Building climate change resilience for African livestock in sub–Saharan Africa

World Initiative for Sustainable Pastoralism (WISP)

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The World Initiative for Sustainable Pastoralism

The World Initiative for Sustainable Pastoralism (WISP) is an advocacy and capacity building platform that seeks a greater recognition of the importance of sustainable pastoral development for both poverty reduction and environmental management. WISP is a global network that is designed to empower pastoralists to sustainably manage drylands resources and to demonstrate that their land use and production system is an effective and efficient way of harnessing the natural resources of the world's drylands.

WISP is hosted by IUCN, The International Union for Conservation of Nature, and is currently funded by the Global Environment Facility (GEF) and the International Fund for Agricultural Development (IFAD). WISP works through partnerships at global, regional and national levels to promote knowledge sharing that leads to policies, legal mechanisms and support systems for sustainable pastoral development. WISP provides the social, economic and environmental arguments for pastoralism to improve perceptions of pastoralism as a viable and sustainable resource management system.
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Contents

Abbreviations and acronyms

ACMAD .... African centre of Meteorological Application on Development
ALG .... Autorité du Liptako–Gourma (Liptako–Gourma Authority)
APESS .... Association pour la promotion de l'élevage au Sahel et en Savane (Association for the Promotion of Livestock in the Sahel and Savannah)
ASAL .... Arid and Semi Arid Lands
AU–IBAR.......... African Union–Inter–African Bureau for Animal Resources
CBO .... Community based organization
CC .... Climate change
CEBV .... Communauté économique du bétail et de la viande (Economic Community for Meat and Livestock)
CEMAC .... Communauté économique et monétaire de l'Afrique Centrale. (Economic and Monetary Community of Central Africa)
CILSS............... Permanent Inter–State Committee for Drought Control in the Sahel
CIRAD .... Centre International de Recherche Agricole pour le Développement (International centre for Agricultural Research for Development)
CIRDES .... Centre international de recherche–développement sur l'élevage en zone subhumide
CLIP................. Climate Land Interaction Project
CORAF .... Conseil ouest et centre africain pour la recherche et le développement
CPP .... Namibian Country Pilot Partnership Program
ECOWAS .... Economic Community of West African States
EMCCA .... Economic and Monetary Community of Central Africa
FAO................. Food and Agriculture Organization of the United Nations
FAOSTAT .... FAO Statistical Database
FARA................ Forum For Agricultural Research in Africa
GDP .... Gross domestic product
GG .... Greenhouse gases
GNP .... Gross National Product
IFAD................ International Food and Agricultural Development
IITA .... International Institute of Tropical Agriculture
ILRI .... International Livestock Research Institute
INERA .... Institut de l'environnement et de recherches agricoles (Environmental and Agricultural Research Institute)
INSAH .... Institut du Sahel (Sahel Institute)
IPCC .... Intergovernmental Panel on Climate Change
IRAD .... Institut de Recherche Agricole pour le Développement (Institute of Agricultural Research for Development)
ISLM................ Integrated Sustainable Land Management
ITC.................. International Trypanotolerance Centre
IUCN .... International Union For Conservation of Nature
NGO................ Non–governmental organization
OECD .... Organization for Economic Co–operation and Development
OIE .... World Organization for Animal Health
PACE................ Pan–African Program for the Control of Epizootics
PAPENOC .... Support Project for Unconventional Animal Husbandry
PDAP .... Projet de développement de l'agriculture Périurbaine (Peri–urban Agricultural Development Project, Mali)
ppm................. Parts per million
RECOPA .... Réseau de communication sur le pastoralisme (Pastoralism Communication Network, Burkina Faso)
ROPPA .... Réseau des organizations paysannes et de producteurs de l'Afrique de l'Ouest (Network of Farmers' and Agricultural Producers' Organizations of West Africa)
SODECOTON .... Société de développement du coton du Cameroun (Cotton Development Corporation, Cameroon)
SWA .... Sahel and West Africa (region)
SWAC .... Sahel and West Africa Club
TLU.................. Tropical livestock unit
UEMOA .... West African Economic and Monetary Union
UICN .... International Union for Conservation of Nature
UNCCD .... United Nations Convention to Combat Desertification
UNCCD .... United Nation Convention to Combat Desertification
UNDP............... United Nations Development Program
UNFCCC........... United Nations Framework Convention on Climate Changes
USAID .... United States Agency for International Development
USD .... United States Dollar
WECARD .... West and Central African Council for Agricultural Research and Development
WHO .... World health organizations
WISP................ World Initiative for Sustainable Pastoralism

