natural Resource Governance in Drylands

Key factors to consider in developing supportive policy and legislation for securing pastoral lands include the need to ensure that the complex nature of land use and governance in pastoral lands is accounted and accommodated for (see figure B.4.1.1). This requires a framework that incorporates diversity and is dynamic and flexible, likely an approach that provides for protection of different layers of resource access and governance systems. This could follow an approach where protection is given to a pastoral "territory" based on the larger landscape or rangeland, with customary governance systems taking care of resource governance therein; or it could follow an approach that requires formal governance structures and institutions for each and every layer of access and tenure arrangement.

Figure B.4.1.1 Existence of pastoral territories within a larger landscape



Source: Flintan (2013).

to water (Turner et al. 2007). Delineating special areas for dry season livestock grazing, although at local level politically sensitive, is an important aspect of maintaining mobility that must be included in land use planning.

Related to the dry season grazing access issue is the development of irrigation schemes. Past irrigation schemes involving pastoralists have often failed because of technical problems, a high turnover of pastoralists settled in the irrigation schemes because of cultural preferences for a livestock-based livelihood, and competition for labor (Sandford 2013). Sandford argues that more recently, pastoralist-related private irrigation schemes are becoming successful as the tech-

nical problems have been addressed, cultural preferences are less pronounced, and the increasing poverty and skewedness of herd ownership have favored labor prices in irrigated agriculture. Pastoralist-related irrigation schemes could be important vehicles in the search for alternative income sources and livelihood diversification, where possible, but more evidence is needed.[2]

In this context, it is interesting to consider the economics of converting dry season grazing areas into arable farming zones. Most studies consider only the productivity of the livestock system during the dry season, ignoring its year-round value. This leads in general to favorable economics for the conversion to agriculture. Behnke and Kerven (2013) took a more comprehensive approach in their assessment of the Awash irrigation scheme for the returns to cotton, cane, and livestock, assuming no production for the latter if access to the valley was closed. They found that livestock owners earned about the same net revenue per ha as efficient private cotton farmers (and a much higher net annual revenue than inefficient state cotton farms). Feasibility studies should consider holistically the options in land use policies, particularly for the conversion of key dry season resources, considering the entire production system and annual production cycle.

In summary, integrated land use planning, covering transhumant corridors and key dry season grazing resources, is needed to safeguard mobility. This needs to occur at the national level with enabling legislation and at the intermediate and local levels with actual planning.

Reducing Numbers of Animals in Drylands

The low offtake rate found by some studies (such the 3.3 percent in the Borana long-term recall survey) highlights the need for enhancing market access. A recent International Food Policy Research Institute (IFPRI) study (Headey et al. 2012) argues for a transformation process, particularly by enhancing commercialization through improved infrastructure and pre-drought destocking activities. Pastoralists would be more likely to sell if they could easily restock once the drought ended. While this argument has some merit, especially for pre-drought early offtake, this background paper argues that the offtake is already higher than often assumed, but that there are other functions of livestock such as animal traction, that leave less scope for major increases in offtake.

One particular form of increased commercialization is integration of extensive drylands production systems with more intensive fattening/finishing operations in higher-potential areas. This could reduce grazing pressure on pastoral areas, thereby leading to higher availability of forage resources for remaining animals, reduced need for mobility, and higher flexibility in case of drought. This is a well-known (and logical) theory, although little quantitative data exist. As shown in chapter 5, this would increase herders' income as well as the overall output of red meat in Sub-Saharan Africa (SSA). Stratification of livestock systems, under which drier zones produce feeder animals that can then be fattened in the higher-rainfall and therefore less drought-prone highlands of East Africa or the savannas of West Africa, provides a way of intensifying the pastoral drylands

value chain. Stratification has not worked well in the past at a regional scale, primarily due to limited demand for the higher-quality meat produced through such systems, and the inefficiency of para-statal companies involved in feed lots, for example in Kenya, Nigeria and Côte d'Ivoire. With demand now emerging for higher-quality cuts, new opportunities are appearing. In effect export-oriented private outgrowing operations are already emerging in East Africa, and have been a traditional cottage industry producing for religious holidays in West Africa. Stratification requires the establishment of more remunerative options for pastoralists to invest the revenues of earlier sales, probably combined with insurance, to reduce the importance of the risk reduction function of drylands livestock. For the rest of the chain, what is needed are credit facilities for outgrowers and processors, and the introduction of market-driven quality standards. On a policy level, introduction of grazing and watering fees would be a positive incentive for destocking stock at an earlier age.

In summary, stratification can increase the value added of drylands livestock, increase herders' income, address the demand and supply gap, increase overall efficiency of rangelands, and possibly free up grazing areas for reproductive stock. As such, stratification can be an important tool for reducing exposure and poverty.

Livelihoods Diversification through Development of Alternative Income Sources within Drylands

Seeking alternative sources of income within the drylands is a means of reducing exposure. Income diversification is particularly relevant during times of drought (Homewood et al. 2009; Little et al. 2008; McPeak, Little, and Doss 2011), as it enables households to recover by using income sources not dependent on livestock production. In addition, the poorest pastoralists and those who are exiting livestock production can benefit from selling their labor and from petty trade activities connected to livestock markets. As pastoral livestock production will remain the most viable production opportunity in drylands, efforts to create markets and value addition opportunities linked to the sale of livestock should be encouraged (Aklilu et al. 2013). In West Africa, small-scale or semi-industrial milk value chain development linked to pastoral areas where market opportunities do exist (near urban areas or rural cities) seems to have a significant impact on pastoral livelihoods (Corniaux et al. 2012). As the authors of Common Market for Eastern and Southern Africa (COMESA) Policy Brief 3 (2009) advise, however, diversification is not a panacea; some forms enhance welfare but others can increase risk. Diversification must therefore complement rather than compete with livestock production. Positive diversification examples include activities such as veterinary and input retail supply, post-slaughter livestock processing, and animal fattening, as they keep value added in the pastoral areas. Taking up crop farming, already quite widespread in West and East African drylands, is, of course, another alternative form of livelihood, although one not normally preferred by pastoralists.

McPeak and Little (2014) classified the herder populations from southern Ethiopia and northern Kenya according to their livestock assets and integration in the cash economy. They showed that households with smaller herds and lower cash income had a much lower rate of "bouncing back" to the income and asset resilience threshold, set here at US$0.50 per capita per day, than households with the same herd size per capita that sought other sources of income. A similar trend occurred for households with larger herds [more than 3.5 tropical livestock unit (TLU) per capita]: those households that sought to combine herding with strong involvement in the cash economy recovered to the income and asset threshold much faster than those who stayed in livestock husbandry only. These interesting trends further support the need for diversification of assets and income.

In this context, the potential of payment for environmental services (PES) is worth exploring, particularly if it can provide an income stream that is not so tightly coupled with drought. Pastoral and agro-pastoral lands deliver a number of ecosystem services from which pastoral people currently benefit, both in financial and other terms. These include the provision of fuel wood and other natural products such as gum arabic, the delivery of water and soil health and nutrients to support rangeland production, carbon sequestration, and rangeland forage production as a support function to livestock and wildlife and cultural services, such as tourism. The concept of paying land users to change land management practices to provide "public good" services recognizes that financial incentives are an appropriate mechanism for compensating people for livestock production lost and services provided.

The drylands of East Africa are home to many wildlife species, and livestock and wildlife have long coexisted. Wildlife tourism is a thriving industry that generates considerable income for Kenya and Tanzania in particular. The recognition of this reality, and to avoid competition between livestock and wildlife, has led to creation of a number of different schemes to pay livestock keepers to manage their lands to enable passage and grazing for wildlife. The practices include: reducing livestock stocking density or restricting grazing; maintaining open wildlife corridors and seasonal dispersal areas; controlling poaching of wildlife; protecting natural vegetation; and avoiding fencing or subdividing land (Silvestri et al. 2012). While there is great interest in payments for wildlife conservation, such schemes are still very new and face certain challenges. Successful cases, such as the Wildlife Lease Program south of Nairobi National Park, rely heavily on external payments for the services provided. One drawback of such schemes is the limited ability of land-based schemes to improve the incomes of women (and other landless groups) given that men control most land access. It is also difficult for the schemes to generate revenues that are competitive with other land uses, such as cropping. Furthermore, during droughts when grazing area is scarce, the pressure to move cattle into prohibited areas is difficult to resist.

There is increasing interest in the potential for delivery of climate regulation services, including sequestration or the reduction of emissions from carbon from

soils and aboveground biomass, and management of the incident light or radiation (albedo) reflected from the rangeland surface. For example, the Global Livestock Cooperative Research Program funded by United States Agency for International Development (USAID) has done extensive research in Central Asia and concluded that the Central Asian rangelands, if well managed, could sequester the equivalent of a 30 percent reduction in carbon emissions caused by humans in this area.[3] But more research and piloting is needed in dryland regions of Africa to understand and identify: (i) how much carbon can potentially be sequestered in rangelands; (ii) the incentives necessary for pastoralists to change their management practices to sequester carbon; (iii) markets for carbon sequestration and mitigation of other greenhouse gases (GHG); and (iv) mechanisms for the distribution of benefits, as the land is collectively owned. Furthermore, pastoral people currently lack connections and skills to develop and tap into such markets. Pastoralists manage rangelands to optimize livestock performance, constantly monitoring forage and water conditions. While "co-managing" rangelands for greater carbon sequestration is likely to bring about healthier rangelands, the tradeoffs between providing carbon versus ensuring livestock productivity need to be assessed, especially given the tremendous spatial and temporal heterogeneity of vegetation in rangelands and the other drivers of change. Through the establishment of silvo-pastoral systems in Central America, PES for the contribution to carbon sequestration and enhancement of biodiversity has demonstrated the mutual benefits to farmers and the environment. There, a small payment in line with the international price of carbon was used to "tip the balance," as it increased milk and meat production. This system is now scaled up in Colombia (Ibrahim et al. 2010).

In summary, the search for additional sources of income should be an integral part of any development investment. In this context, PES, although challenging to implement in collectively used rangelands, has the potential for major environmental and social benefits, fits perfectly in the vision of shifting future drylands' use away from only meat and milk production, and deserves much more attention in drylands development than it is currently given.

Livelihood Diversification through Development of Alternative Income Sources Outside of Drylands

Pastoralists (particularly the poorest, who own fewer animals than the minimum needed to be able to regain their pastoral livelihood in the event of a shock) who leave the drylands and take up alternative forms of employment in more favored regions or in urban areas will reduce their exposure to shocks. Outmigration reduces sensitivity to shocks for those who stay as well, as it increases their resources. Outmigration also reduces the exposure of underemployed pastoral youth to criminal activities related to drug trade. This is politically sensitive, however, as central governments generally want to avoid massive migration to big urban conglomerates. However, with the structural poverty now prevailing for drylands livestock keepers (chapter 3), outmigration is unavoidable. To make it

more socially acceptable, it should be accompanied by skills development. Outmigration therefore must be facilitated through training and credit.

For pastoralists who are just at the minimum threshold herd level, livelihood diversification is a good strategy to reduce exposure and sensitivity to different types of shocks. This diversification has been described as increasing in several situations in Africa and elsewhere. For example in Senegal (Manoli et al. 2014), diversification consists of income from activities in trade, crop production, and services (human or veterinary health, salaried activities, or education, for example) but also from financial support from relatives living in urban areas. To improve access to this diversification, it is quite clear that state and local authorities can play an important role through development programs and incentives.

In summary, diversification of income sources must be a cornerstone of any drylands livestock development effort aimed at long-term sustainability and reduction of emergency aid dependence. Diversification is preferably sought within drylands, but in view of the magnitude of drylands livestock-keeping households' needs, it should also be promoted through skills development for those who migrate to urban areas.

All Drylands Livestock Systems

Given the increasing incidence and severity of conflicts and the increasing number of internal and international displacements (de Haan et al. 2014; Schrepfer and Caterina 2014), conflict resolution must be an integral part of drylands development. The focus should be on peacebuilding efforts at multiple levels, from local to regional, as a critical priority. For East Africa, a recent technical brief by Pavanello and Scott-Villiers (2013) discusses some promising examples, noting that the most effective efforts require multi-level action from both citizens and policy makers to create or enhance effective institutions, and demand lengthy processes requiring multiple agreements and actions. Some specific examples include:

- Supporting local or customary institutions, as many pastoral communities have long relied on traditional bodies, particularly councils of elders, to manage conflict. The erosion or the overriding of these traditional bodies by formal governments leaves a vacuum, as communities consider customary institutions by far the most legitimate form of governance. Local institutions are especially important for managing access to key grazing and water reserves during droughts. In 2009, a 6-year process initiated by customary leaders and backed by women and youth and the Kenyan and Ethiopian governments led to the reconciliation of Borana and Gabra communities in the cross-border area. A series of meetings combined state and customary approaches, focusing on more effective governance, ending divisive politics, and increasing social harmony (Scott-Villiers et al. 2011). Somaliland has remained peaceful in spite of ongoing conflict in Somalia through a political order that rests on a combination of customary pastoralist institutions and modern institutions, including councils of elders, which are important for conflict resolution (Boege et al. 2008).

- Focusing on cross-border conflicts, as pastoralists often move animals across ethnic, district, and national boundaries to bring them to market and to find water and grazing areas. Protecting mobility can be complicated by different governance arrangements and political interests on different sides of borders.
- Implementing information and warning systems. The Intergovernmental Authority on Development (IGAD) Conflict Early Warning and Response Mechanism (CEWARN) was established in 2000 with a mandate to receive and share information concerning the outbreak and escalation of violent conflicts in the region, including monitoring loss of life and livestock. A focus on cross-border pastoral conflict was agreed as an entry point. The CEWARN approach focuses on early response and networking and collaboration among all stakeholders. The Rapid Response Fund established in 2009 is intended to assist quick responses to conflicts (through local monitors) and to build local capacities and institutions. One positive reported outcome has been improved information flow, and in several cases information has helped to prompt both state and local responses (Kassa 2011). In 2012, CEWARN's mandate expanded to include political and administrative engagement, a welcome step towards resolving some of the deeper and more intractable drivers of conflict (Pavanello and Scott-Villiers 2013).

Ultimately national and regional policy must support long-term peace and stability. Few national policy examples exist in East Africa, although Kenya developed the National Policy on Peace Building and Conflict Management in 2009. While it offers a holistic framework for interventions and harmonization of policy areas and recognizes customary institutions, it falls short of making clear links to national legal frameworks (Pavanello and Scott-Villiers 2013). At the regional level, IGAD has a very important role in conflict management in pastoral areas, as does the African Union (AU), although interests of individual member states that override their commitment to the regional bodies hamper both. The AU Policy Framework for Pastoralism in Africa was adopted in 2011 and is widely heralded as an important initiative. The document takes a comprehensive approach to supporting peacebuilding in order to develop pastoralism by properly identifying sources of conflict, providing immediate response, supporting traditional conflict management mechanisms, and sensitizing national laws and regulations (AU 2010). A second important document is the AU Framework and Guidelines on Land Policy in Africa, adopted in 2010. This provides a foundation for engaging multiple partners to mobilize resources and capacity to develop and implement land policy (AU-ADB-ECA 2010).

In West Africa, Turner et al. (2011) highlighted the importance of conflict resolution at the local level, noting that the majority of conflicts are already resolved locally. Social networks are therefore very important. However, pastoralists often feel marginalized, torn between informal and formal governance (chapter 3), and have fewer opportunities for "forum shopping" (that is, selecting the most receptive channel for favorable resolution of their complaints) (de Haan et al. 2014). The same authors recommend combining (although not integrating)

pastoral development with enhanced security inputs to stem the increasing violence and criminality. They plead also for inclusive pastoral development, which reduces the mistrust now prevailing, so that pastoralists can become the "eyes and ears" of the authorities entrusted with the security.

In the place of large-scale resource access reform, policy makers need to concentrate on developing procedures for resolving land disputes and on specifying who is entitled to make legal judgments regarding land ownership, how they may legitimately go about doing so, and how these decisions can be enforced (Toulmin and Quan 2000). Support should be given to civil society groups in countries where it is possible to use the courts, national media, and political processes to represent pastoral interests and rural land rights. International forums and funding conditionality can be employed to support the land rights of rural communities when powerful interest groups genuinely obstruct the representation of their interests at national level.

In summary, conflict resolution mechanisms are an essential part of drylands development. They should focus on strengthening local formal and informal levels and seek to treat all actors equitably.

Reducing Sensitivity to Shocks

Grassland and Pastoral Systems

Improving Early Warning and Response Systems

Investments to better monitor the evolution and impacts of droughts have been used for well over two decades in East and West Africa. Their purpose is to track environmental and social indicators that alert governments, donors, and other aid agencies that a drought is unfolding, predict its likely impacts on livelihoods, and hence identify which early response can prevent the drought from becoming a disaster. Early warning systems (EWS) became popular in the 1990s and were noted for improving the quality and transparency of information about impending drought crises.

Problems remain, however, particularly with respect to the timeliness of responses. After each drought since 1999, analyses of why droughts led to crises have blamed the lack of a sufficiently early response and late interventions that focused on saving lives rather than (livestock-based) livelihoods (Aklilu and Wekesa 2002). Issues include: unclear usefulness for the pastoralist and government centered, with a bias toward food aid; monitoring of lagging indicators rather than true early warning; multiple EWSs used by different agencies; and a lack of trust by donors in national data collection. In 2004, the concept of Drought Cycle Management (DCM) became popular as it advised agencies to treat droughts as regular, cyclical events that could be managed with intervention throughout four stages: normal, alert, emergency, and recovery (IIRR/Acacia Consultants/Cordaid 2004). Such a concept was adopted by the World Bank-funded Arid Lands Project in Kenya. Most practitioners now refer to good practice as one that adopts a Disaster Risk Reduction (DRR) approach, and a number of international as well as regional initiatives are devoted to fostering approaches

such as the Hyogo process,[4] a global and broadly focused DRR (although it is too early to assess its effectiveness in reducing pastoralist sensitivity to climate shocks). DRR is also the core of Regional Learning and Advocacy Program (REGLAP), a mainly European Union (EU)-funded project implemented by Oxfam that has a strong learning component.[5]

Some initiatives have shown promise. For example, the Kenya Food Security Steering Group under the World Bank Arid Lands Project, with participation of other donors such as the EU, established to harmonize across donors and agencies, was eventually institutionalized in the Kenya National Drought Management Authority, a public company. Its EWS is decentralized and community based, collecting human, livestock, and production and market (prices) indicators.[6] Early response is prepared at the district level, with defined steps to be taken at each stage of the drought cycle (Swift 2000) and the Livestock Emergency Guidelines and Standards (LEGS).[7] While Kenya's early response performance can certainly be improved, the Authority and its predecessor (the Food Security Steering Group) have improved the decision-making process.

The EWS in Ethiopia is implemented nationally under the Disaster Risk Management Food Security Sector, placed in the Ministry of Agriculture, and gets its livelihood-focused information from district-level task forces. This information is fed into decision-making processes to allocate relief to emergency-affected areas and districts and to help program the use of newly established contingency funds (Fitzgibbon and Crosskey 2013). The Food Security and Nutrition Analysis Unit (FSNAU) monitoring unit for Somalia has been running for 11 years and is known for its comprehensive and high-quality data.

In West Africa, the Information System on Pastoralism in the Sahel (SIPSA)[8] was established in 2002 as a network of institutions and professional organizations (not as a project). SIPSA is technically supported by Cilss-Agrhymet, Food and Agriculture Organization of the United Nations (FAO), and Centre de coopération internationale en recherche agronomique pour le développement, France (CIRAD) and financially supported by regional and national programs. SIPSA provides EWS information and long-term analysis of trends to facilitate decision making (Toure et al. 2013). This network organization, based on existing regional and national programs and institutions, is relatively inexpensive to maintain (expenses total around US$20,000 per year for the whole region) and enables continuity, but is constrained by heterogeneity of efficiency among partners.

In summary, the critical building blocks for an efficient EWS system are: (i) better involvement of communities in the design and implementation of EWS; and (ii) improved timeliness, quality, and sustainability of the early focus and scope of the response. EWSs are largely political and involve donor and government commitment.

Introducing Incentives and Institutions for Rapid Destocking and Restocking

One of the most important early response activities is to give pastoralists access to markets to sell their animals at the onset of a drought. This is still a relatively

new intervention, with limited experience in northern Kenya after the 1999/2000 drought (Aklilu and Wekesa 2002) and a well-documented experience in Ethiopia in 2006 (Abebe et al. 2008). The concept behind destocking interventions is that pastoralists can receive cash for their not yet completely emaciated animals early in the onset of drought, allowing them to purchase food and inputs to maintain their core herd. It is promoted as an intervention to save livelihood assets and to allow pastoralists to receive decent prices for their livestock, as prices always fall when weak animals flood the market. It requires the involvement of private traders, although support is often provided by nongovernmental organizations (NGOs) or governments and hence involves operational complexities. Slaughter destocking, whereby animals are killed and their meat distributed, is another option.

A comprehensive evaluation of the commercial destocking operation in southern Ethiopia in 2006 indicated that the scheme was successful because of carefully negotiated links between traders and pastoralists, as well as the availability of loans to traders for the advance purchase of animals (prior to selling them in the market). Approximately 20,000 animals were sold with a cost-benefit ratio of 1:41 due to subsidized transport mainly and revenue generated by savings from early destocked animals, as the animals sold for good prices. A subsequent livelihoods impact assessment indicated that the cash earned from the livestock sales was a high proportion of household income, used to purchase food for people as well as inputs to protect remaining livestock.

There is little experience with "restocking" of animals after droughts as part of the recovery phase. The LEGS recommend this as a potentially important intervention to kick-start production recovery. In an evaluation of the social impact of a livestock (cattle and small stock) restocking project in northern Kenya, Heffernan, Misturelli, and Nielsen (2001) found that the distribution of livestock often did not result in a return to a pastoral livelihood, but did have a positive effect on social indicators such as school enrollment and food security. Caution is suggested in ensuring that communities are consulted as to the most appropriate type of animals, and commercial restocking is suggested as a mechanism to support the traditional restocking mechanisms already used by pastoralists (LEGS). Targeting to ensure that the distributed stock is not captured by the wealthy is also a major issue. As this intervention is relatively expensive, ensuring adequate compensation for destocking and local markets and social networks for restocking are probably the best options.

In summary, externally supported destocking and restocking as a buffer against shocks can be effective in sustaining pastoral and agro-pastoral livelihoods through a drought. These are likely to be economically justifiable but operationally complex.

Diversifying Livestock Systems with Better-Adapted Species

Identifying species and breeds better adapted to drylands' harsh conditions has not received much formal attention, although this is a principal strategy used by pastoral

livestock producers to respond to pasture availability and market opportunities (Manoli et al. 2014). For example, as seen in chapter 3, the number of small ruminants, particularly goats, has grown much faster than cattle in both regions due to their drought resilience, faster reproductive rate, better adaptation to the increasing shrub encroachment, and booming market prospects for small ruminant meat. Limited empirical and widespread anecdotal evidence suggests that camel trade has become quite lucrative (Mahmoud personal communication), especially the live trade to the Middle East. Livestock survey numbers from Kenya (Said, personal communication) also suggest that the number of camels is increasing, and that camels are being raised in areas such as southern Kenya where previously they were not.

All Drylands Livestock Systems

Vaccination against contagious diseases is often regarded as a public good, because of the existence of spillover benefits (positive externalities) that are not captured by those who pay for vaccination services. This creates opportunities for free riding and leads to socially suboptimal levels of investment in vaccination services. If one herder vaccinates, the risk is reduced that his neighbor's herd will get the disease, so there is less incentive for the neighbor to vaccinate. Yet the consequences of free riding and underinvestment are severe, because an outbreak of the disease can jeopardize the entire sector through export bans (Nin Pratt et al. 2005; Umali, Feder, and de Haan 1992; World Bank 2009a). However, experience shows that government service providers cannot cost-effectively cover sparsely inhabited drylands areas. Outsourcing vaccination services to private service providers, including para-veterinarians who can be engaged at lower cost than fully accredited veterinarians, can increase coverage and drive down costs, as was demonstrated during the successful Rinderpest eradication campaign. This will require: policy dialogue on the distribution of responsibilities between the public and private sector to avoid unfair competition between public and private service providers; performance-based and well-controlled outsourcing contracts to private sector service providers; and facilitation of access to veterinary products through private and associative sector development.