Foreword

The insight that climate change will in affect agricultural production in developing countries in particular has resulted in support to increase the adaptive capacity among vulnerable populations. This study focuses on livestock production systems in Africa, as African livestock owners are thought to be among the most vulnerable populations on earth. Yet, livestock also has potential to strengthen resilience to climate change, as livestock production systems tend to be more resilient than crop based systems. This scoping study is a welcome addition to the climate change adaptation literature as it addresses a dimension frequently ignored in climate change adaptation studies. It explicitly stresses the resilience of livestock production systems to drought and the associated potential to use livestock to adapt to climate change.

The study clearly dissects the various aspects of climate change and their impacts on the biological and socio economic aspects of the various African livestock production systems. In doing so, it appropriately stresses the differences between modern industrial systems and pays particular attention to impacts on the various traditional livestock production systems in Africa.

Livestock based livelihoods in the drylands of Africa are vulnerable to climate change, and thus likely to be affected. Yet, in other parts of the world livestock is increasingly seen as a driver of climate change, rather than being affected by it. The study rightfully addresses this controversy, and places the African livestock in the perspective where it belongs, an asset to many poor with as yet untapped potential to adapt to climate change.

The study then reviews traditional coping strategies. It also discusses a number of innovative social, technical and management interventions that might be considered to increase the resilience of livestock production systems to climate change. However, substantial controversy exists about the short term and long term effectiveness of a number of them. This will require more in depth analyses over the coming years. The final chapter then provides an overview of the steps to be taken to increase the resilience of livestock production systems and livestock dependent livelihoods to climate change.

Overall the study provides a welcome synopsis of the likely impacts of climate change on African livestock, the need to address these and the management and policy options open to develop more climate change resilient livestock production systems.

Jan de Leeuw,
ILRI – International Livestock Research Institute

Executive Summary

This scoping study was carried out to identify entry points for building the resilience of livestock systems to climate change and variability. The study explores how strengthening the resilience of African livestock systems to climate change, and making current investments to improve African livestock coping mechanisms, can improve the climate resilience of small–holder farmers and pastoralists. The study was implemented in 2009 through two sub–regional reviews (one in eastern and southern Africa, the second in West and Central Africa), six country visits (Kenya, Namibia, Malawi, Cameroon, Niger and Mali), and an e–conference.

This report uses a simplified categorization of livestock systems, grouping systems that have a degree of similarity in how they will be affected by climate change:

1. Range based livestock systems including pastoralism and ranching (including game ranching);
2. Mixed farming systems in which farmers produce both livestock and crops, although it is recognized that livestock in such systems may also rely on rangelands and therefore overlap with the first category;
3. Off–land systems, predominantly urban and peri–urban livestock farms, which use either cut–and–carry (zero grazing) or purchased feed inputs.

'Climate change' refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period and warming of the global climate is now unequivocal. Climate change is characterized by increasing temperature and related climate phenomena, including an increase in the frequency and intensity of extreme weather events such as hot spells, droughts and floods, and an increase in climatic uncertainty. Climate change impacts on the natural environment by changing growing seasons of plants, migration and reproduction patterns of wildlife, and shifts in the range that species cover. Climate change impacts adversely on the agricultural sector through increased water stress through changing patterns of run–off, shifting (and unpredictable) seasonality, and through changes in temperature. Areas affected by drought are projected to expand, whilst simultaneously there are increased risks of flood.

Africa's livestock sector will be specifically affected by climate changes through: changes in the pattern and quantity of rainfall; an increase in temperature; changes in winds; changes in seasonality; more frequent catastrophic events; a decrease in feed and fodder production; reduced water availability; changing patterns and distribution of disease; changes in the marketing and prices of commodities.

Traditionally, however, livestock keepers have been capable of adapting to livelihood threats and indeed—for some people—livestock keeping is itself an adaptation. It is important, however, to recognize that the outcomes of climate change are uncertain and the precise adaptations will vary from location to location and person to person. Strengthening resilience in the livestock sector relies on building the adaptive capacity of livestock keepers and it is necessary to take an ambitious approach to address the fundamental determinants of capacity. Four dimensions of adaptive capacity are discussed in this report:

1. The ability to make informed assessment of imminent threats;
2. The ability to make to make an informed choice, from a range of options, about the best response measure;
3. Being capable of deploying the preferred option (skills, money, infrastructure);
4. Being free to implement this option (policy, governance, rights).

It is also important to build adaptive capacity in recognition of the fact that climate change is not the only threat with which livestock keepers are struggling. Important pre–existing threats to livestock keeping populations include: population pressure, from both external encroachers and internal demographic growth; insecure tenure and weakening or breakdown of customary governance institutions; loss of land, and in particular key resource pockets; restriction of transhumance and loss of access to key resources; sedenterization policies leading to land degradation and severely reduced carrying capacity; conflicts between pastoral groups as well as with crop farmers (linked to weakening governance above); market failures and entry barriers; inequity in global livestock trade (subsidies and concessions) undercutting local markets; poor access to foreign markets.

Improving the assessment of the threat of climate change can enable planners and farmers to react appropriately. Improving informed decision–making requires a strengthening of the knowledge base and building awareness to make use of that knowledge. At a local level this may require greater emphasis on raising awareness of the implications of climate change, although this is challenging considering the uncertainties in climate change predictions. Appropriate methodologies should be used to build awareness based on local experiences and existing understanding. At a national level the focus should be on both improving meteorological data collection and also making that information available regularly and reliably across the country.

Enabling livestock keepers and advisors/planners to make better–informed choices requires the development of new and relevant information and ensuring that farmers and planners can make both sense and use of that information. In other words, an effort is needed to ensure that information is transformed into knowledge. At a community level this requires the building of basic human capabilities through education and extension programs and through better access to information sources. To make informed choices, people need access to the full range of options at their disposal rather than a limited selection that has been determined by other people. At the national level greater emphasis should be placed on building the capacity of extension workers to understand local experiences and knowledge, which implies modification of university and technical training curricula. Collaborative research is also needed to investigate different adaptation options, both endogenous and exogenous, to broaden the array of options from which decision makers can select. Key technology/knowledge gaps on the ground include local breed development, best management practices and strategies, land use planning, fodder production and conservation, livestock health, and use of carbon finance and other payments for environmental services.

Understanding the threat of climate change and knowing the options for adaptation will enable stakeholders in the livestock sector to make informed choices, but many actors lack the basic capabilities to act on those choices. In the language of the widely understood 'livelihoods framework', these capabilities relate to the core livelihood assets: human, social, physical, financial and natural capital. In more practical terms, to be capable of deploying a preferred adaptation option, people need particular skills, resources and infrastructure. Many of the basic capabilities of livestock keepers are weak, leading to their underdevelopment and contributing to their vulnerability to climate change as well as other threats.

Livestock keepers need to understand the threats that they are facing and know the options that are at their disposal to adapt to the threat, and they need to have the wherewithal to implement the option of their choice. However, livestock keepers may still come up against significant challenges if the policy and legal environment is not conducive to adaptation. The freedom to choose the appropriate adaptation measure cuts across policy, governance and rights. At a local level, farmers need secure land rights, strong and equitable local institutions, and functioning legal systems. They may also need government to put in place supportive policies, or more importantly to relax policy disincentives. Significant attention is needed to strengthen policy and its implementation with respect to markets, local organizations, natural resource governance and tenure, women's rights and the regulation and protection of transhumance routes.