In summary, high levels of immunity to contagious diseases reduce livestock-keeping households' sensitivity to disease shocks (and even drought shocks). Vaccination is a public sector responsibility but a close private-public partnership is needed for it to be efficiently implemented.

Enhancing the Capacity of Livestock-Keeping Households to Cope with Shocks

Introducing Weather IBLI

Livestock insurance recognizes that livestock loss due to droughts is a major risk that shapes the behavior as well as livelihoods of pastoral livestock producers, given that livestock are their main productive asset. Insurance is a mechanism for compensating livestock owners if the predicted livestock mortality or loss of for-

age from a drought threatens to diminish their herds below a critical threshold from which it is hard to regain herd productivity (10–15 TLU per household) (chapters 3 and 5). The insurance system now being tested in East Africa (Index-Based Livestock Insurance or IBLI) is based on the Normalized Difference Vegetation Index (NDVI). This is the best indicator of pasture conditions available across African drylands, and provides an objective means of determining whether drought has occurred, as it is based on a measure of vegetation "greenness." The NDVI is linked to a model that predicts livestock mortality for a given area based on historical data. Beneficiaries receive a payout if the NDVI drops below a threshold that predicts a certain level of livestock mortality (say 15 percent). The insurance (hopefully) prevents households from falling into a "poverty trap" and from having to rely much more on non-livestock-based sources of income (Chantarat et al. 2013).

IBLI was first piloted in Marsabit district, Kenya, in 2010, in partnership with a Kenyan insurer and a local bank, using a product designed by International Livestock Research Institute (ILRI) and Cornell University. Payouts are made if the index predicts that on average more than 15 percent of insured livestock will die. The first payout was made in one division of Marsabit in October 2011, and two more in March of 2012 in different divisions. Coverage is currently being expanded to six districts in northern Kenya. IBLI was initiated in Ethiopia in mid-2012. The attractiveness of IBLI as a way to protect pastoralists is linked to the low transaction costs, as the use of an index makes costly verification of actual deaths unnecessary. Second, it allows for quick payouts and eliminates moral hazard and adverse behavior. Technical issues include the commonly erratic spatial distribution of rain, which, together with the mobility of herds, complicates the identification of beneficiaries, although this is handled by issuing contracts for specific locations. Challenges include the need for long-term historical data to calculate the index and the technical complexity of the product, which needs to be explained to insurers, financiers, and prospective clients. A major issue is the commercial viability of such a new product, coupled with the huge challenges in implementing sales of the product at sustainable levels. While impact assessment of IBLI to date is limited, early results indicate that clients who received payouts in 2011/12 were appreciative.[9]

In summary, the introduction of livestock insurance, although still faced with technical, commercial, and marketing challenges, is promising enough to scale up to larger areas and greater numbers of beneficiaries.

Enhancing Access to Domestic and Foreign Markets

This standard intervention is aimed mainly at domestic markets. Market infrastructure in drylands is often of poor quality, and investments (often from external donors) including improvements in loading ramps, pens for holding animals, weighing scales, etc. are often poorly maintained, and have shown to be unsustainable after external supports stops. In addition, they have often been associated with increased fees (Aklilu and Catley 2009). One of the main reasons for

the lack of sustainability is that municipalities often manage markets and rural slaughterhouses and divert their revenues to other municipal needs. One emerging model is the "co-management" of markets, whereby a formal partnership is established between communities and local councils, ensuring that improvements meet the needs of communities and that communities take responsibility for maintaining the infrastructure (Were 2012). Road improvements, especially along tertiary routes, do stimulate market activity, as transporting animals to markets and road conditions are a major issue for pastoralists, since lorries cannot move along poor roads. Intensification of production can make a difference as well, as shown in Senegal, where a network of big mechanized watering points in the pastoral area of Ferlo since the 1950s has increased human and livestock population density, stimulated the organization of marketing and transportation of goods, and facilitated access to services (Ickowicz et al.2012a; Touré et al. 2013; Wane et al. 2009a).

There are limited abattoirs and cold storage facilities to enable trading in meat products, which is more profitable than live animals. The few located in Kenya and Ethiopia, for example, are located far away from either production sources or ports (Aklilu et al. 2013). Improving activity in secondary or "bush" markets can also improve access for poorer pastoralists, as well as provide a basis for enhancing value addition through the introduction of weight- or grade-based transactions (Aklilu et al. 2013). However, establishment of grades is a private good (no externalities involved) and should be market-driven and -monitored, otherwise it will become subject to rent-seeking by officials (World Bank 2009a).

For the important cross-border trade in both regions, policies should focus on improving security and reducing high transport costs and unfair market practices, as well as informal (illegal) taxes by government officials (COMESA 2009). However, excessive intervention in cross-border trade may result in it going further underground. Moreover the economic importance of the live animal trade (chapter 3) makes regulating these porous borders difficult, and administering these borders is challenging as well as risky (Mahmoud 2010). Stabilizing the borders and supporting livestock trade could have financial benefits, in particular if it would bring security. For example the "Cash against Commodity/Advance Payment" (CAC/AP) arrangement put in place by the Ethiopian government allows safe transit of animals across the border, and has increased camel and cattle trade by more than 400 percent across one corridor alone (FAO 2012). FAO (2012) also recommends a "drought-time" cross-border trade strategy, relaxing government controls and recognizing the flexibility provided by moving animals across borders in times of severe drought, including commercial destocking.

Sanitary and phytosanitary (SPS) standards remain an important barrier to engaging in export trade. The severe effects of an import ban from Saudi Arabia were described in chapter 3. Disease-free zones are not an economically and financially viable option for drylands, where mobility is so important (Aklilu 2008; Little et al. 2010). Another option is to improve compliance with SPS standards. However, this currently requires improvement of quarantine facilities,

as evidenced by recent Foot and Mouth Disease (FMD) related export through Djibouti to Arab Republic of Egypt, as private Saudi Arabian companies control the ports (Little et al. 2010). Joint vaccination campaigns, harmonization of standards, and facilitation of cross-border trade requirements are important regional policy issues already in the programs of regional organizations. For example, COMESA and the Economic Community of West African States (ECOWAS)/West African Economic and Monetary Union (WAEMU) strongly support regional harmonization of SPS standards (Magalhães 2010), but this is constrained by national bureaucratic interests. The regional pastoral projects supported or in the pipeline for funding by the World Bank in East and West Africa, respectively, further support this harmonization. Other nontariff barriers to trade (fiscal policies and asymmetric information flows) are reviewed in the background paper on trade written for the Africa Drylands study.

Sanitary standards are based on keeping the entire country free of a disease, unlike phytosanitary standards, which are based on the safety of products. Towards the end of the last decade, a commodity-based approach was propagated, for example by COMESA and Department for International Development, UK (DfID), to allow trade for meat on the basis of product safety. This approach has, in principle, been accepted by the World Organization for Animal Health (OIE), but beyond some export of deboned beef from foot and mouth disease (FMD) areas, it has not (yet) led to a significant increase of beef from areas with main transboundary, high-risk animal diseases[10] to remunerative markets, and with FMD, there is still uncertainty regarding the safety of the deboned product.

In summary, while some investment in infrastructure improvement for livestock marketing and processing of livestock is needed and useful if embedded in the appropriate institutional framework, most attention in trade development needs to be directed to trade facilitation, including harmonization of regulations.

Establishing Fodder and Feed Reserves

This intervention holds promise. Providing supplementary feed to breeding stock and weak animals is considered best practice (LEGS), and the few impact assessments that exist (Feinstein International Centre 2007) suggest that communities like practices that help save their animals, and pastoralists will spend their own income on fodder (Ickowicz et al. 2012b). Feed transport systems are emerging, in particular in the Sahel even combined with hay making, as in Burkina Faso, although most feed is directed to peri-urban livestock keepers, not pastoral populations. Challenges include: the lack of experience with growing and selling fodder in drylands areas; the lack of appropriate transport and storage; and the need to ensure that communities are involved in the design of fodder interventions. A similar initiative helps pastoral communities maintain the ability to protect and manage traditional dry season grazing areas, which are under threat from degradation, bush encroachment, and appropriation by elites (for example, Kinfe 2011).

Generally speaking, prospects for increasing primary production from rangelands are dim, partly because they are already so efficiently used (chapter 3). A

special approach to increase range productivity is advocated in holistic resource management (HRM), which reports beneficial effects of heavy animal hoof impact (such as provided by herds of wildlife) for a short duration (Keppel 2005). According to this approach, overgrazing is not so much a function of animal numbers, but more of the time the pasture is exposed to grazing. Private farms can easily apply HRM principles on their pastures. HRM methods have often proved unsuccessful in situations of open access of grazing areas, because as soon as a group of pastoralists leaves the grazing area so that it can recover, others herders may use it, hindering the recovery process or even degrading the land. HRM of common grazing areas is therefore only possible if strict and disciplined herding is monitored by a group of people who have secure communal land rights. Limited scientific and economic analysis is available on this approach. In addition, it would apply less to the arid/pastoral areas as the annual grasses of the Sahel and horn are less sensitive to continuous grazing pressure than the perennial grasses of the semi-arid zones.

Fodder production is an option in riverine or irrigation areas that could foster value addition for pastoral producers and provide highly needed income diversification, as well as improve grazing shortages during droughts. There is little documented experience with forage production in drylands, although several projects have worked on this in recent years, as many believe this intervention holds promise. One long-running project is the Rehabilitation of Arid Environments (RAE) trust in Baringo in northern Kenya.[11] RAE has worked in the area to reclaim degraded lands through grass reseeding and establishment of community-based and private grasslands. Some of these also sell grass as fodder to supplement their incomes (Mohammad Said ILRI personal communication). The Kenya Drylands Livestock Development Program (KDLDP) and the Kenya Rural Development Program (KRDP) also promote fodder production in drylands, but there is little solid evidence of the costs and benefits. Essential preconditions for fodder production are credit and a viable seed industry.

Fodder conservation (that is, making hay from high-quality, rainy season natural vegetation to be used as dry season (emergency) feed) is another important measure to enhance households' capacity to cope with shocks for a small part of the herd (lactating female, young cattle), as collective land and reciprocity make large-scale hay harvest difficult. Fodder conservation is becoming increasingly popular; for example, in Burkina Faso, the production of six million bales is foreseen in 2012.[12] Again, this intervention provides alternative income sources to livestock keepers. The provision of (micro)-credit and advice are important components needed to support this activity.

In summary, growing or conserving fodder and improved range management have a place in drylands, although mostly in favorable niches in the landscape.

Strengthening Clinical Veterinary Services

Better clinical veterinary care becomes particularly important after a shock has hit, as reducing mortality among young stock can play a critical role in reducing

losses and ensuring rapid recovery in herd numbers. Mortality in young stock can be reduced through the provision of accessible and affordable clinical veterinary services. Most clinical veterinary services have the attributes of private goods; preferably they are supplied through a network of private veterinarians and para-veterinarians. Community animal health workers (CAHW) should operate with formal recognition, as they are the main providers of services to pastoral populations (Aklilu 2008), and providing services to remote areas is expensive if it relies on fixed point veterinary services (Catley et al. 2004). Ethiopia has legitimized the role of CAHWs (including publishing the "Minimum Standards and Guidelines for CAHW System in Ethiopia") and created private veterinary pharmacies, resulting in improved service provision. CAHWs were important in eliminating Rinderpest from Afar and South Sudan (Leyland et al. 2014). Good progress has been made in West Africa, as reported, for example for Senegal in a special edition of the OIE Technical and Scientific Review (Niang 2004).

Tradeoffs

The interventions described in this chapter are likely to involve number of tradeoffs, especially with regard to efficiency versus equity. For example:

- *Stratification* will favor large herd owners, who can better provide the uniformity and volume of feeder animals, but might further crowd out small livestock keepers.
- *Product differentiation* will benefit larger herd owners who are better equipped to make the investments to meet the stricter standards.
- *Skills enhancement leading to outmigration* will benefit the poorer parts of society, who depend for a larger part on remittances, but it could cause increases in labor costs for larger producers.
- *PES schemes* will particularly benefit larger agro-pastoral households because of the economies of scale involved in the measurement.

Challenges

Efforts to reduce the vulnerability and increase the resilience of livestock keepers will have to overcome a series of challenges. Three prominent ones are described next.

Maintaining Equity

Evidence is accumulating that livestock ownership both in the Sahel Region and in the Horn of Africa is becoming increasingly concentrated. In East Africa, wealthy traders have been increasing their purchases of animals and consolidating stock into large herds (Catley et al. 2004), in the process crowding out many of the small herders who traditionally accounted for the largest share of the market. Absentee ownership by government officials and traders, who manage

their herds with the help of hired herders, has also become more common in the Sahel. Within each of the major systems, worrisome trends have also emerged in gender roles. Both in the Sahel and the Horn of Africa, women have traditionally played an important role in livestock management and have correspondingly benefited from certain dedicated revenue streams. Interventions designed to improve productivity and ensure the sustainability of livestock productions systems therefore need to be designed in ways that do not jeopardize the benefits that have traditionally flowed to women. Chapter 5 provides an assessment of the impact of policies to redress equity (that is, preferential allocation of grazing rights to collectives of smallholders, progressive grazing and watering fees, taxation, etc.).

Improving Governance

Design of effective policies and programs to reduce vulnerability and increase resilience among livestock keepers in the drylands of Africa will be challenged in many countries by the lack of voice of many livestock keepers in the national policy discourse. A relationship of mutual respect and trust needs to be reestablished between many of the groups living in drylands and national governments. Positive signs have been observed in recent months of a renewed willingness to engage in constructive dialogue, as reflected in the commitments expressed in the N'djamena and Nouakchott Declarations. Following up on these important documents with concrete actions will be critical for developing more resilient and stable drylands livestock economies. Of particular importance will be implementation of the "Codes" in West Africa (Toure et al. 2013), now lagging behind due to bureaucracy, and in East Africa the preparation of legislation that better safeguards pastoralists' rights. Some progress has been made with group ranches in Kenya, to be redefined in the new Constitution, Land Policy, and the upcoming Community Land Bill, and more comprehensive progress is under way in Uganda and Tanzania (box 4.2).

Box 4.2 Providing Access Rights to Rangeland Resources in Tanzania

Tanzania provides the most progressive policy and legislation in East Africa, as its Village Land Act (VLA) 1999 requires villages to allocate village land between individual and communal categories, as well as set aside some lands for future use (*akiba*). The first step is for a village to confirm and secure its boundaries by obtaining a village land certificate. Certificates of Rights of Occupancy (customary or granted) are then issued to land users, and land use planning is carried out. In addition, legislation states that villages should produce a "village resource management sector plan" to provide for sharing of resources and movement across administrative boundaries. This can provide a useful tool for legitimizing shared rangelands resources such as grazing areas. Challenges include low awareness and inadequate institu-

box continues next page

Box 4.2 Providing Access Rights to Rangeland Resources in Tanzania *(continued)*

tionalization of the process, conflicts over village boundaries and resources, budget constraints, reluctance amongst district officials to relinquish their own power over land, excessive bureaucracy, and poor skills levels. In addition, pastoralists can often be left out of decision-making bodies and processes, and it remains difficult to control access and use of grazing lands. A provision in the Grazing Land and Animal Feed Resources Act (No. 10, 17(23), 2010) states that grazing land should be protected and secured for pastoralists—providing a set of steps follow including the formation of a Pastoralist Association to whom a defined grazing area can be registered. Regrettably, no data are available on how well the pastoral grazing rights have been respected.

To register village land and produce a village land use plan (VLUP) costs between 12 and 20 million Tanzanian shillings (US$4,000–12,000) per village, or more if there are conflicts over boundaries. This is one of the factors limiting implementation of the VLUP process; only about 1,000 villages of a total of around 8,800 in the country have completed the process. However, a number of ways exist in which costs can be reduced and the efficiency of the process increased, for example, by sharing resources and surveying several villages simultaneously. Though it may not be appropriate to replicate the entire Tanzania process described above, the case provides important experiences upon which other countries can build.

Source: Flintan (personal communication).

Financing Recurrent Costs

Most of the "best bet" interventions described in this chapter (pastoral water resource development, PES, EWSs, animal health services) require recurrent funding that, as experience has shown, cannot be assured in many African countries. To ensure that financial support is sustained over the longer term, development partners will have to be convinced of the international public good character of these investments. While the resources needed to implement the interventions described here may seem significant, the amounts are certainly much smaller than the economic losses caused by drought and civil conflict, combined with the cost of emergency aid spent in the region. Chapter 5 gives a summary of the costs involved.

Notes

1. Several good overviews are available on pastoral development issues in the drylands. For example, the Livestock Emergency Guidelines (LEGS) are an excellent example of up-to-date information and decision tools on livestock-related emergency aid. See http://www.livestock-emergency.net/about-legs/
2. Some studies are underway; for example, see McPeak (2004) for a study in the Senegal River valley (crsps.net/wp-content/uploads/2013/07/McPeak-Syracuse-U-Integrating-Animals-Legumes.pdf)

3. http://crsps.net/wp-content/downloads/Global%20Livestock/Inventoried%208.15/2-1998-3-266.pdf. This comes from a popular piece from the University of California –Davis.
4. http://www.preventionweb.net/english/hyogo/framework/?pid:507&pil:1
5. http://policy-practice.oxfam.org.uk/our-work/food-livelihoods/reglap
6. www.ndma.go.ke
7. http://www.disasterriskreduction.net/drought-online0/documents/detail/en/c/3464/
8. http://www.fao.org/agriculture/lead/themes0/drylands/information0/les-composantes-du-sipsa/fr/
9. More information, with several case studies on: https://livestockinsurance.wordpress.com/category/about-ibli/.
10. The following diseases are in the former list A and their occurrence can preclude import in the countries free of these diseases: Foot and Mouth Disease (FMD), bovine spongiform encephalopathy (BSE), Rift Valley Fever (RVF), contagious bovine pleuro-pneumonia (CBPP), lumpy skin disease (LSD), and bluetongue.
11. www.raetrust.org.
12. http://www.irinnews.org/report/96663/burkina-faso-preventing-conflict-between-farmers-and-herders.

CHAPTER 5

Vulnerability and Resilience in Livestock Systems in the Drylands of Sub-Saharan Africa[1]

Cornelis de Haan and Raffaello Cervigni with Anne Mottet, Giulia Conchedda, Pierre Gerber, Siwa Msangi, Matthieu Lesnoff, Frederic Ham, Erwan Fillol, and Kidus Nigussie

Introduction

Chapters 1–4 clearly showed an urgent need to move the African drylands livestock sector from emergency aid-dependence to a state characterized by more resilience. This chapter seeks to inform policy makers on desirable policy and investment options to enhance the resilience of drylands livestock production systems (LPS) and livestock keepers.

Identification of policy and investment options for livestock systems in dryland regions of Africa is constrained by the lack of analytical framework, as little work has been done to model livestock production, combining the physical (vegetation, feed resources, animal production) and economic (market integration, income, and livelihoods effects) factors associated with these arid environments. This chapter reports on a first attempt to develop and apply such an analytical framework. Its novelty is that it incorporates several modeling tools never before used in an integrated, interactive manner to provide, for a small number of climate and intervention scenarios, quantitative information on feed availability, meat and milk production, household income, and vulnerability in select drylands countries.[2] More specifically for three climate and two intervention scenarios, the analytical framework is used to estimate the number of livestock-dependent households that could be lifted out of poverty by 2030. This analysis therefore consists of three complementary parts and corresponding estimates:

- The livestock population (numbers of cattle, sheep, goats, and camels) that can be fed on available feed resources on a year-round basis with and without mobility;

- The impact of different interventions and climate scenarios on production and greenhouse gas emissions (GHG); and
- Under different scenarios, the number of households that can be expected to meet the resilience level, or conversely, the number of households for which additional (for those who can stay) or alternative (for those are probably exiting or remain extreme poor) sources of income are needed.

Setting the Scene

Models Used

Five simulation models were used to estimate the impacts of the selected climate patterns and interventions on feed balances, livestock production, and household income resilience.

- The *BIOGENERATOR model* developed by *Action Contre la Faim* (ACF) uses the NDVI (Normalized Difference Vegetation Index) and DMP (Dry Matter Productivity) data products collected from Spot 4 and 5 satellites since 1998 (Ham and Filiol 2011). In this modeling exercise the model provides, on a pixel basis, the usable (that is, edible by livestock) biomass data of the natural vegetation of drylands;
- The *Global Livestock Environmental Assessment Model—GLEAM* developed by Gerber et al. (2013) calculates at pixel and aggregate level: (i) data on crop byproducts and crop residues' usability; (ii) livestock rations for the different types of animals and production systems, assuming animal requirements are first met by high-value feed components (crop byproducts if given, and crop residues), and then by natural vegetation; (iii) feed balances at pixel and aggregate level, assuming no mobility at pixel level and full mobility at grazing shed level; and (iv) GHG intensity;
- On the basis of the feed rations provided by GLEAM, the *IFPRI/IMPACT model*[3] developed by IFPRI calculates (in this exercise) the drylands' production of meat and milk and how they will affect overall supply of and demand for these products in the region. By taking the sum of animal production at the national level, the IMPACT model conforms with the boundaries of market exchange and price formation, normally harmonized with the Food and Agriculture Organization of the United Nations (FAO) food production and consumption balances;
- The *CIRAD/MMAGE model*[4] consists of a set of functions for simulating dynamics of animal populations that are categorized by sex and age class. In this exercise, it calculates the sex/age distribution of the four prevailing ruminant species (that is, cattle, camels, sheep, and goats), the feed requirements in dry matter, and milk and meat production; and
- The *ECO-RUM model*, developed by Centre de coopération internationale en recherche agronomique pour le développement, France (CIRAD) under

the umbrella of the African Livestock Platform (ALive), is an Excel-supported herd dynamic model based on the earlier International Livestock Research Institute (ILRI)/CIRAD DYNMOD.[5] The expansion concerns the socioeconomic effects of changes in the herd/flock's technical parameters (return on investments, herder household income, and contribution to its food security).

In addition, the modeling exercise benefitted from the outputs of the *FAO supply/demand* model[6] reported in Robinson and Pozzi (2011) and the livestock distribution data from the Gridded Livestock of the World (GLW) (Wint and Robinson 2007) and its most recent update GLW 2.0 (Robinson et al. 2014).

Figure 5.1 and table 5.1 illustrate how the various simulation models were applied. The top of the diagram shows how feed availability and feed requirements for the animals were assessed—with the combination of the BIOGENERATOR, GLEAM, and MMAGE models and various key datasets. For feed availability, the BIOGENERATOR model evaluated the total biomass from natural vegetative cover on the landscape of the drylands regions, and the

Figure 5.1 Models Used for the Livestock Systems Analysis

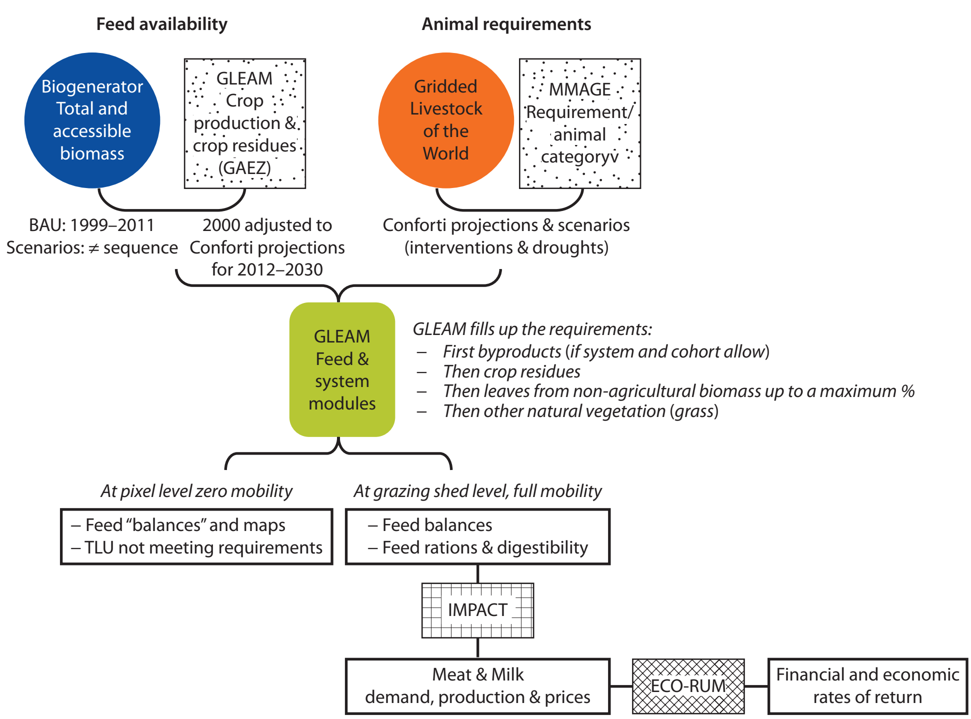


Table 5.1 Outputs of the Models Used in this Analysis

Model	*Feed Availability*	*Feed Requirements*	*Feed Balances and Feed Rations*	*Herd Performance and Animal Production*	*Income, Livelihoods Impacts (Costs and Benefits)*	*Supply, Demand, and Trade of Animal Products*	*GHG Intensities*
BIOGENERATOR	X						
GLEAM	X	X	X	X			X
MMAGE		X		X			
ECO-RUM		X		X	X		
IMPACT						X	

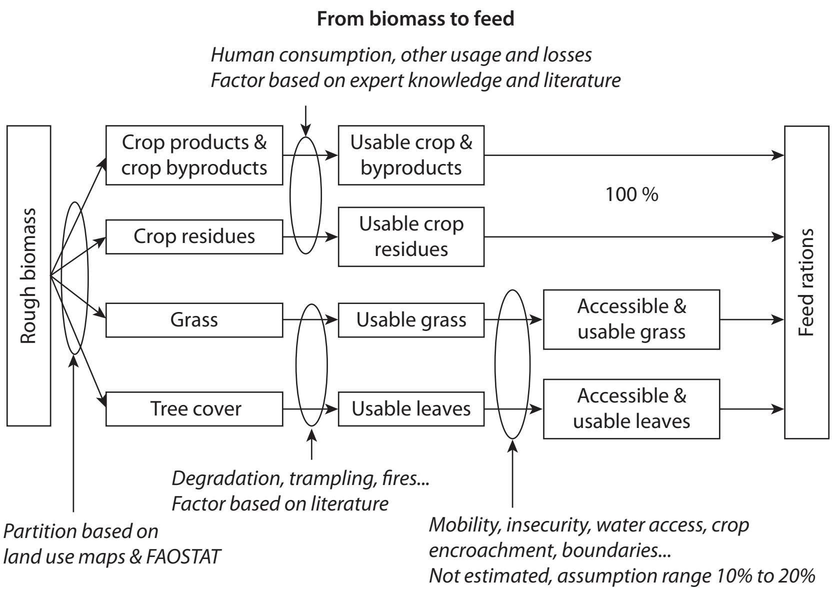
Notes: Cells marked with X show where a particular modeling tool generated an output used in the analysis. BIOGENERATOR provides biomass from vegetative cover. GLEAM provides agricultural biomass and what is usable from crop byproducts and crop residues. GLEAM calculates a feed "basket" for each animal species and category that is consistent with the livestock system type and what is available. GLEAM computes emission intensities within species, systems, and regions for the main sources of GHG along livestock supply chains. MMAGE projects the animal requirements implied by projected herd growth. MMAGE uses production projections to give demographic projections of the herd (age/sex breakdown), and both the implied feed requirements and meat/milk production. ECO-RUM is calibrated to match the herd performance and production trajectory of MMAGE. In addition, it calculates incomes at household level and the costs and benefits of various interventions. IMPACT reconciles supply with country-level demand to generate prices and trade. The results of FAO's Global Prospective Group (Conforti et al. 2011) are used as comparators. GHG = greenhouse gas emissions; GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations.

quantity of the overall total that is usable (that is, edible) to the ruminant animals in those regions. This assessment of feed availability from natural vegetative cover was complemented by the GLEAM model's assessment of feed available from crop residues, grain, and concentrates. These two sources combined were then compared with the assessment of animal feed requirements across the various livestock systems in the dryland region generated by the MMAGE model, as shown on the right-hand side of figure 5.1. The MMAGE model generated a forward-looking projection of animal numbers and production growth that was initially calibrated to FAO's long-term agricultural projections baseline to 2030, generated by Conforti (2011) and Alexandratos and Bruinsma (2012). This baseline was then modified according to the "best bet" intervention scenarios for the livestock sector—that is, improving animal health and adjusting herd demographics (through early offtake of male cattle for fattening in higher-rainfall areas).

Data Sources

Because of its importance in determining the viability of maintaining livestock production in dryland regions over time, major attention is paid to simulating on an annual basis for the 2012–30 period the volume and quality of local feed supplies and the degree to which they are expected to meet animals' requirements under different climatic and investment scenarios. Figure 5.2 provides a flow chart of the conversion of grass, trees, and crop biomass to usable and accessible feed for animals, including:

Figure 5.2 Stages in the Conversion of Drylands Vegetation to Livestock Feed Rations



- *From crops to crop byproducts* (such as cottonseed cake and brans*) and crop residues* (such as straw and stovers). Factors used are provided by GLEAM: the Mass Fraction Allocation and the feed use efficiency provide information for each feed component on the share of dry matter produced that is used for animal feed. Factors for the most common feeds are provided in appendix C.
- *From natural vegetation (trees and grass) to usable feed*, adjusting for losses due to trampling, fire, and poor palatability of standing vegetation. For this study, the usability factor used varied from 50 percent under Sahelian climate (north of 400 millimeter isohyets) to 30 percent under Sudanese climate (south of 600 millimeter isohyets). A progressive variation is set between 400–600 millimeter isohyets, following the annual rainfall quantity. These factors are based on data from the literature (de Ridder 1991; Toutain and Lhoste 1978).
- *From usable to accessible feed*, adjusting the usable feed quantity and quality to the inaccessibility of certain feed resources due to distance to water, conflicts, borders, and the heavy density of crop farms, all of which preclude passage. For example, the maximum distance that cattle can trek to a water point under an every second day watering regime in the dry season is about 25 kilometers (King 1983); any feed beyond this radius has to be excluded from the available feedstock. No data are available, however, on the share of drylands' natural rangelands that are out of this range. Regarding the water constraint, lacking are both a comprehensive overview of underground water sources (boreholes) and quantitative data on the period animals stay in a

particular area (at the pixel level) in the rainy season before they move towards higher rainfall areas. Given this lack of data on the degree of herd/flock mobility (that is, the share of the total year that animals are in any particular pixel), feed balances cannot be calculated at pixel level. Comparing the availability of local feed resources to animal requirements assuming—incorrectly—a complete absence of mobility can, however, highlight the extreme importance of mobility in the arid areas, as nowhere in these areas are local feed resources shown to be sufficient to feed the local animal stocks on a year-round basis. More research is required on the importance of the constraining factors to access eventual unused feed and the amounts available.

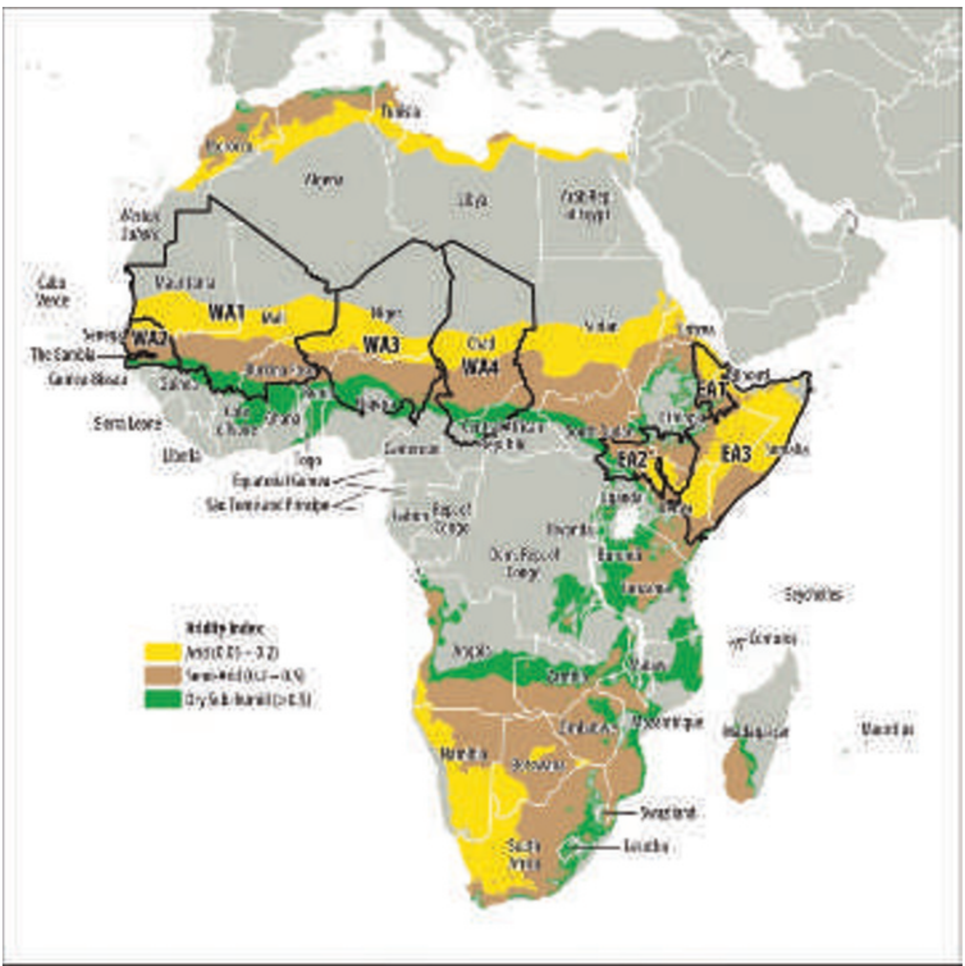
The modeling exercise used the following data:

- A time series of biomass availability was extracted from BIOGENERATOR at pixel level over the period 1998–2013;
- Livestock numbers per pixel assuming no movement outside that pixel were calculated using the GLW;[7]
- Livestock population dynamics for the different species and cohorts (adults, replacement, juveniles) were calculated using MMAGE for the period 1998–2011, using key technical performance parameters (fertility, mortality, milk yields, live-weight, offtake for the different age classes) collected through a major literature review and expert opinions at the Dakar experts' consultation;
- Scenarios for the assessment of future trends (2012–30) were defined as a combination of climatic patterns (no drought, mild drought, and severe drought) and management interventions (health improvement and early off-take of young bulls). The impact of these scenarios on livestock population dynamics was calculated by MMAGE;
- Using MMAGE animal numbers and requirements and BIOGENERATOR biomass availability, GLEAM computed feed requirements and agricultural and natural vegetation per pixel. Assuming no mobility, GLEAM estimates for each scenario the number of tropical livestock unit (TLU) per pixel and livestock production system for which local resources are not sufficient;
- Assuming full mobility of animals and feed resources within each grazing shed, feed rations and feed balances are calculated in GLEAM for each scenario and each production system. Animal requirements are met first by high-value feed components (crop byproducts if given, and crop residues), then by natural vegetation. Feed balances are calculated first in relative terms, using as reference the past sequence 1998–2011, and then in absolute terms assuming a range of 10–30 percent accessibility to natural vegetation[8,9];
- Production, demand, and price estimates for each scenario are provided by IMPACT; and
- ECO-RUM, using the MMAGE livestock numbers, validated with IMPACT outputs and projected meat and milk prices, calculates the financial and economic rates of return.

Level of Analysis

For the calculation of feed balances and feed rations, the definition of a geographical unit to aggregate the pixel-level information on feed availability and requirements received considerable attention. The geographical unit definition was based on animal mobility patterns (transhumance) (SIPSA 2012 and experts' consultation) and consisted of an area that would be self-contained in mobility to a significant degree; that is, used predominantly for transhumance by the same population and herds/flocks each year. These areas were named "grazing sheds" (map 5.1). They exist in a single country or a group of countries, or, where a particular country also covers non-drylands (Nigeria, Ethiopia, Kenya) they are defined by the limits of the sub-humid zones or the highlands. This

Map 5.1 Map of Grazing Sheds in the Drylands of West and East Africa



Source: World Bank based on data from HarvestChoice, IFPRI (2013).
Note: IFPRI = International Food Policy Research Institute; AI = aridity index.

approach enables presentation of areas where, without mobility, large feed deficits occur, whereas towards the higher-potential areas surpluses exists, even under severe drought conditions, thus highlighting the need for mobility or feed transport. Contrary to pixel level, feed balances at grazing shed level assume full mobility of feed resources and animals within each grazing shed.

Scenarios

Climatic Zones and Livestock Systems

As indicated in chapter 2, the Global AI[10] is adopted for the classification of climatic zones.[11] The limits of the different climatic zones are provided in table 5.2.

Livestock production is disaggregated into two main production systems in GLEAM, using the Sere and Steinfeld (1996) classification:

- Pastoral systems correspond to grassland-based systems (more than 90 percent of dry matter fed to animals comes from grasslands and rangelands, and more than 50 percent of household income is from livestock); and
- Agro-pastoral systems correspond to mixed systems (more than 10 percent of the dry matter fed to animals comes from crop byproducts or stubble and more than 10 percent of the total-value of production comes from non-livestock farming activities).

In 2002, Thornton and colleagues spatialized the Seré and Steinfeld classification and produced the first map of LPS for developing countries (Thornton et al. 2002). Land cover and agro-ecological parameters were used as proxy variables due to significant data limitations on the contribution made by livestock to incomes and rural livelihoods at a global scale. In essence, the presence of agriculture from land cover maps is associated with mixed crop-livestock systems, whereas land cover categories such as grasslands and shrub lands are called livestock-only systems.[12]

It is acknowledged that the land cover and climate disaggregation do not fully explain the functional interplay of the systems and actual land uses. In drylands, even otherwise "pure" pastoralists might engage in opportunistic cropping. The analysis at pixel level provides little information on the actual interrelationships

Table 5.2 AI Limits of the Climatic Zones Used in This Analysis

Zone	*AI Limits*
Hyper-arid	< 0.03
Arid	0.031–0.2
Semi-arid	0.21–0.5
Dry sub-humid	0.51–0.65

AI = (Global) Aridity Index.

between cropping and farming activities, for instance on the use of crop residues. However, at the larger scale used for this report, this classification and its spatial representation are considered adequate.

Climate Scenarios

The three different climate scenarios are defined on the basis of the standard deviation in NDVI, used as main proxy for variability in rainfall (Kawabata, Ichii, and Yamaguchi 2001). A simulated vegetation and associated rainfall pattern over the 2012–30 period (figure 5.3) was drawn from standard deviation intervals of the NDVI distribution over the period 1998–2013 as derived from remotely sensed data.[13] Table 5.3 gives the standard deviation intervals of the drought classification used in this analysis.

The three climate scenarios adopted for the livestock modeling exercise are:

- *Stable climate*, extending the known average weather pattern of 1998–2011 to the 2012–30 period;
- *Mild drought*, with 10 years of mild drought, 3 years of average rainfall, and 7 years of good rainfall; and
- *Severe drought*, with 3 years of severe drought, 7 years of mild drought, 3 years of average rainfall, and 7 years of good rainfall.

The health intervention simulates improved access to veterinary and vaccine services for all species and is modeled through changes in the main herd

Figure 5.3 Simulated Precipitation Patterns Used in This Analysis (Severe Drought Scenario)

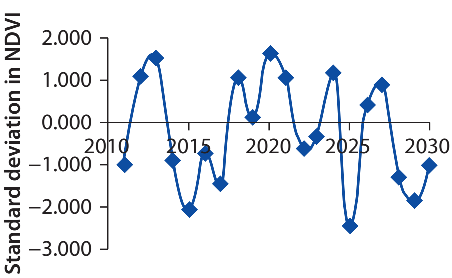
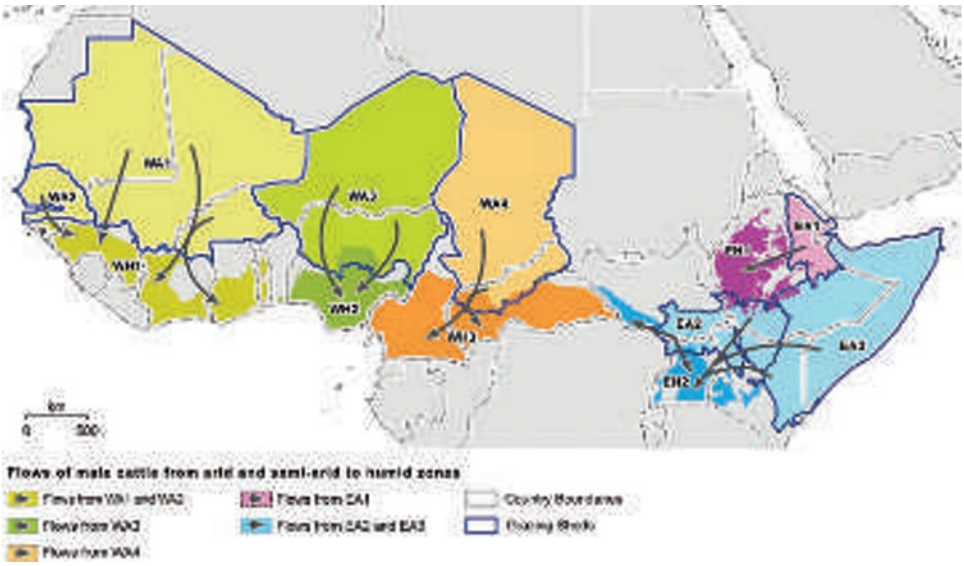


Table 5.3 Standard Deviation Intervals of the Drought Classification Used in This Analysis

Classification	*Sigma Lower End*	*Sigma Higher End*
Very good	2	+ ∞
Good	0.5	2
Average	–0.5	0.5
Mild	–2	–0.5
Severe	– ∞	–2

parameters (fertility and mortality rates). The early offtake models the early exit of young bulls (up to four years old) from herds in arid and semi-arid zones for fattening in areas with higher feed availability (humid areas in West Africa and highlands in East Africa). Based on the Information System on Pastoralism in the Sahel (SIPSA) Atlas and the Dakar workshop, movements were assumed to be as summarized in map 5.2:

Map 5.2 Simulated Movements of Male Cattle from Drylands to Humid Areas for Fattening



Source: FAO. Used with permission; further permission required for reuse.

Note: Simplified from SIPSA Atlas. SIPSA = Information System on Pastoralism in the Sahel.

Table 5.4 MMAGE Results for Animal Population Dynamics (Stock Variation + Offtake) Under Different Scenarios, 2011–30

	West Africa			*East Africa*		
	Cattle	*Goats*	*Sheep*	*Cattle*	*Goats*	*Sheep*
Climate scenario	(%)	(%)	(%)	(%)	(%)	(%)
Baseline	23	42	43	10	34	34
Mild drought	7	11	13	–5	10	10
Severe drought	–7	11	10	–17	9	7
Health intervention production	9	36	29	10	20	12
Impact of early offtake on production within drylands area	3	n.a.	n.a.	6	n.a.	n.a.
(Modeled for cattle only. Early offtake and fattening of sheep and goats in the higher potential area is technically not feasible.)						

Source: Dakar Consultation CIRAD Mega Literature Review.
Note: n.a. = not applicable. Above inputs specifically prepared for this study and are unpublished. Results on increased production in higher-potential areas (humid areas and highlands) due to fattening of additional young bulls are in table 5.8 and section Macroeconomic Implications. CIRAD = Centre de coopération internationale en recherche agronomique pour le développement (France).

Biophysical Modeling

Livestock Population Dynamics

Results of population dynamics from MMAGE are presented in table 5.4. Cattle population growth rates are significantly affected by severe drought (–7 percent and –17 percent, respectively, in West Africa and East Africa) and by mild drought (–7 percent and –5 percent), though to a lesser extent. Small ruminants appear to be less affected by drought in both regions.

Health interventions result in increased animal numbers for production (stock variation + offtake) in both regions, and are more efficient for small ruminants. These results are consistent with the greater prevalence of animal health improvement campaigns for small ruminants (sheep deworming, for example) than for cattle.

Feed Availability, Animal Requirements, and the Need for Animal Mobility

The main results on the variability of feed availability and animal requirements are summarized in table 5.5 and in Tables F.1–F.3 in appendix F. The baseline is illustrated in map 5.3. Maps for other scenarios can be found in appendix D.

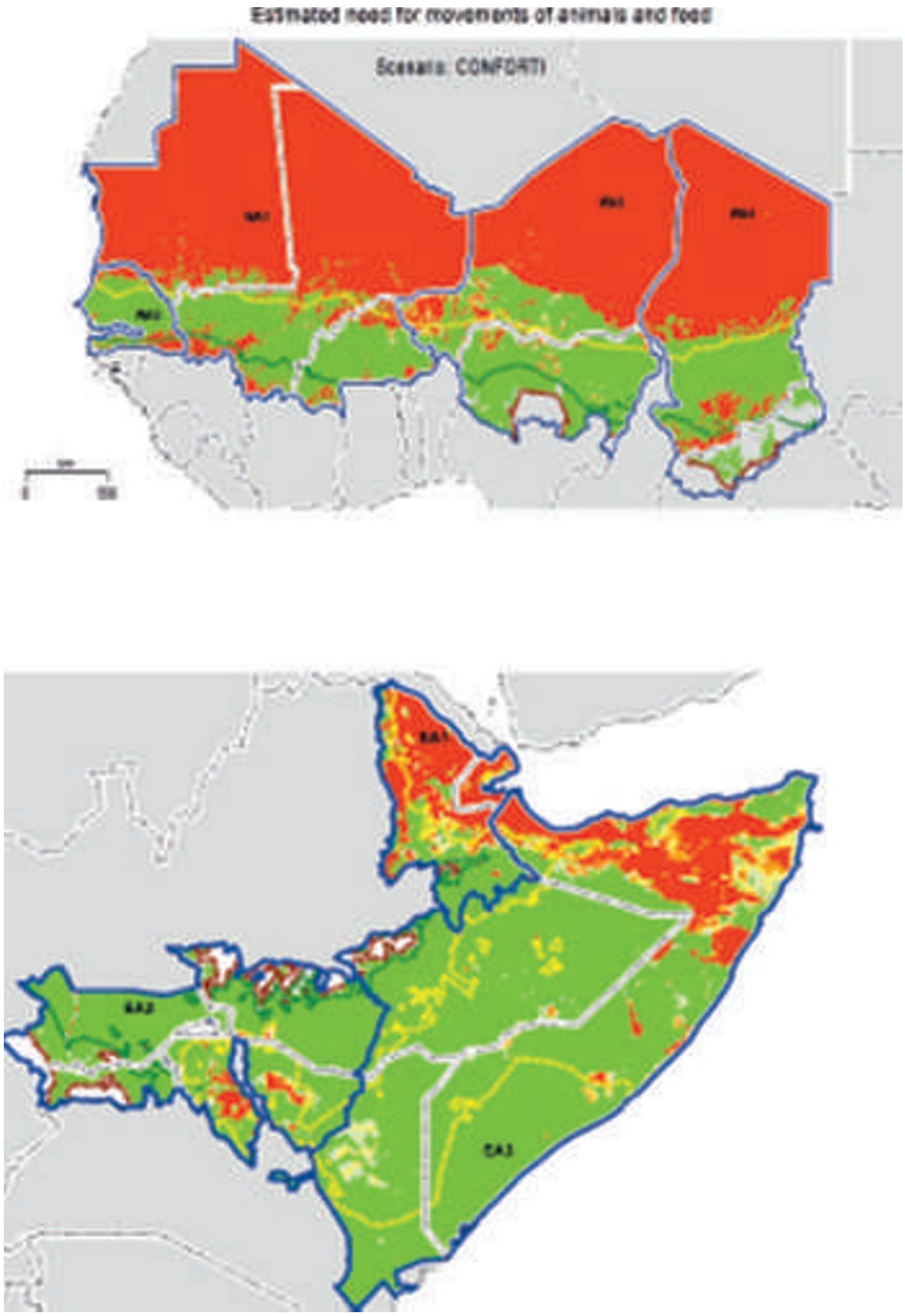
As expected, drought events increase the proportion of animals located in areas where local resources are insufficient to meet their requirements. Likewise, the share of TLU for which local feed resources are insufficient to meet the animal

Table 5.5 Effects of Droughts and Interventions on Feed Availability and Animal Requirements, No Movement of Animal or Feed, 2012–30

	Past Sequence	*Baseline*	*Mild Drought*	*Severe Drought*	*Mild Drought Plus Health*	*Severe Drought Plus Health*	*Severe Drought Plus Health Plus Early Offtake of Males*
West Africa arid (AI 0.03–0.2)							
TLU (million)	20.5	27.9	26.6	24.4	28.7	26.2	24.8
TLU in deficit area (%)	2.7	20.2	22.9	22.5	23.5	23.8	24.3
West Africa semi-arid (AI 0.21–0.5)							
TLU (million)	24.1	31.9	30.3	27.5	33.0	30.1	28.0
TLU in deficit area (%)	2.7	6.6	9.3	11.0	13.1	16.2	13.0
East Africa arid (AI 0.03–0.2)							
TLU (million)	32.3	39.6	37.9	35.9	40.9	38.7	37.6
TLU in deficit area (%)	14.6	18.9	20.9	25.3	22.1	26.9	28.3
East Africa semi-arid (AI 0.21–0.5)							
TLU (million)	42.1	49.3	47.1	43.3	49.9	45.9	43.5
TLU in deficit area (%)	9.4	10.4	10.0	12.2	10.7	12.5	10.9

Source: Based on data from FAO/GLEAM.
Note: GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations; TLU = tropical livestock unit; AI = (Global) Aridity Index.