Although the African livestock sector does not contribute significantly to global climate change, there are options for mitigation of climate change that may provide other incentives for improved livestock production. Such options include a range of methods for reducing rumen emissions, improving waste management, improving carbon capture by rangelands and complementary activities such as silvopastoralism.

General Recommendations

1. Invest in research and communication to improve understanding of the complex relationship between livestock and climate change.
2. Promote understanding of the importance of the livestock sector to the adaptation strategies of rural poor people in Africa.
3. Treat adaptation as a generic capacity rather than specific only to climate change and focus on building adaptive capacities among all stakeholders in the livestock sector.
4. Avoid overspecification of climate change projections and the risk of only equipping livestock keepers to adapt to specific scenarios.
5. Develop adaptive capacity across at least of four distinct dimensions: making an informed assessment of threats; making informed choices about response measures from a range of options; deploying the preferred response measure; creating an enabling environment to implement this measure.
6. Build capacities for improved climate forecasting and warning and increase awareness of climate change and its consequences.
7. Strengthen human capital through basic education and public awareness and make information on adaptation options widely available to all stakeholders.
8. Build capacity of extension workers through community–based and participatory processes whilst promoting collaborative research into both endogenous and exogenous adaptation options.
9. Develop the skills, resources and infrastructure in the livestock sector that are needed to enable various stakeholders to act on the information available to them.
10. Increase livestock keepers' quality of engagement in policy processes and maintain policy dialogue beyond the confines of the livestock sector itself.
11. Promote climate change mitigation to harness new sources of funds for development, in full consultation with livestock keepers.

Recommendations for livestock research & development

1. Strengthen forecasting abilities in the livestock sector, through increased understanding of the impact of climate fluctuations on provision of productive inputs (fodder and water), greater predictions of extreme weather events, improved disease monitoring, and increased information exchange and overall awareness at all levels of the implications of these forecasts.
2. Strengthen the relevance of research and development to the explicit needs of livestock farmers by conducting research through knowledge partnerships and more genuinely participatory approaches, and building on the local knowledge of livestock keepers in the first instance.
3. Strengthen farmers' access to and understanding of information, through improved communication approaches and stronger extension services, including improved extension methodologies and practices based on farmer participation and expanded farmer field schools (and "pastoralist field schools").
4. Promote innovative approaches to local breed development that are driven by the environmental exigencies of livestock keeping groups, focusing on development of local breeds as well as promotion of 'exotic' breeds from comparable environments that display more locally–appropriate attributes such as drought survival and disease resistance.
5. Strengthen understanding of appropriate approaches to improved pasture management that accommodate climatic flux, based on the principles of mobility, fluctuating herd sizes, and diverse livestock species, and identify technological options, such as satellite imagery, for regulation of transhumance and landscape–scale seasonal resource management.
6. Based on improved understanding of pasture management, identify opportunities for livestock keepers to secure carbon credits for improved rangelands management.
7. Increase research into the specific roles of women in the livestock sector, including their role in processing and value addition (e.g. dairy processing) and product marketing, and target specific participatory research at boosting their capacities and security.
8. Develop financial products that are adapted to the production cycle of rural livestock enterprises, addressing appropriate repayment terms and collateral for loans, appropriate insurance products and relevant banking services, for example make use of new mobile telephone payment options.
9. Research and capacity building for landscape–scale rangelands management, integrating multiple land uses including livestock production and biodiversity enterprises (e.g. harvesting wild products or eco tourism), and building understanding of how to optimize production across a range of products rather than maximize production of a single commodity.
10. Continue to support development of the private veterinary sector in most countries, where models for training Community Animal Health Workers are proving successful, but where national level policy and private (and public) sector support are lagging behind, and ensure these approaches adapt to new disease risks associated with climate change.
11. Develop fodder production and conservation extension services, recognizing that in many cases these are tried and tested technologies that have historically been practiced by many livestock keepers, and focusing on addressing the structural/institutional barriers that have led to the loss of such practices.
12. Improve awareness of the shifting relationship between the crop and livestock sectors and identify synergies in mixed farming systems, for example through conservation agriculture or low external input agriculture, or improved adoption of agro–forestry and silvo–pastoral practices.
13. In water scarce areas, work closely with a wide stakeholder group of natural resource managers to identify safe options for improving water availability (options that do not exaggerate conflict or lead to serious resource degradation).
14. Increased support is needed to secure natural resource tenure and strengthen governance of natural resources, particularly in communal systems, to create a more stable foundation for livestock sector resilience.
15. Explore the options and benefits for mitigation strategies in the livestock sector, particularly where there are opportunities to access carbon finance payments, and identifying synergies between productivity and environmental benefits, for example through reduced methanogenesis (lower methane reduction leading to increased fed conversion efficiency), reforestation of rangelands, manure management, or restoration of degraded rangelands.