Map 5.3 Spatial Modeling of the Estimated Need for Movement of Animals and Feed in the Baseline and the Drought + Health + Offtake Scenarios in West African Grazing Sheds



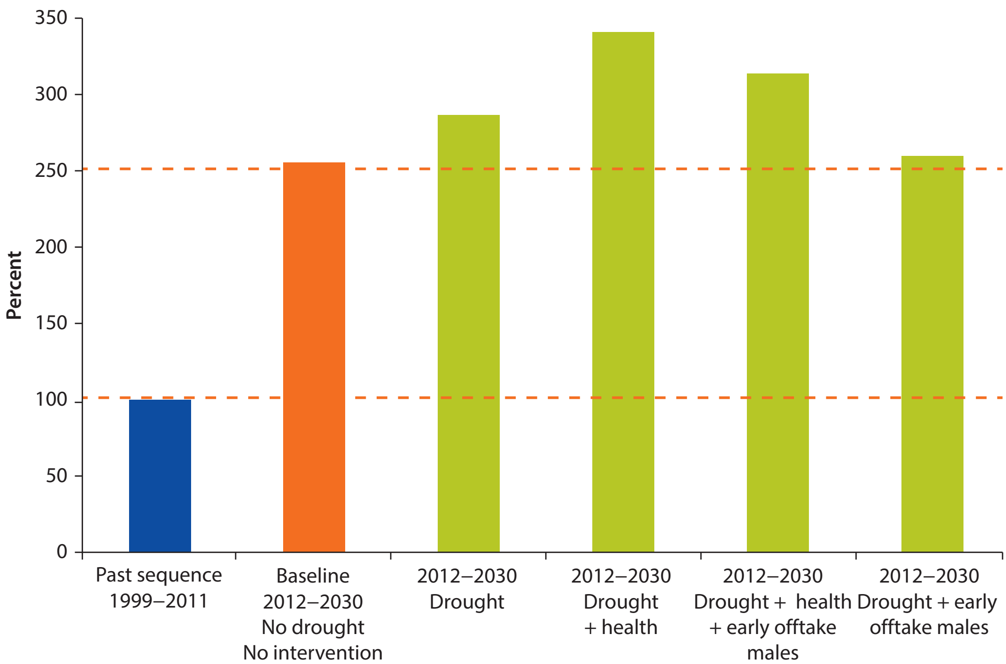
Source: FAO/GLEAM.
Note: GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations.

requirements increase with health interventions due to the relative improvement in fertility and mortality rates and thus in overall animal numbers compared to the same climatic scenarios without intervention. In West Africa, health interventions increase the share of TLU for which local resources cannot meet requirements without mobility of animals or feed by 4 percent in arid zones and 20 percent in semi-arid zones. A similar decrease is observed in East African drylands. There is little difference between the zones in the health intervention effect.

Map 5.3 reveals specific areas where local resources do not meet animal requirements, that is, where there is a need for mobility of animal or feed, for the baseline and for the drought plus health plus early offtake scenario. This can support the targeting of intervention for increased feed accessibility. Maps for the other scenarios can be found in the technical report.

The relative merits of the different policies to reduce feed deficit are summarized in figure 5.4 for the drylands of West Africa and East Africa. The index of animals in deficit of local resources (on average for 2012–30) measures the TLU located in areas where feed resources are insufficient, using the sequence 1998–2011 as the baseline (=100). Values above 100 indicate an increased need for mobility compared to the past sequence to close the feed gap. In case of a severe drought in the future, early offtake of male cattle would bring the index of animals in deficit close to a "no intervention" scenario, whereas adding health improvements would only worsen the feed deficit.

Figure 5.4 Index of Animals in Deficit of Local Resources, West and East Africa, 2012–30



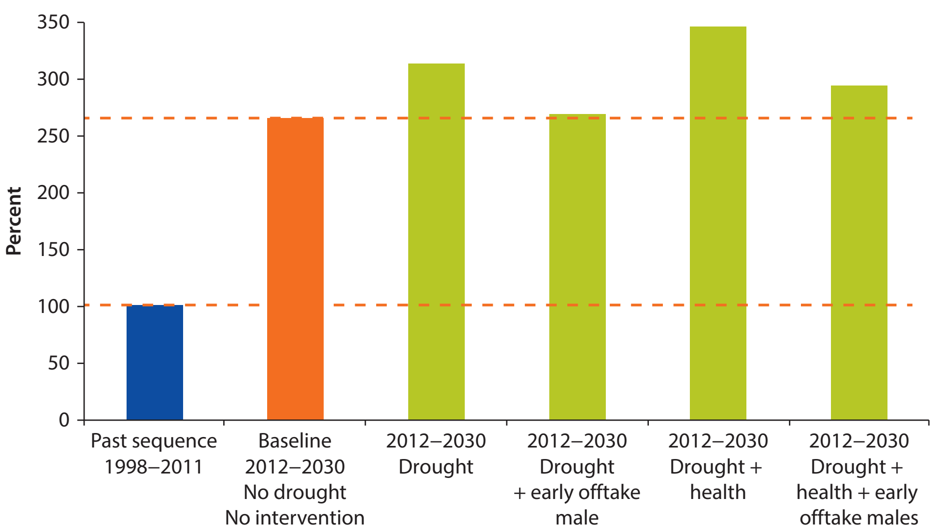
Feed Balances and Feed Rations at Grazing Shed Level

Feed balances were calculated assuming full mobility of animal and feed within grazing sheds. Since little information is available on natural vegetation accessibility, the results are expressed: (i) in relative terms by comparing the average annual balance of each 2012–30 scenario to the balance of the past sequence of 1998–2011; and (ii) in absolute terms by assuming a range of 10–30 percent accessibility to natural vegetation. Relative balances per grazing shed and feed component are presented in appendix E and summarized in figure 5.5.

In the whole of the drylands, the feed balance assuming full animal and feed mobility within each grazing shed would increase from 6 percent of the usable biomass under the past sequence to 15 percent under the future baseline scenario; that is, a 2.5-fold increase. These projections of animal populations and crop production, without drought or interventions, predict the use of about 2.5 times more usable biomass than in the past.

In the severe drought scenario, livestock would use three times as much usable biomass as in the past, whereas adding an early offtake of males results in the same balance as in the baseline without drought. The highest balance is with drought + health intervention, which results in both a decreased amount of usable biomass and an increased number of animals compared to drought only: this scenario results in a use of 3.5 times as much usable biomass than in the past.

Figure 5.5 Feed Deficit Assuming Full Animal and Feed Mobility within Grazing Sheds, East and West Africa Drylands, 2012–30



Source: FAO/GLEAM.
Note: GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations.

Results of absolute feed balances (summarized in table 5.7; details per grazing shed are in appendix F) indicate that resources seem to be sufficient in all scenarios starting with 20 percent accessibility to natural vegetation. With only 10 percent accessibility to natural vegetation, the deficit in feed reaches 4 percent in the drought + early male offtake scenario. Given the assumptions on feed baskets, the absolute feed balances also seem to reveal an excess of crop byproducts in West Africa. This reflects the fact that a significant share of usable byproducts produced in the area is exported to peri-urban areas, as confirmed during the Dakar workshop.

Results also indicate that the earlier assumptions on the contribution of crop residues to the feed baskets in West Africa may have been too low, since an excess of crop residues was observed in most grazing sheds of West Africa. This was corrected and all crop residues accessible were modeled as consumed, as reported in table 5.6.

Table 5.6 Feed Balances Assuming Full Mobility and 10–30 percent Accessibility to Natural Vegetation

		Balance Accessibility 10%	*Balance Accessibility 20%*	*Balance Accessibility 30%*
Past reference	Crops + byproducts	100	100	100
	Crop residues	100	100	100
	Natural vegetation	95	85	75
	Total	95	85	74
Baseline	Crops + byproducts	46	46	46
	Crop residues	100	100	100
	Natural vegetation	106	96	86
	Total	101	91	82
Drought	Crops + byproducts	56	56	56
	Crop residues	100	100	100
	Natural vegetation	109	99	89
	Total	102	93	83
Drought plus male offtake	Crops + byproducts	39	39	39
	Crop residues	100	100	100
	Natural vegetation	108	98	88
	Total	99	90	81
Drought plus health	Crops + byproducts	62	62	62
	Crop residues	100	100	100
	Natural vegetation	111	101	91
	Total	104	95	85
Drought plus health plus male offtake	Crops + byproducts	39	39	39
	Crop residues	100	100	100
	Natural vegetation	109	99	89
	Total	101	91	82

table continues next page

Table 5.6 Feed Balances Assuming Full Mobility and 10–30 percent Accessibility to Natural Vegetation *(continued)*

		Balance Accessibility 10%	*Balance Accessibility 20%*	*Balance Accessibility 30%*
Mild drought	Crops + byproducts	61	61	61
	Crop residues	100	100	100
	Natural vegetation	109	99	89
	Total	102	93	84
Mild drought plus health	Crops + byproducts	68	68	68
	Crop residues	100	100	100
	Natural vegetation	111	101	91
	Total	105	95	86

Source: FAO/GLEAM.
Note: When there are not enough usable crop byproducts, the balance is 100 percent and the remaining requirements are added to those in crop residues. When there are not enough usable crop residues, the balance is 100 percent and the remaining requirements are added to those in natural vegetation. When there is not enough natural vegetation, the balance is > 100 percent, indicating a deficit in feed. GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations.

The detailed balances per grazing shed (appendix F) indicate that WA1[14] (Mali, Mauritania, and western Burkina Faso) and EA1&3 ((northern) Ethiopia and Somalia) are the areas where most deficit can be found.

In the early-offtake-of-males scenarios, male cattle were modeled to be fattened for approximately four months on a basic feed ration of brans, cakes, molasses, and crop residues. In West Africa, the modeled ration was 75 percent crop residues and 25 percent byproducts and fodder crops. In East Africa, the modeled ration was 50 percent crop residues and 50 percent byproducts and fodder crops (Abate et al. 2012; Drabo 2011; Sidibé 2006; Mlote et al. 2012). Table 5.7 presents the summary of outputs by grazing shed.

Though the early offtake of males significantly reduces the pressure on feed resources within drylands, the impact on humid areas is quite high. It results in additional requirements ranging from 4 to 7 percent in most fattening areas, given the assumptions made on the animals' fattening rations. The impact on crop byproducts is higher, around 15 percent of availability in the humid zones. In fattening area EH2 (humid areas of South Sudan and Kenya), fattening bulls from the drylands of East Africa would use about one-quarter of local agricultural biomass.

Total meat production and dry matter requirements for the different scenarios are presented in table 5.8 for all species, including the increase in meat supply due to males fattening in humid areas. Whereas drought reduces average annual meat production by 14 percent in drylands, health interventions seem to restore the baseline level of production while early offtake of males increases production by 5 percent. Coupling male early offtake and health intervention results in a 20 percent increase in average annual meat output. But this scenario requires an additional 7.1 million metric tons (MT) of biomass from humid areas, as modeled in this study.

Table 5.7 Outputs by Grazing Shed for Early Offtake Scenarios

	Drought + Male					*Drought + Health + Male*				
	WH1	*WH2*	*WH3*	*EH1*	*EH2*	*WH1*	*WH2*	*WH3*	*EH1*	*EH2*
Extra male cattle (1,000 head)	1,473	1,621	515	950	2,703	1,541	1,713	549	1,005	2,883
Initial live weight (kg)	297	297	297	264	264	297	297	297	264	264
Daily intake crops + byproducts (kg DM)	2.0	2.0	2.0	3.7	3.7	2.0	2.0	2.0	3.7	3.7
Daily intake crop residues (kg DM)	6.1	6.1	6.1	3.7	3.7	6.1	6.1	6.1	3.7	3.7
Use of usable agricultural biomass	5%	4%	6%	7%	24%	5%	4%	6%	7%	23%
of which crops + byproducts	16%	14%	14%	17%	67%	17%	14%	15%	16%	63%
of which crop residues	4%	3%	5%	4%	8%	4%	3%	5%	4%	14%
Modeled Daily Weight Gain (DWG)(kg/day)	1.0	1.0	1.0	0.6	0.9	1.0	1.0	1.0	0.6	0.9
Modeled live exit weight (kg)	415	416	415	338	376	415	416	415	338	376
Modeled extra meat (1,000 MT carcass weight)	287	317	100	151	478	301	335	107	160	510

Source: Based on data from FAO/GLEAM.
Note: GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations; MT = metric ton; DM = dry matter.

Table 5.8 Outputs for the Different Intervention Scenarios Compared to Baseline

Scenarios	*Production*	*Fattened Males*	*Productivity (Animals Sold per 1000 TLU)*	*Dry Matter Requirement Drylands*	*Extra Dry Matter Requirements Humid Areas*	*Total Meat Production Drylands*	*Total Meat Production Incl. Fattened Males*
Baseline (Conforti 2011)	37 million TLU	–	25%	428 million t	–	4.4 million tcw	4.4 million tcw
Drought	–14%	–	–2%	–26%	–	–14%	–14%
Drought plus health	1%	–	6%	–4%	–	1%	1%
Drought plus male offtake	–26%	7.7 million TLU	13%	–27%	6.8 million MT	–26%	5%
Drought plus health plus male offtake	–12%	9.3 million TLU	25%	–21%	7.1 million MT	–12%	20%
Mild drought	–8%	n.a.	–3%	–4%	n.a.	–8%	–8%
Mild drought plus health	7%	n.a.	4%	3%	n.a.	7%	7%

Source: Based on data from FAO/GLEAM.
Note: n.a. = not applicable. GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations; TLU = tropical livestock unit; MT = metric ton; tcw = ton carcass weight.

These results indicate that at the grazing shed level, there seems to be enough biomass to enable livestock sector growth (independent of the livelihood criteria introduced in section Macroeconomic Implications)—about 60 percent compared to the past sequence in the drought + health + early offtake of males scenario—if it can be made accessible to livestock. Nevertheless, the situation appears more critical in three of the seven grazing sheds: Mauritania and Mali (WA1), northern Ethiopia (EA1), and Somalia (EA3).

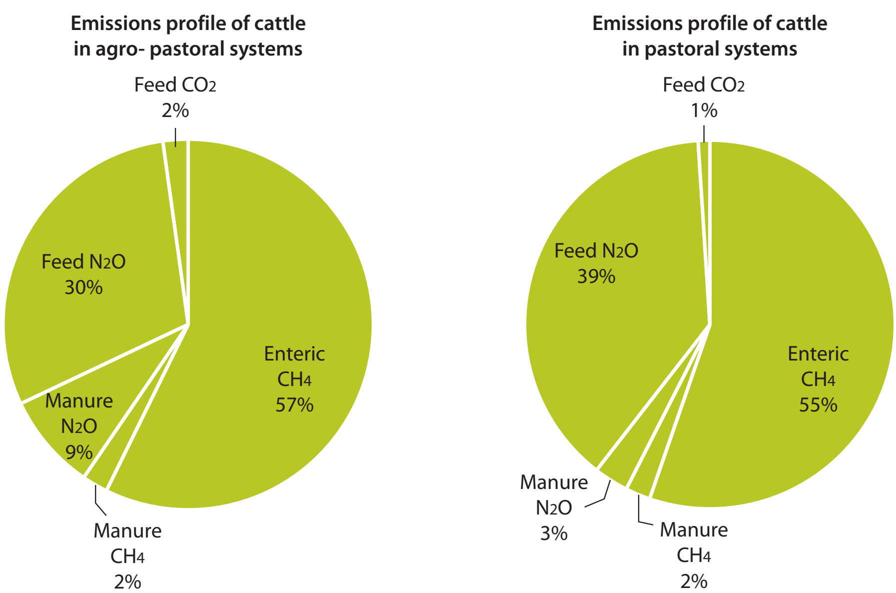
GHG Intensities

Greenhouse gas emissions from livestock production in the drylands were computed in GLEAM. GLEAM uses IPCC (2006) Tier 2 methodology to calculate emissions from enteric fermentation and manure management. In this assessment, using a lifecycle assessment approach, GLEAM considered two main groups of emissions along production chains. Upstream emissions include those related to feed production, processing, and transportation. Animal production emissions comprise emissions from enteric fermentation, manure management, and on-farm energy use. The model covers emissions of methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O). GLEAM's structure consists of five main modules: herd, manure, feed, system, and allocation.

Total GHG from ruminants in African drylands are estimated to reach 1.15 million MT per year as an average over the baseline scenario. Emissions from cattle represent 90 percent of the total (from 78 percent in the grazing shed of Somalia and southern Ethiopia to 97 percent in the grazing shed of Chad).

Enteric methane is the most important source of GHG, accounting for 55 percent of total emissions in pastoral systems and 55 percent in agro-pastoral systems (figure 5.6). This share reaches 66 percent in the pastoral systems of Somalia, Ethiopia, and South Sudan. The second most important source of emissions is N_2O from feed production (deposition or application of manure on crop fields and pastures and crop residue decomposition). It accounts for 41 percent of emissions in pastoral systems and 32 percent in agro-pastoral systems.

Figure 5.6 GHG Profiles for Cattle by Production System, SSA Drylands



Source: Based on data from FAO/GLEAM.
Note: SSA = Sub-Saharan Africa; GHG = greenhouse gas emissions; GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations.

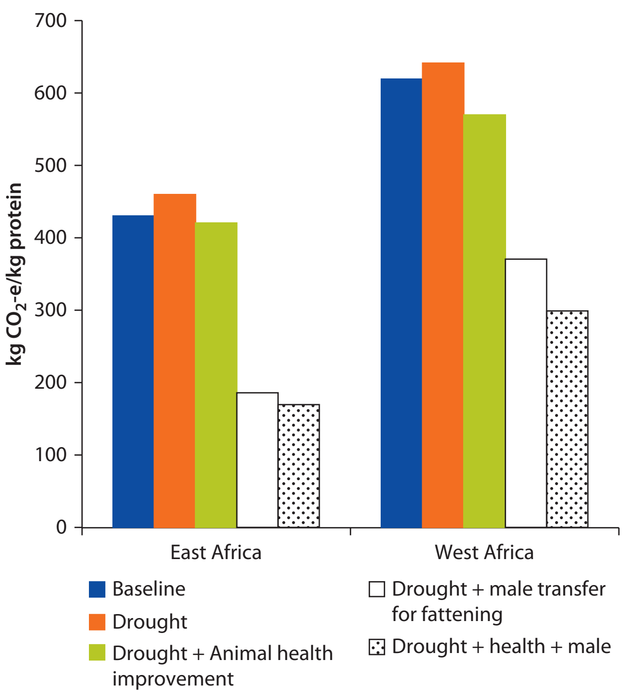
In the baseline scenario, emission intensities range from 423 to 667 kilograms CO_2-e per kilogram protein (figure 5.7). This variability reflects the composition of the ruminant herd and the different levels of milk production: in grazing sheds where milk production is important, total emissions are allocated to a higher amount of protein produced (in Ethiopia but also in Senegal, for example).

Emission intensities are increased by drought. Health interventions tend to reduce emission intensities in all grazing sheds since they reduce mortality rates and therefore the unproductive overhead feed consumption of the herd. But the most significant scenario in terms of GHG reduction is from early offtake of males: males fattened in higher-potential areas have a lower emission intensity than those in drylands since they receive higher-quality feed and are slaughtered at a heavier weight.

Macroeconomic Implications

Supply and demand of meat and milk produced in the drylands of Africa, as well as their prices, differ under the various scenarios. The IMPACT model was used to explore the likely impacts of some of the scenarios on key macroeconomic

Figure 5.7 GHG Profiles for Cattle by Intervention Scenario, SSA Drylands



Source: FAO/GLEAM.
Note: SSA = Sub-Saharan Africa; GHG = greenhouse gas emissions; GLEAM = Global Livestock Environmental Assessment Model; FAO = Food and Agriculture Organization of the United Nations.

parameters. The IMPACT model is a global model that calculates supply, demand, and trade at the national level. As such, it aggregates over some of the subregions of the West and East African countries that fall into the "dryland" categories to calculate the overall country-level market balance and trade with the rest of the world. In the case of Africa, each country is individually represented in the model, with some subnational disaggregation—although this does not necessarily coincide with the drylands boundaries.[15] For the purposes of this study, the definition of LPS was aligned to match those used by the other models, such as GLEAM.[16] IMPACT uses the changes in livestock numbers simulated by the MMAGE model and calculates the corresponding changes in per animal productivity according to the variation in feed availability calculated by GLEAM. The resulting changes in prices, country-level trade, and country-level demand for livestock products are therefore affected by these scenario-based changes in supply, as shown below. Results for meat supply, demand, and prices are shown in table 5.9. Results for milk are shown in table 5.10. The results are reported in terms of five-year averages taken over the yearly simulation results of the model.

These results show that drought has the expected effect of dampening the supply of both meat and milk in West and East Africa. The resulting price changes are quite small under these scenarios—making the changes in demand seem much smaller than the changes occurring on the supply side. This is due to the fact that all livestock products are modeled as being tradable on the international market, which makes the effects observed at the country level relatively small with respect to the size of the wider market. Therefore, the scenario-driven changes in supply are mostly translated into changes in the net balance of supply over demand (that is, net exports) in each region. This means that trade dampens the impacts of these scenarios, which is not always applicable to subregions of the countries where drylands are found. This points to an aspect of IMPACT's structure (as a global rather than a regional model) that may understate the real impact of these scenarios.

Both West and East Africa have a negative net balance (deficit) for meat that increases under the drought scenario and returns closer to the baseline with the health intervention. In the case of milk, East Africa has a positive net balance (that is, a surplus) that decreases under the severe drought scenario, but still remains positive overall. West Africa, by contrast, maintains a net negative balance of milk that becomes slightly more negative under the drought scenario. While in principle East Africa could supply West Africa in dairy, transport and technical barriers probably mean that both regions will have to continue to rely on external suppliers.

In these scenarios, growth in population and income, the main drivers of demand for livestock products, are held constant, so all of the impacts shown are driven by supply-side shocks.