Introduction

Africa is comprised of 53 countries and agriculture is a key component of the continent's economy with livestock production in turn a key contributor to the agricultural sector. Agriculture is the largest productive sector in Africa and employs between 70 and 90% of the total labour force as well as supplying up to 50% of household food requirements and household incomes. Africa covers about 30 million km^2 and livestock production takes place on about 54% of the total area or 16 million km^2, where nearly 80% of the population lives: Sudan, South Africa, Ethiopia and Nigeria together contain about a quarter of Africa's livestock–producing land. Livestock production accounts for about 30% of the gross value of agricultural production, with 92% of that coming from the production of beef cattle, dairy cattle, goats, sheep and chickens (IFAD 2009). The total livestock population in Africa is about 250 million Tropical Livestock Unit (TLU) equivalents[1].

Livestock production is increasing throughout Africa, driven by growth of human population, living standards and urbanization. Total human population in Africa continues to grow at about 2.5% per year (World Bank, 2004) and will double in 16 years while GDP is increasing at 3.2%. Urban population and GDP increase faster at 4.1 and 4.7 respectively. Seventy per cent of the rural poor own livestock and over 200 million people rely on livestock for income. In small–scale mixed crop–livestock farming, livestock provide draught animal power, transportation and manure for fertilizing crop–lands. Apart from economic importance, livestock is socially and culturally important in Africa, for payment of dowry, celebrations and gifts to family members, and also as a source of savings: safer, despite diseases and drought, than the banking system and easier to manage for remote farmers.

Growth in the livestock sector is driven largely by private investment whilst public investment and policy have frequently been either negligible or harmful. The sector is widely constrained by a lack of regulation, which leads to negative externalities such as land degradation, water pollution, loss of biodiversity and emission of greenhouse gasses. Lack of regulation and public investment also leads to market failures, which usually disadvantage the small–holders who make up the majority of the sector in Africa (World Bank 2009). As a result, many people that rely significantly on livestock for their livelihoods face particular vulnerability in a steadily deteriorating environment.

According to various sources, Africa is one of the world's most vulnerable regions due to the fragility of its economies. The latest report of the Intergovernmental Panel on Climate Change (IPCC 2007) confirmed that in the 21st century, global warming would be more intense in Africa than in the rest of the world. Such changes will affect natural resources and all related production systems, including livestock. Various studies indicate that global warming and increased climate variability will severely affect African agriculture. However, it is still difficult to assess the extent and nature of such changes in the future. African agriculture and its slow rate of development has been a serious concern before the issue of climate change arose. Though agriculture is the backbone of the African economy, it has the lowest record of productivity increases in the world.

The general consensus is that climate change and global warming are real, and are due to increased greenhouse gas emissions into the atmosphere. Climate changes are already being perceived in Africa and are influencing the way that agricultural producers operate. Individuals, communities and nations have coped with and adapted to climate variability for centuries, but the new changes may be of a magnitude and speed that overstretch traditional adaptive capacities. Livestock production has historically been one mechanism through which rural producers have coped with climate changes, whether through the accumulation of small stock to buffer against newly arising climate stress during the past century in the Sahel, through the rise of mobile pastoralism in response to long–term climate change several millennia ago, or through the small inter–annual modifications in livestock types that enable livestock keepers to continuously manage the shifting resources of Africa's largely arid and semi–arid landscape.