Table 5.9 Impact of Different Scenarios on Meat Supply/Demand, 2006–11 and 2026–30

	Average Annual Red Meat Demand 2006–11 (Million MT)	*Average Annual Red Meat Supply 2006–11 (Million MT)*	*Net Annual Average Balance 2006–11 (Million MT)*	*Average Meat Price 2006–11 ($/MT)*	*Average Annual Red Meat Demand 2026–30 (Million MT)*	*Average Annual Red Meat Supply 2026–30 (Million MT)*	*Net Annual Average Balance 2026–30 (Million MT)*	*Average Meat Price 2026–30 ($/MT)*
West Africa drylands areas								
Baseline	1.57	1.30	–0.27	1,685	3.58	2.82	–0.76	2,133
Severe drought	1.57	1.29	–0.28	1,685	3.57	2.64	–0.93	2,140
Severe drought plus health intervention	1.57	1.29	–0.27	1,686	3.57	2.65	–0.92	2,143
East Africa drylands areas								
Baseline	1.92	1.54	–0.37	1,622	4.23	3.28	–0.95	2,043
Severe drought	1.92	1.56	–0.36	1,623	4.22	3.20	–1.02	2,049

Source: IMPACT model.
Note: MT = metric ton.

Table 5.10 Impact of Different Scenarios on Milk Supply/Demand, 2006–11 and 2026–30

	Average Annual Milk Demand 2006–11 (Million MT)	*Average Annual Milk Supply 2006–11 (Million MT)*	*Net Annual Average Balance 2006–11 (Million MT)*	*Average Milk Price 2006–11 ($/MT)*	*Average Annual Milk Demand 2026–30 (Million MT)*	*Average Annual Milk Supply 2026–30 (Million MT)*	*Net Annual Average Balance 2026–30 (Million MT)*	*Average Milk Price 2026–30 ($/MT)*
West Africa drylands areas								
Baseline	3.54	2.5	–1.04	153	7.22	4.41	–2.81	159
Severe drought	3.54	2.44	–1.1	153	7.21	4.1	–3.11	159
Severe drought + health intervention	3.54	2.46	–1.07	153	7.21	4.11	–3.1	159
East Africa drylands areas								
Baseline	12.17	16	3.84	149	19.57	24.18	4.62	154
Severe drought	12.16	15.74	3.59	149	19.52	23.25	3.73	154
Severe drought + health intervention	12.16	15.79	3.63	149	19.52	23.24	3.72	154

Source: IMPACT model.
Note: MT = metric ton.

Table 5.11 Summary of Definitions and Assumptions Used in the Livelihoods Modeling

	Definitions					
	Source	*Values Used*				*Comments*
Resilience level		Average US$1.25 per capita per day over 2011–30 period				
Income from livestock		70% in pastoral households; 35% in agro-pastoral households				Outside source of income in line with literature
Interventions tested		Health improvement of all stock except camels and early offtake for fattening of male cattle outside drylands				
Climate scenarios included		Baseline (no drought) and severe drought (3 years with –2 times standard deviation (Δ and 7 years with –1 Δ precipitation)				
Countries covered		Burkina Faso, Chad, Ethiopia, Kenya, Mali, Mauritania, Niger, northern Nigeria, Senegal, and Uganda				Selection based on data availability
Livestock systems and agro-ecological zones		Arid equals pastoral system (more than 50% income from livestock and 90% of feed from range) and semi-arid and sub-humid equal agro-pastoralism (less than 50% income from livestock and at least 10% of feed from crop residues)				
Drivers, assumptions, and values used						
Population growth	UN and World Bank	3% per year pastoral population and 2.5% per year for agro-pastoralists; household size of 6				Driven by fertility and GDP growth/exit correlation
		Baseline weather scenario (TLU)				Based on technical parameters and incremental costs and benefits for interventions tested as defined by scientific consultation. Assumes on a TLU basis a 50% cattle–25% sheep–25% goat herd composition. TLU is defined as a camel equivalent of 0.7, cattle 0.6, and shoats 0.1
Minimum livestock ownership to reach resilience level	ECO-RUM model	Intervention	None	Health improvement	Health improvement plus early offtake of male cattle	
		Pastoralists	14.8	11.5	11.0	
		Agro-pastoralists	9.0	5.3	5.2	

table continues next page

Table 5.11 Summary of Definitions and Assumptions Used in the Livelihoods Modeling *(continued)*

	Definitions						
	Source	*Values Used*					*Comments*
		Severe drought scenario (TLU)					
		Pastoralists	17.4	13.6		13.1	
		Agro-pastoralists	10.7	6.0		6.0	
		Livestock ownership top 1% (in TLU) of livestock-keeping households (%)					
Asset distribution	SHIP survey and rural Gini's and MMAGE for 2030	Burkina Faso	9	Mauritania	17		Countries covered by SHIP: Burkina Faso (2003), Niger (2007), Nigeria (2004), Ethiopia (2011), and Kenya (2005). Asset distribution follows log normal. Assumes that 2030 asset distribution equals 2010 figures
		Chad	23	Niger	17		
		Ethiopia	11	Nigeria	26		
		Kenya	28	Senegal	25		
		Mali	12	Uganda	10		
Feed availability	BIOGENERATOR and GLEAM	Usable (edible) biomass from satellite data (1998–2011), ground truth, and BIOGENERATOR model accessible equals 30 percent of accessible. Severe drought is 90% of mild drought satellite data. Average consumption 2.3 MT/TLU/year					

Note: TLU = tropical livestock unit; MT = metric ton. Δ = standard deviation.

Livelihoods

Introduction and Overview of the Approach

This section provides estimates of vulnerability levels of the livestock-keeping population under different climate, technology, and policy assumptions, one of the key aims of this study. Table 5.11 summarizes the main definitions and assumptions used in these calculations.

Initial calculations clearly show that the feed resources are insufficient to sustain the number of livestock needed to provide all households in 2030 with holdings above the resilience level. Assuming that only households with stock numbers above the resilience level would remain means that large numbers of households would have zero feed resources. Therefore, three groups were distinguished in the modeling:

- "Resilient" households: those households fully meeting the resilience level;
- "Vulnerable" households: those remaining below the income poverty line but with enough livestock to at least meet about half the resilience level. This group would remain vulnerable, but would have at least some assets to buffer shocks. To be fully resilient, this group will require *additional* sources of income; and
- "Potential exits or extremely poor (pushed out in the graphs)": those households with such limited livestock resources that they will be pushed out of the sector and will either find *alternative* sources of income or become permanently food aid-dependent.

The calculations then seek to balance feed and animal resources with income requirements, as demonstrated in table 5.12 for the pastoral system in Burkina Faso.

Results for 2010

Figures 5.8 and 5.9 illustrate the results for 2010. They show that only 23 percent of pastoral households and 34 percent of agro-pastoral households have livestock holdings that provide an income above the poverty line (assuming that 70 percent and 35 percent of income comes from livestock in the respective systems).

The differences between regions and countries are striking: the East African countries are generally better off; in West Africa, Burkina Faso, Mauritania, and Niger have a particularly high incidence of households with livestock holdings below the resilience threshold.

Figure 5.9 demonstrates for 2010 the shares of resilient, vulnerable, and potential exits households under different exit threshold scenarios. If the exit threshold increases from 1 TLU to 5 TLU per family, the number of vulnerable households decreases from 55 to 27 percent, whereas the number of pushed out households more than triples, from 12 to 40 percent. The exact exit threshold to

Table 5.12 Feed Ceilings Under Different Climatic Conditions, Burkina Faso, 2011 and 2030

2011		*2030*		
	Baseline Weather		*Baseline Weather*	*Severe Drought*
Total households	26,324	**Total households**	38,501	38,051
Resilient share	18%	**Resilient share**	10%	2%
Total households resilient	4,641	**Total households resilient**	3,697	691
Total biomass	582,000	**Total biomass**	582,000	308,735
Total TLU based on average feed for 2011–30	407,008	**Total TLU based on average feed for 2011–30**	253,043	134,233
TLU share in resilient households	53%	**TLU share in resilient households**	38%	14%
TLU in resilient households	214,991	**TLU in resilient households**	96,927	18,423
Biomass equivalent	494,480	**Biomass equivalent**	222,931	42,373
Remaining biomass	87,520	**Remaining biomass**	359,069	266,362
TLU supported by remaining biomass	38,052	**TLU supported by remaining biomass**	156,117	115,810
Average TLU of remaining vulnerable households	14.77	**Average TLU of remaining vulnerable households**	4.544	3.100
Household equivalents	2,576	**Exit TLU threshold**	5	3.63
Households that can be maintained above resilience level	7,217 (27%)	**Share of households below exit threshold**	72.4%	87.3%
Households with zero feed	19,106 (73%)	**Households pushed out**	24,883 (65%)	32,606 (86%)
Share of households below exit threshold	44%	**Final remaining vulnerable households**	9,471 (25%)	4,753 (12%)
Resilient households	4,640	**Resilient households**	3,697 (25%)	691 (2%)
Dropout households	11,599	**Dropout households**		
Vulnerable households	10,124	**Vulnerable households**		

Note: TLU = tropical livestock unit.

aim for will depend largely on country-specific conditions, whereby the existing ratio among the three groups, the expected absorptive capacity of the manufacturing and service sectors, and available funds to provide additional income sources for vulnerable households are important criteria.

Results for 2030

The key message for 2030 is that given the major population growth occurring across Africa, a “business as usual” approach will lead to large numbers of “likely dropouts;” that is, those households with fewer than 5 TLU. As shown in figure 5.10, the risk of this is particularly high in pastoral systems (77 percent),

Figure 5.8 Share of Households Above the Resilience Threshold, 2010

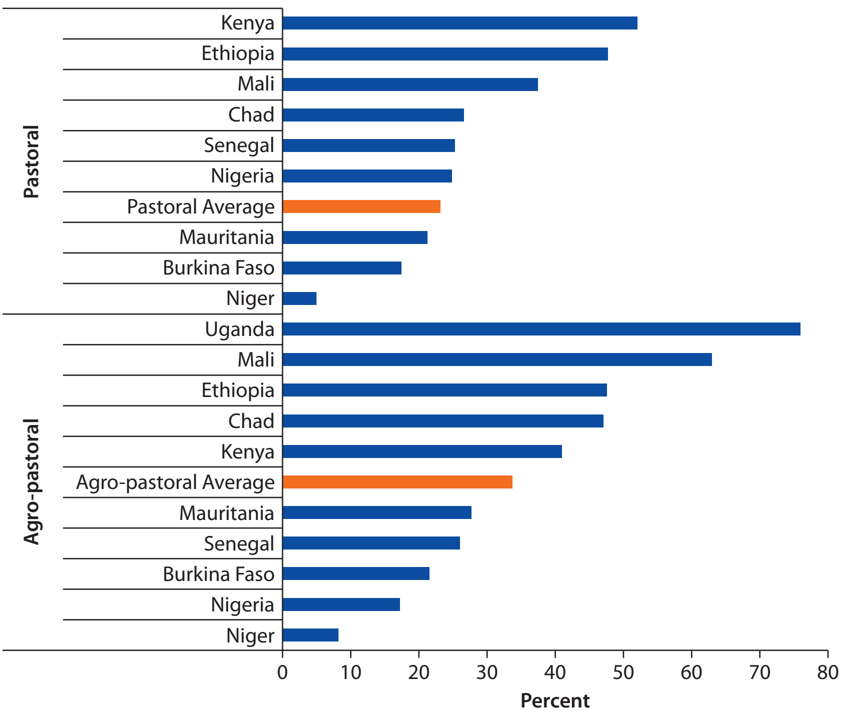
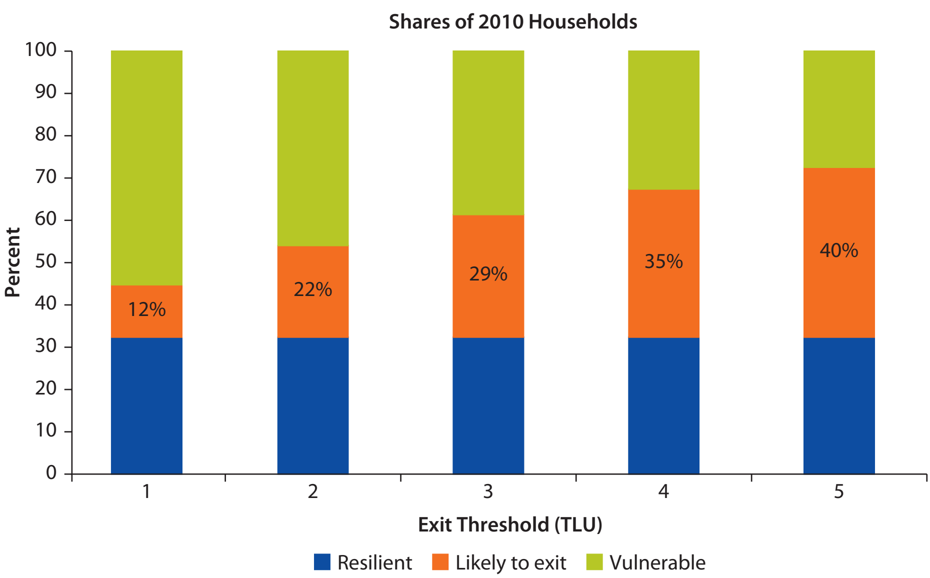
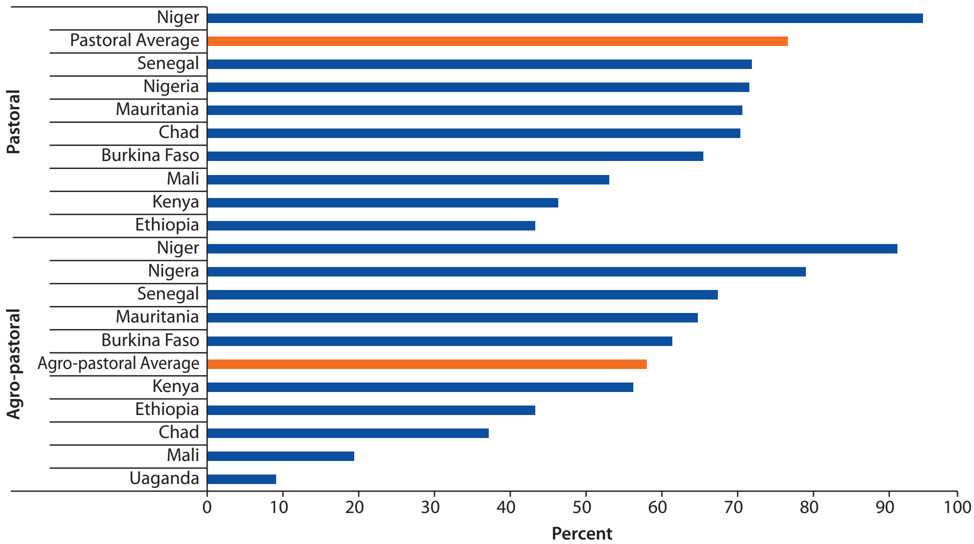


Figure 5.9 Share of Households Likely to be Pushed Out Under Different TLU Exit Thresholds



Note: TLU = tropical livestock unit.

Figure 5.10 Share of Household Dropouts under a Baseline Climate Scenario and No Interventions, 2030



although the figures from Niger strongly affect the average. In addition to this high share of "dropouts," 12 percent of households remain vulnerable.

So without action, an extremely poor and vulnerable population will either remain in drylands and become food aid-dependent and conflict-prone, or it will flood the already overpopulated slums of urban centers. Interventions to manage this essential transition to avoid those outcomes are envisaged in three areas:

1. *Promoting technological change to increase productivity*. In this study, the options assessed include: improvement of animal health (vaccinations, clinical services); closer integration in the market chain (promoting the offtake of bulls at an earlier age for fattening); and finding additional feed, either by identifying un- or underused areas or by increasing on-farm feed production in semi-arid and sub-humid areas;
2. *Promoting structural change in asset distribution*. The options explored in this study are: encouragement of herd consolidation, particularly for the current "vulnerable households"; and redistribution of wealth more generally;
3. *Generating other sources of income from outside the livestock production system*. This could be explored by increasing the percentage of non-livestock income (now at 30 percent for pastoralists and 15 percent for agro-pastoralists). Additional sources of income could cover dryland-related activities (such as processing of livestock products and collection of medical plants and firewood from rangelands), provision of incentives for increasing carbon sequestration, and PES for enhancing rangeland biodiversity. Other sources of income should also be sought from employment generation outside the livestock sector and drylands.

Technological Change

The effects of technological interventions are illustrated in figures 5.11 and 5.12. The relative gains associated with technological change seem rather low. In pastoral systems, the improvements lead to only a 5 percentage point decrease in the number of pushed out households, compensated by an increase in the share of resilient households. In agro-pastoral systems, the decrease in the number of dropout households is more significant (12 percent).

The percentages vary greatly by country and production system and are mainly a function of the feed availability and the percentage of small ruminants in the total herd, as the initial mortality, particularly in the more humid agro-pastoral systems, is higher, and the improvement larger because of the health intervention.

While the improvement in relative terms seems somewhat disappointing, in absolute numbers it is highly significant (table 5.13). The interventions are estimated to increase the number of resilient households by more than 3 million, mostly by reducing the number of likely pushed out households.

As seen in figure 5.13, the share of resilient households decreases slightly under the drought scenario, probably because the already large herds in times of a drought crowd out the smaller livestock-keeping households.

Although a major constraint, in this modeling exercise feed does not seem to make a major impact beyond the 35 percent accessibility level (which already assumes a high level of mobility), but if more feed were made available, it would

Figure 5.11 Effect of Technological Interventions on the Shares of Resilient, Vulnerable, and Likely Exits Households, by Production System

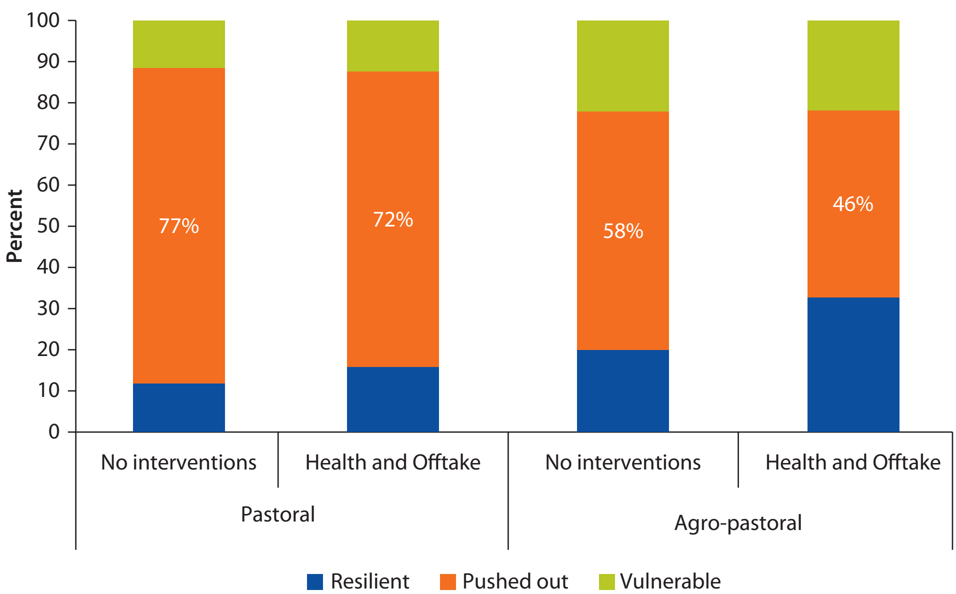


Figure 5.12 Percentage of Avoided Exits due to Interventions in Health Plus Early Offtake

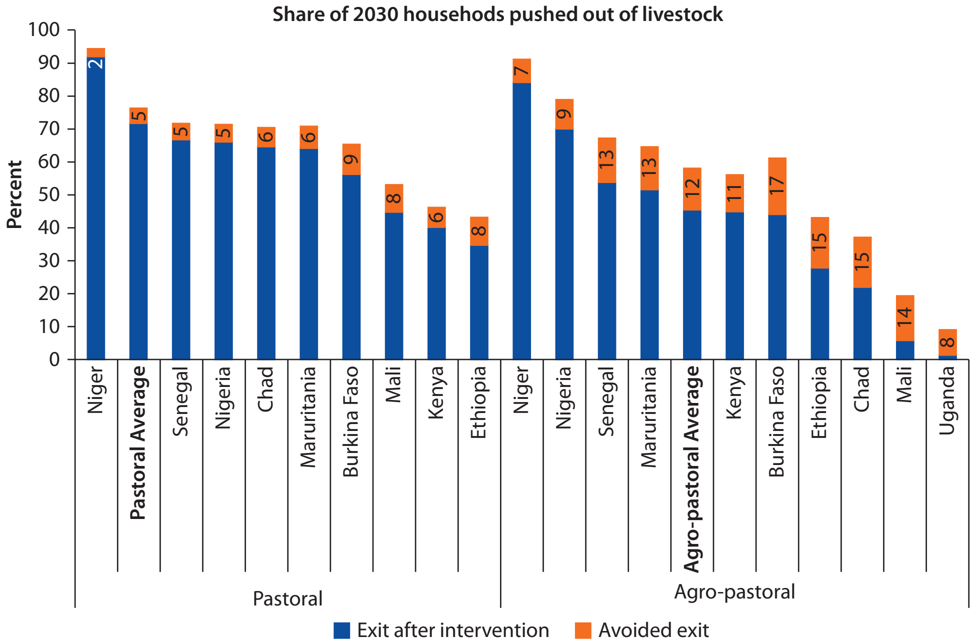


Table 5.13 Impact of Interventions, Baseline Climate Scenario

	Pastoral			*Agro-pastoral*		
Intervention	*Resilient*	*Vulnerable*	*Potential Exits*	*Resilient*	*Vulnerable*	*Potential Exits*
None	543,954	525,953	3,500,828	4,700,649	5,186,613	13,640,662
Health plus offtake	721,916	563,322	3,285,497	7,694,339	5,126,524	10,707,060
Difference	177,963	37,369	(215,331)	2,993,689	(60,088)	(2,933,601)

significantly facilitate the transition of extremely poor dropout households to the vulnerable category (figure 5.14).

Other Structural Changes

Highly inequitable livestock ownership is a root cause of the high shares of vulnerable and pushed out households in the drylands livestock-keeping population. The ongoing transformation of the sector, as described in chapter 3, will exacerbate this inequality and increase the share of vulnerable and dropout households. However, changes in asset distribution are highly sensitive, so the modeling results provided below are mainly meant to stimulate dialogue.