Table 1: Climate change projections for Africa[2]

Temperature	• Warming throughout the continent and in all seasons is very likely to be larger than the global annual mean warming, with drier subtropical regions warming more than the moister tropics.
Rainfall	• Annual rainfall likely to decrease in the Mediterranean Africa and northern Sahara. • Rainfall in southern Africa likely to decrease in much of the winter rainfall regions and western regions. • Likely increase in annual mean rainfall in east Africa. • Unclear how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve. • Predictability of the season and distribution of rainfall is uncertain.
Extreme	• Increase in dry spells likely in most subtropical areas.
Source: Christensen et al. 2007	

[1] Tropical Livestock Units: I unit = I camel, 1.4 bovine, 2.5 donkeys, 10 sheep or goats

[2] Note: there is considerable variation within regions in all these events and their patterns

Rainfall variability is high in Africa, increasing with aridity, and at least 65% of Africa is classified as dryland. This variability between years and over decade–long periods, combined with generally poor meteorological data across the continent, makes it challenging to observe changes and to predict future patterns (Hulme et al. 2001). The Sahel has displayed considerable multi–decadal variability over the past century with recent drying, and although East and South East Africa appear to have a relatively stable rainfall regime, there is also marked inter–decadal variability (ILRI 2006). Despite the uncertainty, certain trends are projected, with different patterns of climate change across the African continent (Table 1).

The inter–relationship between climate change and the livestock sector is important to explore for a number of reasons. First of all, the livestock sector has recently been blamed for contributing more to global climate change than the automobile industry (FAO 2006). At the same time, the sector is booming due to a surging global demand, which is closely linked to both economic growth and urbanization: two factors which are in turn linked to climate change. Thirdly, livestock play a critical role in the livelihoods of many of the world's poorest people, acting as a source of both credit and savings in rural areas that are remote from financial services, providing food and cash income for the urban as well as the rural poor, and for many people offering a route out of poverty. A fourth point to consider is that some major livestock systems are credited with providing environmental services, including promoting rangeland health (and total biomass) and thereby helping to capture atmospheric carbon and mitigate climate change. The contradictions between these points highlight the inconsistencies in how different groups of people view the livestock sector as well as the great diversity within the livestock sector. This report endeavors to shed light on some of these inconsistencies and resolve some of the misunderstandings. This report also explores how livestock keepers are adapting to climate change, as well as to other stimuli and threats, and highlights ways through which these adaptive capacities can be built.

Purpose and methodology of the study

The study was carried out to help test the hypothesis that strengthening the resilience of African livestock systems to climate change, and making current investments to improve African livestock coping mechanisms will improve the climate resilience of small–holder farmers and pastoralists. The study was implemented through two sub–regional reviews (one in Eastern and southern Africa, the second in West and Central Africa), six country visits (Kenya, Namibia, Malawi, Cameroon, Niger and Mali), and an e–conference, conducted in 2009.

This scoping study provides an overview of climate change in Africa, with a focus on the way climate change is affecting, or is projected to affect, the livestock sector. The study examines adaptation strategies and capacities amongst different livestock keeping communities and reports on a range of initiatives that are being carried out by both research and development agencies in Africa, ostensibly to strengthen these capacities or to introduce new strategies for adaptation.

Regrettably this study lacked detailed discussion with livestock keepers over their perceptions of and experiences with climate change, although some of their representatives were consulted. The study compensates for this to some extent by drawing on a large body of literature including a range of studies that had largely investigated rural livestock producers.

Target countries for case studies

This publication provides an overview across sub–Saharan Africa (North of the Limpopo River). The following six countries were singled out for more detailed review and examples are drawn from studies of these countries to provide boxes throughout this report that complement the main discussion.