Figure 5.13 Impact of Interventions, Different Climate Scenarios, 2030

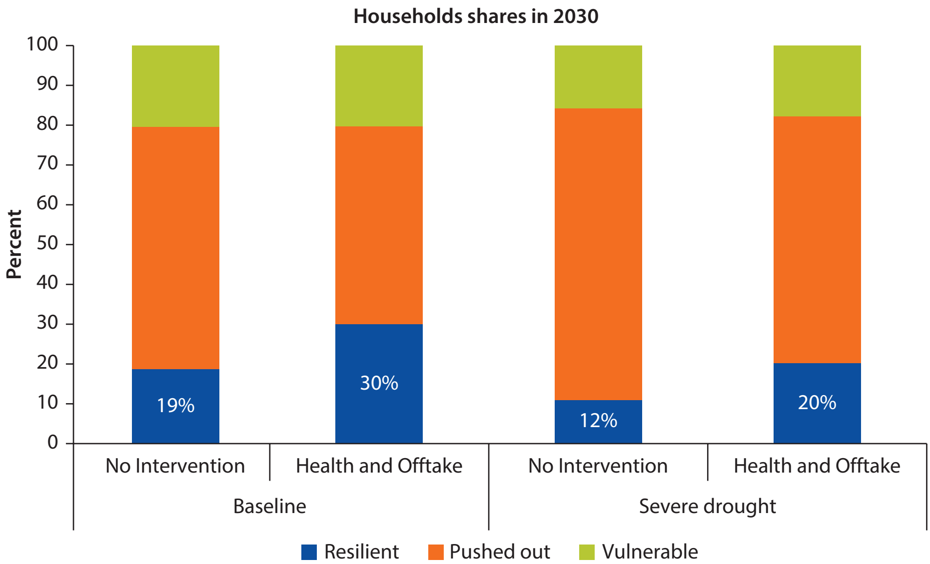


Figure 5.14 Relative Shares of Resilient, Vulnerable, and Likely-to-Exit Households as Affected by Feed Accessibility, Baseline Climate and No Interventions Scenario, 2030

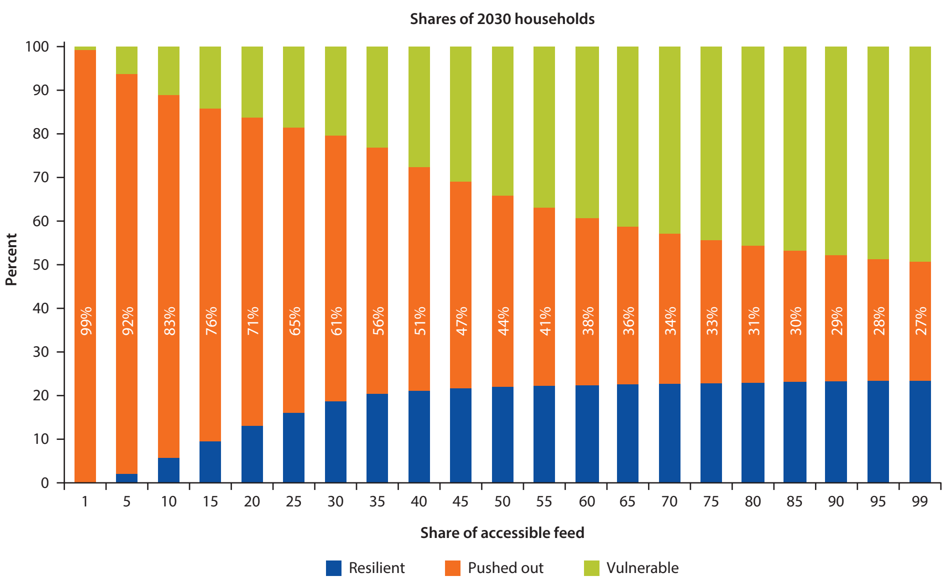


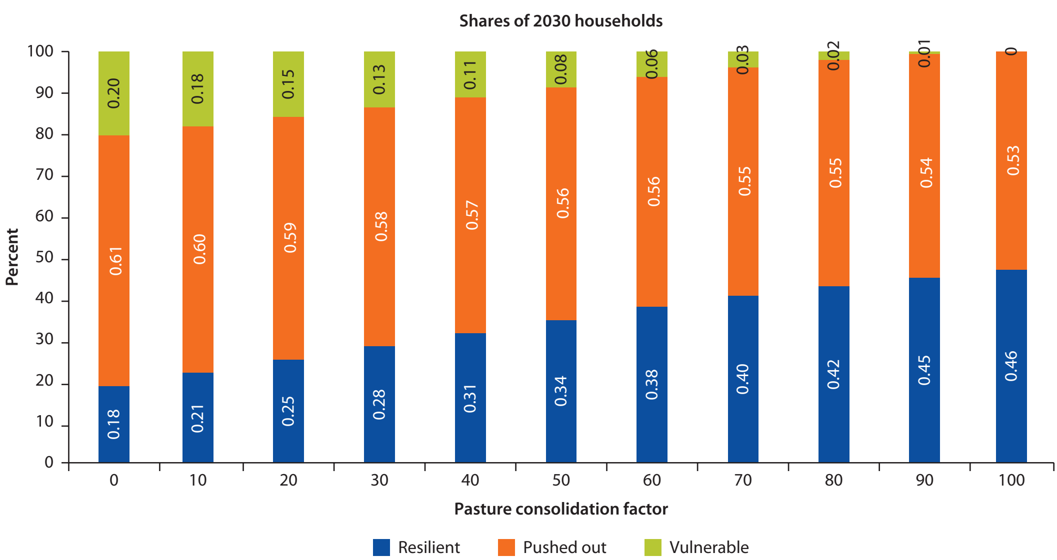
Figure 5.15 shows the effect of consolidation of pasture land by: (i) maintaining the area allocated to resilient households constant at the expected 2030 level; and (ii) allocating different shares (the consolidation factor in figure 5.15) of the remaining area exclusively to vulnerable households (that is, seeking to consolidate vulnerable and likely dropout households). It shows that under such a land consolidation policy, the number of potential exits is reduced to nil, and there is also a slight reduction in the share of vulnerable households.

Allocation of exclusive land and water access rights to vulnerable households at the exclusion of large herd owners will be challenging under the open access system of the drylands. Policies to promote consolidation include:

- Stopping land grabbing by large herd owners, and enhancing mobility;
- Allocating exclusive water and grazing rights for the wet and dry season to groups of smallholder livestock keepers (although this is difficult and has shown disappointing results in the past); and
- Giving a high priority to small ruminants' improvement, as these are the main source of income for the poor.

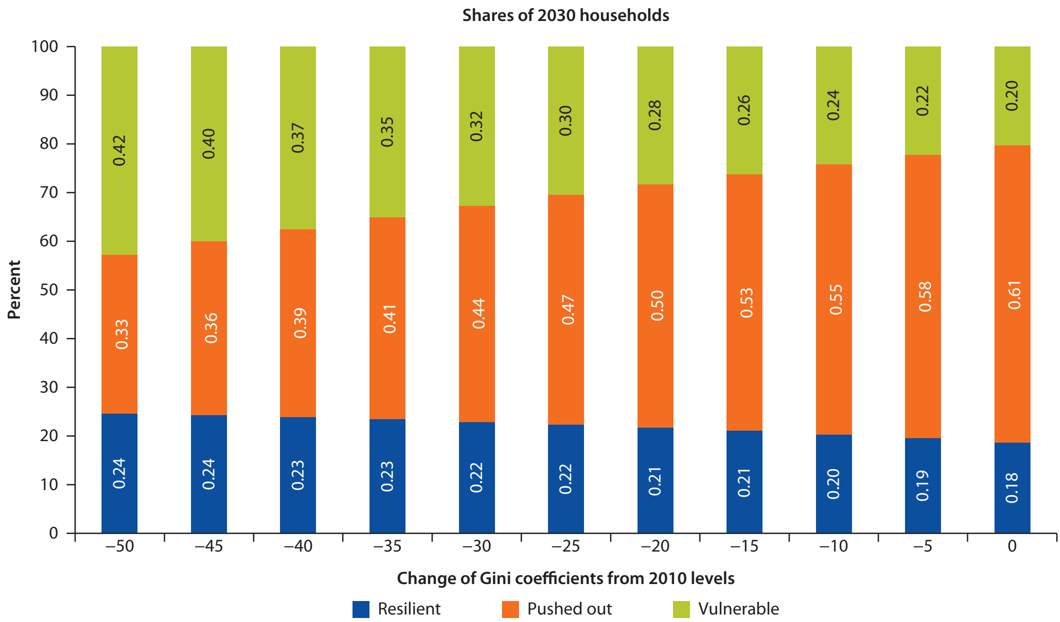
In line with such a consolidation program, the possibility of redistributing livestock wealth could be explored. Figure 5.16 provides an estimate of the

Figure 5.15 Effect of Different Degrees of Consolidation of Feed (Pasture) Resources to Vulnerable Households (Over 5 TLU/Family), Baseline Climate and No Intervention Scenario, 2030



Note: TLU = tropical livestock unit.

Figure 5.16 Effect of Changes in the Gini Coefficient on the Share of Resilient, Vulnerable, and Potential Exits Households, Baseline Climate and No Intervention Scenario, 2030



impact of a change in the Gini coefficient as a proxy for asset distribution: an increase in pasture consolidation of 50 percent from the 2010 level (no consolidation) would halve the number of pushed out households.

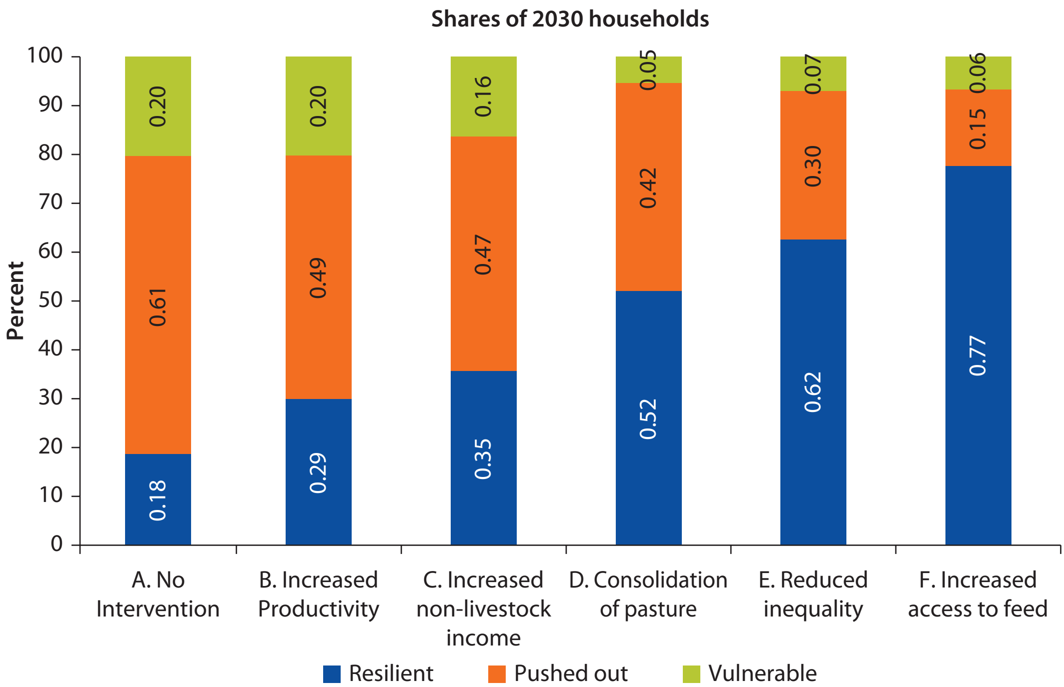
Policies to bring about such a change in the Gini coefficient include:

- Progressive taxation of large herd owners, either through a direct tax per head or progressive grazing and watering fees;
- Differential service fees (such as for vaccination) for large herd owners; and
- Introduction of or an increase in the export tax, as the large herd owners supply more animals for export.

Individually introduced, none of the above measures would make a major dent in the share of vulnerable households. The final model therefore sequentially combines all of the above policies and investments, as shown in figure 5.17. If all interventions are combined, major reductions in the share of vulnerable and dropout households can be gained.

Although admittedly based on a large number of assumptions, the model shows that livelihoods in drylands can be substantially improved, vulnerability

Figure 5.17 Impact of Sequentially Combining Different Policy and Investment Options on Resilient, Vulnerable, and Potential Exits Households, 2030



reduced, and the rural to urban flow diminished when aggressive policies and interventions are taken in combination. It would be wrong, however, to adopt an "all or nothing policy." Individual interventions such as enhancing mobility would make a difference

Summary and Conclusions

These results are based on a large number of assumptions and significant levels of underlying uncertainty. The conclusions should thus be interpreted as indicative only. However, the overall picture is rather clear:

On feed resources:

- The GLEAM/BIOGENERATOR models show that, depending on the climate and interventions, on average for the period 2011–30, 19–29 percent of TLU in arid areas and 9–16 percent in semi-arid areas would have insufficient local feed resources to meet their nutritional requirements without mobility.
- With full mobility of animals and feed within grazing sheds, 2.5 times more usable biomass would be required than in the past. In the scenario of a severe

drought and animal health interventions, biomass use increases 3.5-fold compared to the past sequence.
- Results regarding absolute feed balances indicate that resources seem to be sufficient in all scenarios, starting with an assumption of 20 percent accessibility to natural vegetation. With only 10 percent accessibility to natural vegetation, the deficit in feed reaches 4 percent in the 2011–30 drought + male early offtake scenario, enabling about 60 percent growth compared to the past sequence (1998–2010) in the drought + health + early offtake of males scenario.
- Some grazing sheds appear to have greater feed deficits than others, across scenarios. Mali, Mauritania, and western Burkina Faso (WA1) and northern Ethiopia and Somalia (EA1&3) are the areas where the greatest deficit is found.
- Whereas drought reduces average annual meat production by 14 percent in drylands compared to the baseline, health interventions seem to restore the baseline level of production while early offtake of males increases production by 5 percent. Coupling male early offtake and health interventions even results in a 20 percent increase in average annual Sub-Saharan African (SSA) meat output. But this scenario requires an additional 7.1 million MT of biomass from humid areas.

Therefore, to sustain growth in the sector, policies and investments need to aim at:

- Maintaining and probably even expanding pastoralists' possibilities for seasonal herd/flock mobility to higher-potential areas through interventions in territorial organization (corridors, security, border regulations, water development, allocation of dry season grazing areas);
- Enhancing feed marketing possibilities (storage, processing, transport);
- Supporting market integration through stratification of arid and semi-arid areas (early male offtake) to reduce grazing pressure in arid areas and increase overall meat production; and
- Combining animal health interventions with interventions that increase access to feed. Unconstrained growth of livestock numbers without increased access to additional feed resources will most likely lead to resource degradation and increased conflicts over resources.

On macroeconomic aspects:

- There is potential for growth. The GLEAM/IMPACT modeling shows that health improvement and stratification/closer market integration through fattening outside the region. The combined package could halve the projected meat deficit by 2030.

On livelihoods:

- Livestock ownership in the drylands is highly skewed: the wealthiest 1 percent own 9–26 percent of the livestock (expressed in TLU). Cattle ownership is particularly vested in the better-off groups.
- Currently, about 23 percent of pastoralist and 34 percent of agro-pastoralist households are resilient; about 40 percent have livestock holdings that place them in extreme poverty, probably forcing them out of the system. Under a "business as usual" approach, the shares of resilient pastoralist and agro-pastoralist households are projected to decrease in 2030 to 10 percent and 20 percent, respectively, and 77 and 58 percent, respectively, will be forced to drop out.
- Urgent and concerted action is therefore required; although feed and animal resources will not be sufficient to provide a livelihood for all drylands livestock keepers, several measures are possible, including:
- Introducing improved health care and market integration by inducing offtake at an earlier stage than is now practiced, and fattening these animals in areas of higher potential. In the pastoral zone this will increase the share of resilient households from 10 percent to 15 percent and decrease the share of pushed out households from 77 to 72 percent. In the agro-pastoral zone, comparable figures are from 20 to 30 percent for resilient households, and from 58 to 46 percent for pushed out households. Additionally, the total production of red meat would increase by about 20 percent (although drylands red meat production would reduce by 12 percent).
- Finally, GHG per kg animal protein produced would reduce by about 10 percent;
  - Increasing non-livestock income, in addition to increased productivity, would further increase the share of resilient households from 30 to 36 percent and reduce the share of pushed/dropout households from 50 to 48 percent;
  - Ensuring greater access to feed resources (through water development and opening of feed markets) from 15 to 30 percent accessibility would increase the share of resilient households from 7 to 18 percent and reduce the share of pushed/dropout households from 71 to 61 percent;
  - Redressing inequity through preferential allocation of grazing rights to the vulnerable part of the population would increase the share of resilient households from 18 to 40 percent and reduce the share of households likely to be pushed out from 61 to 53 percent. Similarly, changing the Gini coefficient through, for example, progressive taxation could theoretically reduce the share of families pushed out from 61 to 33 percent; and
  - Implementing all measures combined—this would result in resiliency for 78 percent of households, while only 15 percent of households would be pushed out.

In view of the above analysis, recommended policies would:

- Be country specific;
- Establish the enabling environment for technological change (extension, infrastructure; credit) to: (i) strengthen animal health services; and (ii) increase early offtake of male animals. The specific policies would cover for both interventions an appropriate distribution of responsibilities between the public and private sectors, and for incentives for early destocking, such as the introduction of grazing and watering fees and facilitating market integration (enabling the private sector to develop the value chains, infrastructure, credit, support for standard setting, including harmonization of international standards);
- Be pro-poor in its allocation of grazing rights and taxation, and focus on small ruminants;
- Develop institutions that help the poor with early destocking and restocking (subsidized transport, livestock insurance);
- Seek additional (such as PES) and alternative (such as crop farming and employment generation within or outside the value chain) income sources for drylands populations; and
- Focus on intensification of land use in semi-arid and sub-humid areas.

Data Gaps

Serious gaps exist in practically all categories of data needed for this analysis. Future investments need therefore to give priority to the following issues:

- Livestock technical performance data are scarce and mostly come from experimental stations under conditions quite different from those prevailing in practice. They are mostly collected over a very short period (1–2 years) and lack the long-term time series needed to capture the climate variability in drylands;
- Information on feed availability from natural vegetation is overestimated, as the critical accessibility factor is unknown;
- Livestock ownership data, in particular per wealth category, are scarce and normally suffer from underreporting. Poverty rates from ILRI are based on some rather bold assumptions by Livestock in Development (LID) dating back to 1999;
- Livestock numbers come almost uniquely from FAOSTAT, with known bureaucratic weaknesses;
- Data on human demographics, particularly differentiating between pastoral, agro-pastoral, and crop farmers, are critical for future projections regarding conflict situations but are essentially unavailable;
- Income and expenditure data at the household level, especially for revenues from non-livestock outside sources, are only available for a very limited number of sites; further, pastoral groups are often missed in household surveys;
- Crop projections used in the modeling to account for trends in land cover and land use changes and changes in the spatial distribution of cropped area are scarce; and

- More data are needed on actual growth rates using crop byproducts and residues for fattening, as significant differences exist between the GLEAM projections and those identified at the experts' consultation held in Dakar.

Financial and Economic Returns

This section provides an overview of: (i) the wider macroeconomics of resilience in the livestock sector, mainly based on a literature review heavily reliant on Venton et al. (2013); and (ii) the costs of and returns to investments of the interventions described above.

Macroeconomic Aspects: Wider Dimensions of Resilience

The main macroeconomic issue concerns the comparison of the costs of emergency aid and other humanitarian support with the total package of investments to reduce livestock-keeping households' exposure and sensitivity to shocks and enhance their capacity to cope. As shown below, the costs of the former are generally higher than the cost of drought preparedness. Most of the work in this area has been done in East Africa, and has been based on modeling, as "with/without" field assessments are not feasible in the highly variable SSA environment.

Venton et al. (2013) compare the cost and benefits of late and early responses with those of building livestock keepers' resilience. They make the point that under a late response/emergency scenario, while it helps to ensure that people and livestock stay alive, asset depletion is often the result, and when the next drought hits, people often have not recovered their asset levels, falling into a downward spiral of emergency aid dependency. Under an early intervention scenario, per capita intervention costs are generally lower and a significant share of livestock (estimated at 50 percent by the authors) can still be commercially destocked and valued. The resilience-building scenario prepares communities to cope without external support, and depending on the severity of subsequent shocks, to continue to build their assets.

For the Wajir grasslands in Kenya (with 367,000 inhabitants), the main results from Venton et al. (2013) are presented in table 5.14 as an example.

This estimate shows that a commercial destocking (as described in chapter 4) would yield a benefit of about US$250 million over a 20-year period. The total resilience package C even has a positive return, with a cost-benefit ratio of 1:5.5 resulting from a reduction in food aid and livestock losses.

Other interventions for this area such as water development would result in a cost-benefit ratio varying from 1:26 for a shallow well, to 1:6 for a drilled well for 5,000 people, to 1:1.1 for a drilled well for only 1,000 people.

Also at the national level, early intervention and resilience building yields positive returns. For example, discounted over a 20-year period for the arid and semi-arid areas of Kenya, a late response would cost US$29 billion; with an early response this would go down to US$22 billion; and with the resil-

Table 5.14 Costs (US$ Million) of Various Response Scenarios—Wajir Grasslands, Kenya

Intervention/ Outcome	*A: Late Humanitarian Response (US$ Million)*	*B1: Early Response: Destocking (US$ Million)*	*B2: Early Response: Destocking Plus Improved Animal Condition (US$ Million)*	*C: Resilience Building*
Aid costs assumed every fifth year	176	88	66	Residual risk: Full costs under B2 in year 0, decreased by 50% year 5, 25% carries on every event thereafter
Losses (animal deaths)—assumed every fifth year	81	62	19	Residual risk: Full costs under B2 in year 0, decreased by 50% year 5, 25% carries on every event thereafter
Cost of program assumed every fifth year		0.28	5.8	US$50 million annually (US$137 per capita for beneficiary population) [a]
Net cost over 20 years, discounted at 10%	606	354	214	Pos. balance US$54 million[b]

Source: Adapted from Venton et al. (2013).
Note:
a. Broken down as follows: Livestock interventions US$24; Water and sanitation interventions US$25; Livelihood interventions US$60; Road interventions US$11; and Education support US$17.
b. Assuming a conservative benefit of US$1.1 for every US$1 invested.

ience-building package, to US$9 billion. The same work in Ethiopia showed similar results.

All indications are that early intervention and a resilience package will provide positive returns, reducing losses and human suffering, and should thus be the direction of future development.

Cost of Interventions

For the economic assessment, a cost estimate was first prepared. In the absence of data in the literature, cost estimates were based on cost projections from five recently started, major internationally funded projects dealing with pastoral areas[17] and on a further literature review. Table 5.15 provides a summary of the cost per pastoral/agro-pastoral person associated with these projects.

The range of values is significant, particularly for health improvement. However, the average is in line with the estimates of the OIE-sponsored study (CIVIC Consulting 2007) for Uganda.

For development decision making, it is important to know the distribution between technology adoption-related and non-adoption-related costs, as well as between investment and recurrent costs. Based on the projects analyzed, and the authors' experience, the assumptions used are provided in table 5.16.

Table 5.15 Average Cost/Person/Year of the Main Interventions in Five Drylands Livestock Development Projects

Intervention	*Average Cost/Person/Year (US$)*	*Number of Projects/Sources*	*Range (US$)*
Health improvement	3.95	3	3.37–20.12
Market improvement (early offtake of bulls)	6.00	3	3.67–8.33
EWS	3.72	2	1.79–2.09
Social services, etc.	5.30	2	2.39–5.82

Table 5.16 Assumptions About the Allocation of Adoption- and Non-Adoption-Related Costs and of Investments and Recurrent Costs for Animal Health and Early Offtake Interventions

Item	*Allocation*
Animal health non-adoption-related	Of total health improvement budget, 20% in investments and 25% in recurrent costs
Animal health adoption-related	Of total health improvement budget, 25% in investment and 30% in recurrent costs
Animal health improvement adoption-related by livestock system	10% higher/person (higher delivery costs) in pastoral systems
Early offtake (market integration)	Of total budget, 70% in investment and 30% in recurrent costs (high capital investment needed in infrastructure such as transport, processing facilities).
Early offtake non-adoption-related costs	Nil, because of its currently nascent character
Adoption rate	70% for pastoral and 80% for agro-pastoral households for health improvement and 60% and 70%, respectively, for early offtake
Public and private sector contribution	Public sector: 80% for cross-cutting costs, 60% for adoption costs in animal health improvement, and 20% for early offtake; the remainder belongs in the private sector

With these very hypothetical assumptions, the costs per household for the different interventions can be calculated on a country basis[18] (table 5.17).

The distribution of costs between public agencies and livestock owners (private sector) can also be estimated (table 5.18).

In aggregate, these figures seem high at a total of about US$ 10 billion over the 20 year period or about US$500 million per year (about US$200 million per year for the public sector. They look more reasonable when calculated per beneficiary (number of people made resilient), as shown in figure 5.18.