Cameroon	Temperate tropical country bordering with the Central African Equatorial climatic zone, with various livestock production systems, mainly intensive, peri–urban/urban and non–conventional.
Kenya	Equatorial eco–climatic zone and a communication hub and regional network centre with numerous international and inter–governmental agencies and good availability of relevant data, where multiple livestock production systems are found.
Malawi	Tropical climate with a range of extensive and intensive livestock production systems but generally not well researched.
Mali	Sahelian eco–climatic zone and a regional hub for Francophone countries with networks and easier communication where extensive livestock keeping (pastoralism) predominates on the edge of Sahara.
Namibia	Dryland country and transition (mineral based) economy where commercial livestock production and extensive pastoralism predominate.
Niger	Sahelian eco–climatic zone, and a regional hub with several research and inter–government agencies, where extensive livestock keeping (pastoralism) predominates.

Livestock Systems in Africa

There is no single agreed system for classifying livestock enterprises but in an effort to ensure appropriate coverage of different forms of livestock production around Africa it is necessary to be aware of the range of production systems that are in question. There is considerable diversity of production systems across the continent, shaped largely by climate (rainfall amount and distribution, as well as temperature) and landscape as well as socio–cultural and economic factors. The West and Central Africa study that contributed to this report used the following categorization (adapted from OCDE, 2008):

1. Pastoralism (traditional extensive systems) in which availability of grazing dictates the herd movements;
   a. Nomadism—random movements with the herder's family;
   b. Transhumance—seasonal movements following precise routes;
2. Ranching (private or State owned) in which meat production or breed development is carried out on an enclosed area of land;
3. Agro–pastoralism in which livestock are reared extensively and crops are also produced;
4. Off land systems that use animal feed such as cultivated fodder and agro–industrial by–products, and are typically found on the outskirts of towns and expand with urbanization, focusing mainly on poultry, pig and milk production;
5. Unconventional livestock, including the rearing of cane rats, snails, rabbits and fish.

This categorization is quite exhaustive but not particularly useful in distinguishing different systems. For example, unconventional livestock systems have been categorized into ranching (e.g. game farming) or off land systems (e.g. cane rats), rendering the last category unnecessary. Agro–pastoralism and transhumance systems are hard to distinguish since most 'agro–pastoralists' practice transhumance. Even the term 'ranching' is increasingly understood to overlap considerably with 'pastoralism', and in many countries (particularly in the industrial world outside Africa), ranching systems increasingly follow transhumant patterns.

The eastern and southern Africa study that contributed to this report used a modification of an FAO livestock systems classification based on two main types:

1. Those solely based on animal production, where more than 90% of dry matter fed to animals comes from rangelands, pastures, annual forages or purchased feeds, and less than 10% of the total values of production comes from non–livestock farming activities;
2. Those where crops and livestock are associated in mixed farming systems, where more than 10% of the dry matter fed to animals comes from crop by–products or stubble, or more than 10% of the total value of production comes from non–livestock farming activities.

The problem with this system is that it clearly overlooks livestock systems that are common in certain parts of Africa, such as back–yard production, which supplies significant meat in urban areas. In order to simplify the differences and minimize overlap, this study uses a different categorization, with the following three categories that are intended to each have a degree of homogeneity in terms of resilience to climate change:

1. Range based livestock systems including pastoralism and ranching (including game ranching);
2. Mixed farming systems in which farmers produce both livestock and crops, although it is recognized that livestock in mixed farming systems may also rely on rangelands and therefore overlap with the first category;
3. Off land systems, predominantly urban and peri–urban livestock farms, which use either cut–and–carry (zero grazing) or purchased feed inputs.

In terms of analysis of climate change and adaptive capacity it is important to recognize the diversity of livestock production within each of these categories. Range based systems include herders with hundreds of head of cattle as well as hired shepherds who own no livestock. Mixed farming systems may include producers in high potential crop–land as well as those living on the margins of arable areas. Off land systems can include both intensive dairy producers and urban backyard producers. These differences are alluded to in the following narrative but for the sake of clarity, the categories are kept to these three.

Rangeland Livestock Systems

Strictly speaking (according to most dictionary definitions), rangelands livestock production is synonymous with the term pastoralism, but in Africa the word 'pastoralism' has taken on many connotations that create confusion with the term. Rangelands are particularly difficult to define and definitions may be based on climate (e.g. nearly synonymous with drylands) or may be based on productive potential (e.g. land that can be used for grazing). Either way, rangelands occupy the majority of the African continent and in West and Central Africa they account for 30% of cattle and 50% of small ruminant production, supplying 60% of beef, 40% of sheep and goat meat and 70% of milk.