Figure 5.18 shows that with the exception of Niger, the costs per person made resilient are significantly below the US$100–135 normally calculated for food aid. As expected, the annual cost per person made resilient is higher in

Table 5.17 Costs of the Health Improvement Intervention in Pastoral and Agro-pastoral Systems for the Drylands Countries Analyzed, 2011–30

	System	*Total Crosscutting Costs (US$)*	*Animal Health Costs Related to Adoption (US$)*	*Early Offtake Cost Related to Adoption (US$)*
Burkina Faso	Pastoral	2,001,340	4,375,668	8,761,819
	Agro-pastoral	146,411,191	296,312,335	611,860,734
Chad	Pastoral	22,269,103	46,248,843	94,322,021
	Agro-pastoral	80,355,873	153,572,465	325,511,901
Ethiopia	Pastoral	40,450,812	84,084,728	200,001,914
	Agro-pastoral	215,420,784	475,994,713	945,777,249
Kenya	Pastoral	11,639,980	24,028,169	57,297,407
	Agro-pastoral	100,380,624	190,548,382	405,157,258
Mali	Pastoral	18,237,102	35,108,525	73,647,630
	Agro-pastoral	108,214,483	189,929,255	419,156,401
Mauritania	Pastoral	22,825,513	47,451,895	96,740,466
	Agro-pastoral	1,022,503	1,956,348	4,144,523
Niger	Pastoral	110,077,554	214,747,897	448,217,398
	Agro-pastoral	30,208,044	67,968,123	134,012,642
Nigeria	Pastoral	6,708,289	13,742,922	28,167,673
	Agro-pastoral	403,725,668	759,884,598	1,622,137,722
Senegal	Pastoral	6,713,968	14,168,716	33,518,259
	Agro-pastoral	64,583,740	125,656,019	308,179,228
Uganda	Agro-pastoral	38,844,123	77,107,686	160,618,168
Total		1,430,090,694	2,822,887,289	5,884,440,004

Table 5.18 Summary of Costs (2011–14 Prices) of Health and Early Offtake Interventions and Their Distribution between the Public and Private Sectors (2011–30)

	Cross-Cutting Cost (US$)	*Adoption Costs Animal Health (US$)*	*Early Offtake Costs (US$)*	*Total (US$)*
Public sector	1,144,072,555	1,693,732,373	1,176,888,001	4,014,692,929
Private sector	286,018,139	1,129,154,916	4,707,552,003	6,122,725,057
Total	1,430,090,694	2,822,887,289	5,884,440,004	10,137,417,987

pastoral areas. In general, the costs in East Africa seem to be lower than in the Sahel. At an average cost of US$27 per person per year, they are half the US$65 per person per year estimated by Venton et al. 2013.[19]

Micro-Economic and Financial Returns

The financial and economic rates of return were determined for the interventions based on the ECO-RUM projections, using the parameters in appendix A (table 5.19).

Figure 5.18 Estimated Unit Cost (US$/Person/Year) Made Resilient (Presented at Log Scale) Under Baseline Climate and Health and Early Offtake Scenarios

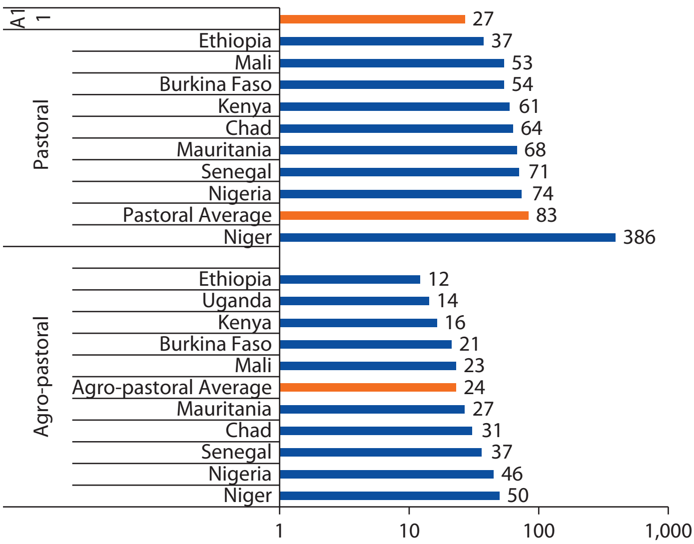


Table 5.19 Financial Rates of Returns (%) of Different Interventions at Household Level for Different Species

	Baseline Plus Health Intervention	*Mild Drought Plus Health Intervention*	*Severe Drought Plus Health Intervention*	*Baseline, Health Plus Early Offtake*	*Mild Drought Plus Health Plus Early Offtake*	*Severe Drought Plus Health Intervention Plus Early Offtake*
Pastoral households						
Cattle	11	11	2	29	16	4
Sheep	26	31	42	NA	NA	NA
Goats	29	41	65	NA	NA	NA
Camels	21	31′	57	NA	NA	NA
Agro-pastoral households						
Cattle	Neg.	Neg.	Neg.	14	15	22
Sheep	High	36	36	NA	NA	NA
Goats	High	46	53	NA	NA	NA

As in the earlier modeling results, because of the paucity of data and the wide variation in environments under which these systems and species function, the results from table 5.19 should be evaluated based on their order of magnitude, rather than taken as precise data on the rates of returns of these interventions. However, it can be concluded that:

- Health interventions for small ruminants and camels seem highly remunerative;
- In pastoral areas, the rate of return of animal health improvements for small ruminants and camels increases in drought situations;
- For cattle, the situation is less clear-cut. With the existing technical and financial data provided at the experts' consultation in Dakar, health improvement on its own is only marginally remunerative in pastoral areas, and even yields a negative rate of return in agro-pastoral areas. Early offtake of young males increases the rate of return.

The policy implications are that:

- In animal health improvement, attention should be paid particularly to small ruminants, which are normally neglected. This would also address inequity; and
- Health improvement for cattle should be accompanied by further intensification through early offtake of young males or through other husbandry improvement (genetics, feeds) to be financially attractive. This supports the earlier results of the feed balance modeling.

Notes

1. A more detailed technical paper is being prepared.
2. Unless otherwise reported, the countries covered include: in the Sahel—Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, and Senegal; in the Horn of Africa—the countries included are different from those used in chapter 2 as they cover only Ethiopia, Kenya, Tanzania, and Uganda. The feed balance work with Global Livestock Environmental Assessment Model (GLEAM) also includes Djibouti and Sudan (statistics from the former Sudan) and Somalia.
3. http://www.ifpri.org/book-751/ourwork/program/impact-model.
4. http://livtools.cirad.fr/mmage
5. http://livtools.cirad.fr/dynmod
6. www.fao.org/docrep/014/i2425e/i2425e00.pdf
7. The spatial distribution used 2010 as reference year.
8. No estimates could be found in the literature on the share of natural vegetation accessible to livestock. The authors' estimate is based on the initial estimates from the ACF work with BIOGENERATOR, also discussed at the Dakar workshop, of 30 percent for water only. A further reduction to 10–20 percent was assumed because of other movement constraints (insecurity, high crop intensity, constructed areas, etc.).
9. The results of the additional scenario of 30 percent accessibility are the basis of the livelihood analysis (see section Macroeconomic Implications).
10. The (Global) Aridity Index (AI) is calculated from MAP/MAE, where MAP is the Mean Annual Precipitation and MAE is the Mean Annual Potential Evapotranspiration.
11. http://www.cgiar-csi.org/data/global-aridity-and-pet-database

12. This differs from the classification used in the subsection on livelihoods modeling, where agro-ecological zones were used assumed to represent the systems (that is, arid equals pastoral and semi-arid and sub-humid equal agro-pastoral).
13. See description below of the BIOGENERATOR data and model.
14. The geographical limits of the different grazing sheds are depicted in map 5.3.
15. In IMPACT, the subnational spatial units are defined according to how certain key river basins intersect with national boundaries, rather than with the aridity zones used in this study.
16. In GLEAM, the distribution of animals is highly disaggregated on a spatial scale, so that the production systems are delineated by their feed characteristics and the aridity zones in which they are located.
17. The Ethiopia-Drought Resilience & Sustainable Livelihood Program in the Horn of Africa (PHASE I), funded by the African Development Bank (US$48.5 million, 2012); the IFAD- and World Bank-funded Regional Pastoral Livelihoods Resilience Project for Kenya and Uganda (US$132 million, 2014); the World Bank-funded Regional Sahel Pastoralism Support Project (US$250 million, under preparation); the WB/IFAD-funded Ethiopia Pastoral Community Development Project—Phase II (US$133 million, 2013); and the IFAD-funded Sudan Livestock Marketing and Resilience Program (US$ 119 million under preparation).
18. A detailed worksheet is available from the authors upon request.
19. US$54/person/year for Kenya and US$77/person/year for Ethiopia. No data are available for the Sahel.

CHAPTER 6

Summary and Conclusions

Cornelis de Haan

The preceding chapters summarize the state-of-the-art interventions and policies in drylands livestock development and, using a set of modeling tools, provide projections on the future production and livelihood status of the livestock sector in the Sahel Region and Horn of Africa countries. The modeling is admittedly based on a weak data foundation, but the results confirm the view of many (although not all) specialists, as well as that of the target population. The long-term view is one of opportunities, tremendous challenges, and the need for a firm dose of realism.

Opportunities

First, the drylands livestock-keeping populations, particularly pastoralists, are highly skilled at handling harsh and variable physical conditions, and are keen to adopt proven technologies such as animal health improvements and water development. *Second*, livestock products (red meat in particular) are expected to enjoy a rapidly expanding market. *Third*, there is extensive experience with livestock development in the Sub-Saharan Africa (SSA) drylands, and much can be done to lift the livestock-keeping population from poverty. The model shows that the technological package would reduce the number of households pushed out of the sector by 17 percent, with some further reduction from non-modeled technological interventions, such as improving genetics and implementing an effective early warning and response system (EWS). According to the model, a further increase of 15 percent in non-livestock income could reduce the number of potential exits by another 4 percent, whereas the exclusive consolidation of pasture to vulnerable households and a rather dramatic change in the Gini coefficient reduce that number by another 28 percent. A large increase in feed supply, combined with all other interventions, could reduce the share of people

pushed out to 17 percent, with another 6 percent remaining vulnerable. *Finally*, the sector can profit from the emerging interest of African policy makers and international investors in the pastoral sector.

Challenges

The package of measures required to lift such a large share of the population from poverty consists of a dramatically increased level of investment, a resource policy that allocates preferential grazing and water access to the poor, and a social policy that addresses inequity. These policies will go against major powerful interests. The much higher level of investment in animal services, water development, value chain improvement, and EWSs than hitherto has been made available will not be easy to source. Finally, implementing such a package will require a fully inclusive dialogue between all stakeholders, and a rebuilding of the trust between public institutions and livestock-keeping populations, particularly pastoralists. The challenge will be to master the political commitment to introduce and enforce such a package, and to engender the attitude change to regain the trust of the target livestock-keeping population. This will require first the unified vision of pastoral scientists, and clear acknowledgement of pastoralists that the above developed package, with local adaptations of course, is the way to go. It would also need to be internalized by the donor community, and integrated in their support investments. It would then need to be presented by key high-level champions to major policy meetings dealing with the drylands.

Need for Realism

With many conflicting interests, it is highly unlikely that the combined package can be fully implemented in all drylands countries. For a large share of the population, additional or even alternative sources of income outside the sector will have to be sought. And even under the highly unlikely situation that the full package is implemented in the entire region, about 4.5 million households are still likely to be pushed out of the sector. Future development plans (which must be country-specific in view of the large differences within and across countries) should therefore take this into account, and make facilitation of exit from the livestock sector a major part of any development effort.

APPENDIX A

Technical Parameters Used in Livestock Modeling

	Future Baseline (2011)	*Mild Drought (2030)*	*Severe Drought (2030)*	*Mild Drought and Health Intervention (2030)*	*Severe Drought and Health Intervention (2030)*	*Severe Drought and Health Intervention and Early Offtake Males (2030)*
Cattle in pastoral systems						
Fertility (%)	54	45	45	45	45	45
Mortality young (%)	21	26	26.0	17	17	17
Mortality sub-adult (%)	6	8	7.5	6	6	6
Mortality adult (%)	3	6	6.3	5	5	5
Average live-weight at sale (kilograms)	297	267	267	267	267	267
Average milk yield (lactation, human consumption) (liters)	250	150	150	150	150	150
Incremental costs of improvement/TLU	n.a.	n.a.	n.a.	US$2.75	US$2.75	US$2.75 + US5 marketing costs and US$2 feed costs
Cattle in crop-livestock systems						
Fertility (%)	54	45	45	45	45	45
Mortality young (%)	19	24	24	20	20	20
Mortality sub-adult (%)	3	4	4	4	4	4
Mortality adult (%)	2	3	3	3	3	3
Average live-weight at sale (kilograms)	297	267	267	267	267	267
Average milk yield (lactation, human consumption) (liters)	250	150	150	150	150	150
Costs of improvement/TLU	n.a.	n.a.	n.a.	US$4.50	US$4.50	Same as pastoral
Sheep in pastoral systems						
Fertility (%)	92	78	78	78	78	n.a.
Mortality young (%)	25	28	28	20	20	n.a.
Mortality sub-adult (%)	25	28	28	20	20	n.a.
Mortality adult (%)	9	10	10	10	10	n.a.
Average live-weight at sale (kilograms)	31	28	28	28	28	n.a.
Incremental costs of improvement/TLU	n.a.	n.a.	n.a.	US$7.50	US$7.50	n.a.

	Future Baseline (2011)	*Mild Drought (2030)*	*Severe Drought (2030)*	*Mild Drought and Health Intervention (2030)*	*Severe Drought and Health Intervention (2030)*	*Severe Drought and Health Intervention and Early Offtake Males (2030)*
Sheep in agro-pastoral systems						
Fertility (%)	103	88	88	88	88	n.a.
Mortality young (%)	33	36	36	20	20	n.a.
Mortality sub-adult (%)	33	36	36	20	20	n.a.
Mortality adult (%)	17	19	19	17	17	n.a.
Average live-weight at sale (kilogram)	31	29	29	29	29	n.a.
Incremental costs of improvement/TLU	n.a.	n.a.	n.a.	US$10	US$10	n.a.
Goats in pastoral systems						
Fertility (%)	92	78	78	78	78	n.a.
Mortality young (%)	25	28	28	20	20	n.a.
Mortality sub-adult (%)	25	28	28	20	20	n.a.
Mortality adult (%)	9	10	10	10	10	n.a.
Average live-weight at sale (kilograms)	23	21	21	21	21	n.a.
Incremental costs of improvement/TLU	n.a.	n.a.	n.a.	US$7.50	US$7.50	n.a.
Goats in agro-pastoral systems						
Fertility (%)	103	88	88	88	88	n.a.
Mortality young (%)	33	36	36	20	20	n.a.
Mortality sub-adult (%)	33	36	36	20	20	n.a.
Mortality adult (%)	17	19	19	17	17	n.a.
Average live-weight at sale (kilograms)	23	21	21	21	21	n.a.
Incremental costs of improvement/TLU	n.a.	n.a.	n.a.	US$7.50	US$7.50	n.a.

Note: n.a. = not applicable.

APPENDIX B

Livestock and Livestock-Keeping Population Numbers

Table B.1 Livestock Numbers by AI-Derived Livestock Production System, Focus Countries

		Livestock Only Systems			*Mixed Systems*						
Livestock Type	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Humid*	*Urban*	*Other*	*Total*
Cattle	3,240,651	18,968,913	19,116,580	5,678,496	12,825,785	51,594,303	17,731,255	35,744,915	2,738,076	11,964,149	179,603,122
	2%	11%	11%	3%	7%	29%	10%	20%	2%	7%	100%
Camels	2,901,679	8,513,392	3,015,262	66,687	1,449,209	2,752,309	26,350	219,564	67,426	435,578	19,447,454
	15%	44%	16%	0%	7%	14%	0%	1%	0%	2%	100%
Sheep	13,830,308	33,528,615	17,212,907	3,471,569	16,391,945	57,215,991	8,767,690	16,714,011	2,844,434	9,143,996	179,121,466
	8%	19%	10%	2%	9%	32%	5%	9%	2%	5%	100%
Goats	10,956,815	36,214,624	18,756,868	5,241,252	18,951,701	66,307,354	15,940,741	21,360,843	4,094,808	14,811,881	212,636,888
	5%	17%	9%	2%	9%	31%	7%	10%	2%	7%	100%
TLU	6,454,278	24,315,046	17,177,608	4,325,060	12,244,282	45,235,533	13,128,041	25,408,129	2,383,968	9,878,981	160,550,927
	4%	15%	11%	3%	8%	28%	8%	16%	1%	6%	100%

Source: Robinson and Conchedda (2014).

Notes: TLU refers to Tropical Livestock Units, which are: cattle = 0.6; camels = 0.7; sheep and goats = 0.1. Numbers presented are totals for West Africa (Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, and Senegal) and East Africa (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and South Sudan (combined), Tanzania, and Uganda). AI = Aridity Index. Available statistics for the former Sudan do not yet reflect the divide of the country into Sudan and South Sudan so these are merged.

Table B.2 Livestock Numbers by Country and AI-Derived Livestock Production System for the Focus Countries

			Livestock Only Systems			*Mixed Systems*					
	Hyper-Arid	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Humid*	*Urban*	*Other*	*Total*
Cattle											
Burkina Faso	–	388,350	1,694,061	942,569	17,911	4,007,510	556,452	–	146,215	6,052	7,759,120
Chad	978,073	1,122,570	688,717	264,181	1,096,440	2,117,805	205,837	11,765	18,029	176,703	6,680,120
Mali	91,617	1,991,830	1,001,779	522,166	348,888	2,758,180	440,689	16,667	82,170	176,960	7,430,945
Mauritania	289,077	1,141,200	11,101	–	136,125	29,969	–	–	6,346	46,087	1,659,905
Niger	722,715	1,710,100	205,903	–	2,868,390	2,156,476	–	–	105,414	6,677	7,775,675
Nigeria	–	12,272	68,888	173,855	2,374,960	7,919,600	2,385,660	1,605,175	247,963	1,227,260	16,015,633
Senegal	–	258,201	254,513	145,486	249,588	1,746,828	118,344	7,353	61,644	294,615	3,136,572
Djibouti	32,298	189,809	3,374	–	1,761	65	–	–	1,259	67,127	295,694
Eritrea	2,017	437,371	193,020	86	46,047	644,710	570	–	7,124	617,235	1,948,180
Ethiopia	–	1,064,190	2,997,010	895,070	419,357	6,835,610	6,455,520	21,870,900	517,994	2,068,920	43,124,571
Kenya	–	1,096,880	2,271,500	292,215	7,754	1,668,513	1,473,350	4,520,055	304,783	769,430	12,404,480
Somalia	34,542	1,948,200	2,184,442	–	52,704	756,390	–	–	14,599	324,790	5,315,668
Sudan	1,090,312	7,607,940	6,624,920	1,210,730	5,205,860	17,696,030	174,323	354,104	144,193	885,523	40,993,936
Tanzania	–	–	864,419	1,082,820	–	2,986,166	4,181,740	4,203,498	1,014,430	3,756,570	18,089,643
Uganda	–	–	52,932	149,318	–	270,451	1,738,770	3,155,398	65,913	1,540,200	6,972,982
Total	3,240,651	18,968,913	19,116,580	5,678,496	12,825,785	51,594,303	17,731,255	35,744,915	2,738,076	11,964,149	179,603,122
Camels											
Burkina Faso	–	10,227	3,511	–	355	1,555	–	–	62	1	15,710
Chad	190,693	444,064	53,061	8,410	87,645	325,040	8,347	–	1,388	8,350	1,126,999
Mali	279,562	279,488	7,890	–	5,151	5,236	–	–	141	423	577,890
Mauritania	599,754	735,283	12,852	–	82,604	30,540	–	–	2,007	21,607	1,484,647
Niger	422,688	736,647	12,284	–	312,341	100,240	–	–	1,414	128	1,585,742
Nigeria	–	33	102	133	703	12,924	1,771	639	266	1,899	18,469
Senegal	–	1,162	15	–	1,626	630	–	–	236	16	3,684
Djibouti	2,779	63,565	470	–	342	7	–	–	652	1,002	68,817

table continues next page

Table B.2 Livestock Numbers by Country and AI-Derived Livestock Production System for the Focus Countries *(continued)*

			Livestock Only Systems			*Mixed Systems*					
	Hyper-Arid	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Humid*	*Urban*	*Other*	*Total*
Eritrea	5,383	192,397	34,501	6	10,536	71,269	16	–	786	18,252	333,146
Ethiopia	–	1,105,220	445,656	1,060	15,102	567,640	8,477	13,237	2,979	1,286	2,160,657
Kenya	–	782,557	239,084	1,427	7,478	18,978	944	679	175	6,577	1,057,899
Somalia	272,486	3,566,380	1,804,745	–	362,343	876,398	–	–	7,427	107,106	6,996,884
Sudan	1,128,333	596,370	401,091	55,650	562,982	741,855	6,796	205,009	49,893	268,930	4,016,910
Tanzania	–	–	–	–	–	–	–	–	–	–	–
Uganda	–	–	–	–	–	–	–	–	–	–	–
Total	2,901,679	8,513,392	3,015,262	66,687	1,449,209	2,752,309	26,350	219,564	67,426	435,578	19,447,454
Sheep											
Burkina Faso	–	308,410	1,363,210	379,781	17,339	4,751,780	280,055	–	216,701	6,981	7,324,257
Chad	527,490	400,767	230,189	182,034	386,329	757,014	121,740	13,185	10,980	61,415	2,691,143
Mali	1,412,882	3,098,540	893,323	292,298	234,114	2,471,051	215,536	16,170	122,804	114,945	8,871,663
Mauritania	2,729,414	5,433,500	14,925	–	472,946	60,915	–	–	32,991	101,838	8,846,529
Niger	1,132,452	2,254,450	178,483	–	3,502,010	2,213,758	–	–	218,147	14,507	9,513,807
Nigeria	–	20,387	131,187	281,843	3,726,730	19,832,370	4,071,100	2,045,350	915,701	1,267,090	32,291,758
Senegal	–	391,888	291,212	69,947	435,273	3,188,346	61,154	2,892	280,149	261,412	4,982,273
Djibouti	51,295	288,699	3,032	–	1,753	41	–	–	9,002	105,373	459,195
Eritrea	3,306	496,294	191,354	30	39,913	716,935	293	–	17,828	703,089	2,169,043
Ethiopia	–	5,550,250	2,066,932	182,198	354,853	2,953,310	2,076,630	9,277,282	194,455	977,059	23,632,969
Kenya	–	1,826,070	2,800,675	226,346	15,359	1,103,091	751,325	2,075,882	124,416	934,791	9,857,955
Somalia	1,507,062	9,234,580	1,275,276	–	335,655	468,139	–	–	28,049	238,848	13,087,609
Sudan	6,466,406	4,224,780	7,455,720	1,704,220	6,869,670	17,720,630	423,121	2,071,820	425,910	2,970,720	50,332,997
Tanzania	–	–	314,525	143,607	–	973,261	595,795	355,886	179,552	849,617	3,412,243
Uganda	–	–	2,865	9,264	–	5,350	170,941	855,544	67,748	536,311	1,648,024
Total	13,830,308	33,528,615	17,212,907	3,471,569	16,391,945	57,215,991	8,767,690	16,714,011	2,844,434	9,143,996	179,121,466

table continues next page

Table B.2 Livestock Numbers by Country and AI-Derived Livestock Production System for the Focus Countries *(continued)*

			Livestock Only Systems			*Mixed Systems*					
	Hyper-Arid	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Humid*	*Urban*	*Other*	*Total*
Goats											
Burkina Faso	–	482,716	1,979,837	489,689	28,719	7,287,210	332,453	–	356,350	9,466	10,966,439
Chad	587,251	1,677,140	351,991	277,018	1,188,310	1,440,253	209,450	20,517	31,304	187,801	5,971,035
Mali	1,663,592	5,115,110	1,097,388	370,188	377,785	3,403,320	341,255	15,315	130,070	134,171	12,648,194
Mauritania	1,661,586	3,655,190	5,218	–	207,062	21,427	–	–	4,338	48,196	5,603,018
Niger	1,193,684	2,883,840	165,515	–	4,663,960	2,569,475	–	–	191,558	19,665	11,687,697
Nigeria	–	37,583	357,998	693,019	5,628,780	24,478,700	7,426,570	7,757,790	1,169,230	3,614,540	51,164,211
Senegal	–	282,297	259,168	132,761	357,941	2,650,524	501,325	38,405	165,304	392,899	4,780,624
Djibouti	56,100	367,415	5,971	–	2,127	121	–	–	2,644	77,597	511,975
Eritrea	14,891	714,723	229,410	112	45,995	498,106	710	–	11,265	177,888	1,693,100
Ethiopia	–	4,909,320	2,690,795	295,984	271,402	4,576,660	1,932,590	3,082,915	162,557	637,505	18,559,728
Kenya	–	2,357,130	3,710,560	204,776	29,536	2,796,410	786,985	1,510,933	154,243	1,272,240	12,822,813
Somalia	494,875	8,607,110	1,451,753	–	762,125	942,348	–	–	75,031	356,143	12,689,385
Sudan	5,284,836	5,125,050	5,894,250	1,871,370	5,387,960	13,588,880	532,473	1,907,634	837,341	2,279,120	42,708,914
Tanzania	–	–	497,257	765,131	–	1,788,776	2,256,990	3,126,658	700,629	3,660,660	12,796,101
Uganda	–	–	59,757	141,204	–	265,144	1,619,940	3,900,675	102,944	1,943,990	8,033,653
Total	10,956,815	36,214,624	18,756,868	5,241,252	18,951,701	66,307,354	15,940,741	21,360,843	4,094,808	14,811,881	212,636,888
TLU											
Burkina Faso	–	319,281	1,353,199	652,488	15,601	3,609,493	395,122	–	145,077	5,276	6,495,539
Chad	831,804	1,192,178	508,591	210,301	876,680	1,717,938	162,464	10,429	16,017	136,788	5,663,189
Mali	558,311	2,212,105	805,661	379,548	274,128	2,246,010	320,093	13,149	74,688	131,384	7,015,076
Mauritania	1,032,374	2,108,287	17,672	–	207,499	47,593	–	–	8,946	57,781	3,480,151
Niger	962,124	2,055,542	166,541	–	2,756,270	1,842,377	–	–	105,209	7,513	7,895,575
Nigeria	–	13,183	90,323	201,892	2,361,019	9,191,914	2,582,402	1,943,866	357,457	1,225,849	17,967,905

table continues next page

Table B.2 Livestock Numbers by Country and AI-Derived Livestock Production System for the Focus Countries *(continued)*

			Livestock Only Systems			*Mixed Systems*					
	Hyper-Arid	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Humid*	*Urban*	*Other*	*Total*
Senegal	–	223,152	207,756	107,562	230,212	1,632,425	127,254	8,542	81,696	242,212	2,860,812
Djibouti	32,063	223,992	3,253	–	1,685	60	–	–	2,377	59,275	322,705
Eritrea	6,798	518,202	182,039	70	43,594	558,218	453	–	7,734	471,215	1,788,324
Ethiopia	–	2,458,125	2,585,938	585,602	324,811	5,251,711	4,280,168	14,367,826	348,583	1,403,709	31,606,472
Kenya	–	1,624,238	2,181,383	219,440	14,376	1,404,342	1,038,502	3,071,190	210,858	686,965	10,451,294
Somalia	411,659	5,449,555	2,846,690	–	395,040	1,208,361	–	–	24,267	329,347	10,664,919
Sudan	2,619,145	5,917,206	5,590,713	1,122,952	4,743,366	14,267,868	204,911	753,914	247,766	1,244,549	36,712,390
Tanzania	–	–	599,830	740,566	–	2,067,903	2,794,323	2,870,353	696,676	2,704,970	12,474,620
Uganda	–	–	38,021	104,638	–	189,320	1,222,350	2,368,860	56,617	1,172,150	5,151,957
Total	6,454,278	24,315,046	17,177,608	4,325,060	12,244,282	45,235,533	13,128,041	25,408,129	2,383,968	9,878,981	160,550,927

Source: Robinson and Conchedda (2014).
Note: AI = Aridity Index.

Table B.3 Rural Livestock Keepers by Country and by AI-Derived Livestock Production System *(continued)*

			Livestock only Systems			*Mixed Systems*				
Country	*Hyper-Arid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Arid*	*Semi-Arid*	*Dry Sub-Humid*	*Humid*	*Other*	*Total*
Burkina Faso	–	144,874	1,260,161	631,844	5,670	2,151,578	504,458	–	4,602	4,703,187
Chad	3,225	767,144	1,155,353	851,017	187,975	1,029,436	507,721	35,102	30,597	4,567,570
Mali	8,334	745,192	724,873	627,879	155,347	1,472,636	653,354	16,720	13,593	4,417,928
Mauritania	124,605	1,119,739	12,404	–	142,997	174,963	–	–	2,971	1,577,679
Niger	13,397	2,057,381	254,447	–	3,940,160	6,738,231	–	–	1,525	13,005,141
Nigeria	–	29,518	158,783	1,069,400	507,854	7,643,415	6,589,802	23,472,572	1,305,930	40,777,274
Senegal	–	273,620	232,134	288,604	282,216	3,249,834	259,777	150,734	43,545	4,780,464
West Africa	149,561	5,137,468	3,798,155	3,468,744	5,222,219	22,460,093	8,515,112	23,675,128	1,402,763	73,829,243
Djibouti	–	150,582	2,340	–	739	779	–	–	1,668	156,108
Eritrea	20	855,206	577,361	725	55,235	1,019,970	10,257	–	11,348	2,530,122
Ethiopia	–	2,613,620	3,364,160	1,654,740	48,278	1,653,447	8,048,885	23,777,674	498,705	41,659,509
Kenya	–	1,296,710	1,372,584	398,124	12,372	395,111	3,006,951	11,111,871	212,540	17,806,263
Somalia	112,531	1,719,102	1,561,193	–	81,459	483,248	–	–	107,553	4,065,086
Sudan & S. Sudan	447,417	5,019,660	2,712,821	440,660	3,261,955	6,830,267	80,498	245,175	173,772	19,212,225
Tanzania	–	–	47,926	298,593	–	4,007	3,964,194	14,982,202	141,710	19,438,632
Uganda	–	–	1,593,864	2,423,780	–	687,743	6,143,824	6,568,514	639,313	18,057,038
East Africa	559,968	11,654,880	11,232,249	5,216,622	3,460,038	11,074,572	21,254,609	56,685,436	1,786,609	122,924,983
Total	709,529	16,792,348	15,030,404	8,685,366	8,682,257	33,534,665	29,769,721	80,360,564	3,189,372	196,754,226

Source: Robinson and Conchedda (2014).
Note: AI = Aridity Index.

Table B.4 Rural Poor and Rural Poor Livestock Keepers by Region and by AI-Derived Livetock Production System

					Livestock Only Systems			Mixed Systems				
	Region	Poverty Measure	Hyper-Arid	Arid	Semi-Arid	Dry Sub-Humid	Arid	Semi-Arid	Dry Sub-Humid	Humid	Other	Total
Rural poor	West Africa	Rural Nat. Pov. Rate	287,396	4,035,654	2,777,893	2,281,078	4,766,095	23,985,892	5,197,102	12,537,800	2,011,482	57,880,394
		Int. Rate $1.25	133,837	3,399,038	2,828,680	2,620,211	4,823,152	30,725,187	7,776,964	22,065,509	3,403,443	77,776,021
		Int. Rate $2.00	239,131	4,828,936	4,001,037	3,653,519	6,414,438	42,031,331	10,374,060	28,786,782	4,473,772	104,803,006
	East Africa	Rural Nat. Pov. Rate	1,442,823	7,269,195	7,395,543	2,982,945	3,554,246	15,409,287	13,510,197	35,722,931	3,072,061	90,359,226
		Int. Rate $1.25	1,392,353	6,407,874	7,579,348	4,306,637	3,409,238	16,618,212	16,790,163	36,883,917	3,994,378	97,382,119
		Int. Rate $2.00	1,959,758	10,029,747	11,299,821	5,736,244	4,817,461	24,653,175	24,581,909	59,900,362	5,482,776	148,461,252
	Total	Rural Nat. Pov. Rate	1,730,219	11,304,849	10,173,436	5,264,023	8,320,341	39,395,179	18,707,299	48,260,731	5,083,543	148,239,620
		Int. Rate $1.25	1,526,190	9,806,912	10,408,028	6,926,848	8,232,390	47,343,399	24,567,128	58,949,426	7,397,820	175,158,140
		Int. Rate $2.00	2,198,889	14,858,683	15,300,857	9,389,763	11,231,899	66,684,506	34,955,969	88,687,143	9,956,548	253,264,258
Rural poor livestock keepers	West Africa	Rural Nat. Pov. Rate	218,421	3,067,097	2,111,199	1,733,619	3,240,945	16,310,406	3,534,030	8,662,226	522,985	39,400,929
		Int. Rate $1.25	101,716	2,583,269	2,149,797	1,991,360	3,279,743	20,893,127	5,288,336	15,241,449	884,895	52,413,693
		Int. Rate $2.00	181,740	3,669,991	3,040,788	2,776,674	4,361,818	28,581,305	7,054,361	19,884,921	1,163,181	70,714,779
	East Africa	Rural Nat. Pov. Rate	1,096,545	5,524,588	5,620,612	2,267,038	2,416,887	10,478,315	9,186,934	24,543,643	798,736	61,933,299
		Int. Rate $1.25	1,058,188	4,869,984	5,760,304	3,273,044	2,318,282	11,300,384	11,417,311	25,396,004	1,038,538	66,432,040
		Int. Rate $2.00	1,489,416	7,622,607	8,587,864	4,359,546	3,275,874	16,764,159	16,715,698	41,206,020	1,425,522	101,446,705
	Total	Rural Nat. Pov. Rate	1,314,966	8,591,686	7,731,811	4,000,657	5,657,832	26,788,721	12,720,963	33,205,870	1,321,721	101,334,228
		Int. Rate $1.25	1,159,904	7,453,253	7,910,101	5,264,404	5,598,025	32,193,511	16,705,647	40,637,453	1,923,433	118,845,733
		Int. Rate $2.00	1,671,156	11,292,599	11,628,652	7,136,220	7,637,692	45,345,464	23,770,059	61,090,940	2,588,702	172,161,484

Source: Robinson and Conchedda (2014).
Note: AI = Aridity Index.

APPENDIX C

Factors Used to Estimate the Production of Crop Byproducts and Crop Residues and the Share of Biomass Accessible to Livestock

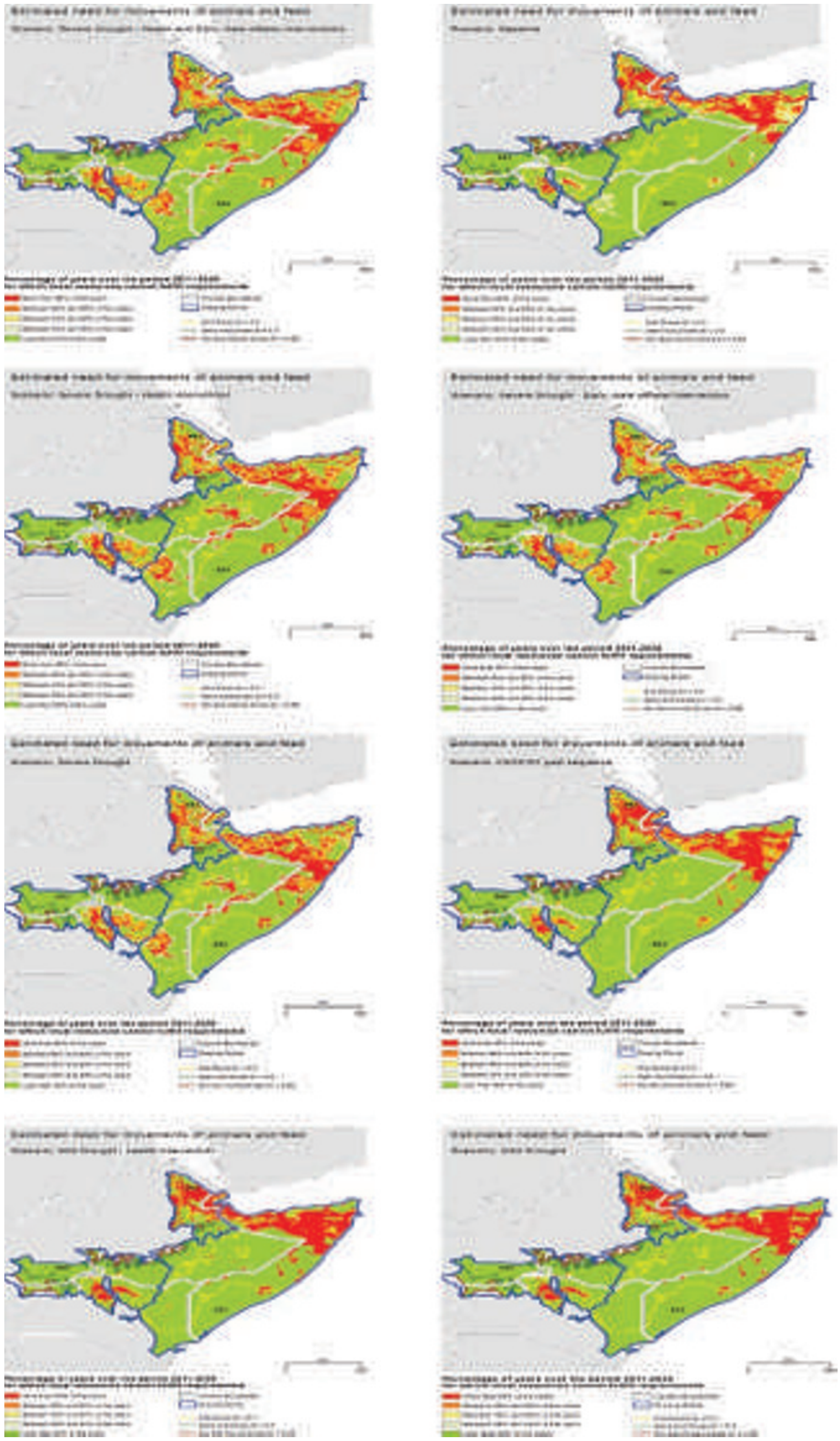
Table C.1 Feed Use Efficiency and Mass Fraction Allocations

	Feed Use Efficiency (fraction of gross yield as intake for the animals)	*Mass Fraction Allocation (fraction of biomass going to feed component after processing)*
Crop residues (straws, stover, cane tops)	0.7	0.32 (sugarcane tops) to 0.9 (maize stover)
Grains (wheat, barley, sorghum)	1	1
Corn	1	1
Cotton	1	0.45
Soy	1	0.80
Rapeseed	1	0.58
Sugar beet	1	0.19 (pulps) to 0.13 (molasses)

Source: GLEAM.

APPENDIX D

Maps of Feed Balances at Pixel Level



APPENDIX E

Relative Feed Balances Under Different Scenarios

(assuming complete access to resources and full mobility, by reference to the past sequence)

Table E.1 Relative Feed Balances Under Different Scenarios in West and East African Grazing Sheds

		West Africa				*East Africa*		
	Usable Biomass	*WA1 (%)*	*WA2 (%)*	*WA3 (%)*	*WA4 (%)*	*EA1 (%)*	*EA2 (%)*	*EA3 (%)*
Baseline	Byproducts	47	43	39	48	28	43	35
	Crop residues	37	39	21	29	24	34	28
	Natural vegetation	281	241	299	262	357	256	228
	Total	290	242	229	276	363	291	231
Drought	Byproducts	69	56	51	78	31	47	35
	Crop residues	40	44	23	32	20	33	24
	Natural vegetation	327	305	322	267	393	331	279
	Total	350	320	245	296	399	372	283
Drought plus male	Byproducts	52	40	38	63	18	28	26
	Crop residues	31	33	18	24	12	18	19
	Natural vegetation	282	245	272	229	317	251	263
	Total	295	252	203	249	327	297	266
Drought plus health	Byproducts	81	65	60	95	33	49	37
	Crop residues	44	49	25	36	21	34	26
	Natural vegetation	365	346	363	293	426	360	306
	Total	391	362	277	326	431	396	309
Drought plus health plus male	Byproducts	52	40	38	63	18	29	27
	Crop residues	33	36	19	25	13	18	20
	Natural vegetation	309	279	304	242	344	269	288
	Total	77	61	57	88	353	314	291
Mild drought	Byproducts	44	46	25	36	34	50	38
	Crop residues	352	327	340	292	21	35	26
	Natural vegetation	378	344	261	325	365	339	256
	Total	88	73	68	98	372	374	259
Mild drought plus health	Byproducts	48	53	28	39	34	51	39
	Crop residues	401	444	433	319	22	36	27
	Natural vegetation	428	448	325	353	376	357	264
	Total	47	43	39	48	382	389	267

Note: This table can be read as follows: in the grazing shed WA1, total use of usable biomass will increase by 290 percent in the baseline future scenario compared to the past.

APPENDIX F

Absolute Feed Balances Under Different Scenarios

Table F.1 Absolute Feed Balances Assuming Full Mobility and 10 percent Accessibility to Natural Vegetation

		West Africa			*East Africa*			
	Usable Biomass	*WA1 (%)*	*WA2 (%)*	*WA3 (%)*	*WA4 (%)*	*EA1 (%)*	*EA2 (%)*	*EA3 (%)*
Baseline	Byproducts	32	17	19	45	581	194	480
	Crop residues	100	100	100	100	354	123	305
	Natural vegetation	108	100	143	95	138	95	108
	Total	105	95	95	95	137	94	108
Drought	Byproducts	46	22	24	73	654	211	478
	Crop residues	100	100	100	100	293	118	261
	Natural vegetation	110	103	151	95	143	96	112
	Total	107	96	93	95	141	95	112
Drought plus male	Byproducts	35	15	18	59	372	125	355
	Crop residues	100	100	100	100	181	100	202
	Natural vegetation	108	102	147	95	133	95	111
	Total	103	93	88	94	131	94	111
Drought plus health	Byproducts	54	25	29	89	678	219	501
	Crop residues	100	100	100	100	307	124	278
	Natural vegetation	112	104	154	96	147	96	114
	Total	110	98	97	96	146	96	114
Drought plus health plus male	Byproducts	35	15	18	59	380	128	366
	Crop residues	100	100	100	100	186	100	212
	Natural vegetation	110	103	150	95	136	95	113
	Total	105	95	90	94	135	94	113
Mild drought	Byproducts	52	23	27	83	698	224	515
	Crop residues	100	100	100	100	309	126	277
	Natural vegetation	111	104	152	96	139	96	110
	Total	109	97	95	96	138	96	110
Mild drought plus health	Byproducts	59	28	33	92	716	230	531
	Crop residues	100	100	100	104	319	131	291
	Natural vegetation	114	108	160	96	141	96	111
	Total	112	101	103	96	139	96	111

Table F.2 Absolute Feed Balances Assuming Full Mobility and 20 Percent Accessibility to Natural Vegetation

		West Africa				East Africa		
	Usable Biomass	*WA1 (%)*	*WA2 (%)*	*WA3 (%)*	*WA4 (%)*	*EA1 (%)*	*EA2 (%)*	*EA3 (%)*
Baseline	Byproducts	32	17	19	45	581	194	480
	Crop residues	100	100	100	100	354	123	305
	Natural vegetation	98	90	133	85	128	85	98
	Total	95	86	88	85	127	84	98
Drought	Byproducts	46	22	24	73	654	211	478
	Crop residues	100	100	100	100	293	118	261
	Natural vegetation	100	93	141	85	133	86	102
	Total	98	87	86	85	132	86	102
Drought plus male	Byproducts	35	15	18	59	372	125	355
	Crop residues	100	100	100	100	181	100	202
	Natural vegetation	98	92	137	85	123	85	101
	Total	94	84	81	84	122	84	101
Drought plus health	Byproducts	54	25	29	89	678	219	501
	Crop residues	100	100	100	100	307	124	278
	Natural vegetation	102	94	144	86	137	86	104
	Total	100	89	90	86	136	86	104
Drought plus health plus male	Byproducts	35	15	18	59	380	128	366
	Crop residues	100	100	100	100	186	100	212
	Natural vegetation	100	93	140	85	126	85	103
	Total	96	85	84	84	125	85	103
Mild drought	Byproducts	52	23	27	83	698	224	515
	Crop residues	100	100	100	100	309	126	277
	Natural vegetation	101	94	142	86	129	86	100
	Total	99	88	88	86	128	86	100
Mild drought plus health	Byproducts	59	28	33	92	716	230	531
	Crop residues	100	100	100	104	319	131	291
	Natural vegetation	104	98	150	86	131	86	101
	Total	103	92	96	86	130	86	101

Table F.3 Absolute Feed Balances Assuming Full Mobility and 30 Percent Accessibility to Natural Vegetation

		West Africa			East Africa			
	Usable Biomass	*WA1 (%)*	*WA2 (%)*	*WA3 (%)*	*WA4 (%)*	*EA1 (%)*	*EA2 (%)*	*EA3 (%)*
Baseline	Byproducts	32	17	19	45	581	194	480
	Crop residues	100	100	100	100	354	123	305
	Natural vegetation	88	80	123	75	118	75	88
	Total	86	76	80	75	117	75	88
Drought	Byproducts	46	22	24	73	654	211	478
	Crop residues	100	100	100	100	293	118	261
	Natural vegetation	90	83	131	75	123	76	92
	Total	88	78	79	75	122	76	92
Drought plus male	Byproducts	35	15	18	59	372	125	355
	Crop residues	100	100	100	100	181	100	202
	Natural vegetation	88	82	127	75	113	75	91
	Total	85	75	74	74	112	74	91
Drought plus health	Byproducts	54	25	29	89	678	219	501
	Crop residues	100	100	100	100	307	124	278
	Natural vegetation	92	84	134	76	127	76	94
	Total	91	80	83	76	126	76	94
Drought plus health plus male	Byproducts	35	15	18	59	380	128	366
	Crop residues	100	100	100	100	186	100	212
	Natural vegetation	90	83	130	75	116	75	93
	Total	86	76	77	75	116	75	93
Mild drought	Byproducts	52	23	27	83	698	224	515
	Crop residues	100	100	100	100	309	126	277
	Natural vegetation	91	84	132	76	119	76	90
	Total	90	79	81	76	119	76	90
Mild drought plus health	Byproducts	59	28	33	92	716	230	531
	Crop residues	100	100	100	104	319	131	291
	Natural vegetation	94	88	140	76	121	76	91
	Total	93	83	89	76	120	76	91

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Prospects for Livestock-Based Livelihoods in Africa's Drylands examines the challenges and opportunities facing the livestock sector and the people who depend on livestock in the dryland regions of Sub-Saharan Africa. It presents a novel way of thinking about pastoral development, grounded in a conceptual framework that focuses on the multiple shocks that drylands livestock keepers face and how those shocks can be addressed, drawing on a state-of-the-art literature review carried out by scientists of leading research institutes and development organizations, and integrating the results of an innovative approach to modeling development options for the drylands livestock sector.

Looking to the future, the picture is mixed. On the positive side, demand for red meat is expected to strengthen in domestic and regional markets, suggesting that livestock keepers will have good market opportunities. On the negative side, a large majority of livestock keepers are classified as poor, and the natural (feed) resource base is likely to be sufficient to enable improved meat and milk production for the growing human population.

Prospects for the livestock sector through 2030 vary by aridity zone. In arid and semi-arid zones, a reasonable goal for 2030 is to have land use, training, and microfinance systems established that promote an appropriate balance between human and livestock carrying capacities, featuring mainly grassland/pastoral systems that reliably and sustainably satisfy the minimum income needs of herder households, produce at least a significant part of the demand in local markets for animal source food, and provide environmental services for which livestock keepers receive compensation. The goal includes significant employment generation outside the sector. In the higher rainfall zones of the semi-arid areas, and in the subhumid zones, a reasonable goal for 2030 is to have intensified production systems established, featuring mainly mixed livestock/arable farming or agro-pastoral systems that are closely linked to nearby grassland/pastoral systems and that consistently generate marketable surpluses of differentiated red meat and livestock products that can compete not only in the expanding domestic market but also in selected regional markets.

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