Animal production in the African rangelands depends essentially on the use of natural vegetation (pasture and shrubs) that is grazed or browsed predominantly by mixed herds of ruminants and equines (OCDE 2008). Different species are suited to different ecological niches and herd diversity is an important adaptation of traditional pastoral systems; livestock keepers maintain diverse herds that can harness a range of different resources that thrive under different climatic and environmental conditions.

Rangeland livestock production is an ancient form of human activity and present–day pastoral peoples carry forward an array of diverse cultures, ecological adaptations and management systems that have changed with modernity. Defining these systems is complex and requires certain generalizations to be made. In this report, the term pastoralism will be used to refer to extensive production of herbivorous livestock using pasture (or browse) in which herd mobility is a central management strategy typically associated with the use of common property (as well as private) resources. The term 'pastoralist' refers to one who practices pastoralism and is not used as a general ethnic label.

The term 'ranching' is used to describe extensive livestock systems in which land ownership is more individualized and organized livestock mobility (other than paddock grazing) is not a deliberate management strategy. However, this term has been greatly abused in African development and is often used to refer to idealized livestock production concepts imported from the USA and Australia, despite the fact that ranching systems in those countries may (increasingly) have elements of communal land ownership or managed seasonal migration.

The term 'nomadism' is avoided in this report since its precise definition varies from country to country and because in some places the term is used in a pejorative sense (equated with vagrancy) or is used as an excuse for alienating land (nomads are defined as landless and thus their resource rights can be ignored). Where the term is used in the literature, it is sometimes synonymous with mobile pastoralism (i.e. it inappropriately replaces the term transhumance) and other times it indicates the absence of any permanent home. Where clarity over the nature of mobility is required, the term transhumance is used to imply a seasonal movement of livestock between distinct resource areas, such as wet and dry season pastures, or high and low altitude zones.

Pastoralism

Many efforts have been made to define pastoralism and all have struggled to embrace the great diversity of pastoral systems that exist around the world and within Africa. Some definitions focus on ethnic identity (e.g. Baxter 1994) whilst others focus on reliance on livestock (e.g. Ellis and Swift 1988) but none provide an adequate means of differentiating among various livestock production systems. This may be, in part, because people have different reasons for categorizing livestock keepers and is common to include criteria to add definition to pastoral systems, such as the use of common property and private resources, the practice of mobility, the use of family labour, husbandry or of a mixture of indigenous and cross–bred livestock. For the sake of following the trend (and in the absence of other terms) these features are retained in this definition, although it is recognized that none of these criteria agree with the mainstream dictionary definitions of pastoralism.

Pastoral mobility is highly diverse, driven by both typical and atypical climatic events and seasonal patterns, and by social, economic, political and cultural factors. Mobility among clearly defined resource areas may be highly regular, sometimes even following clearly defined transhumant routes that have not changed for centuries, or it can be nearly random (Niamir–Fuller 1999). The former is called transhumance and the latter tends to be referred to as nomadism, particularly where livestock keepers to not 'own' defined areas of land.

Because of the necessity for and the complexities of communal resource management and transhumance, pastoral systems demand a high degree of social organization and control. The capacity to self–govern is pivotal to the resilience of pastoral communities and many of the challenges that African pastoral societies face today can be traced to weakening of self–governance capacity. Pastoralists manage rangelands through a complex system of common and individual property rights and where their land has become degraded, it is usually a combination of the weakening of customary management institutions and the loss of key resources that make up the pastoral system (McGahey et al. 2008, Niamir–Fuller 1999, Scoones 1995). Both of these factors are closely linked with insecurity of land tenure, which is perhaps the single most important challenge facing African pastoral producers.

Pastoral systems in Africa are undergoing major social transformations with many commentators suggesting that pastoralism is in decline. Figures do not bear this prediction out, but they do paint a bleak picture for many pastoral societies: increasing population density, loss of key pastoral resources and almost static livestock populations all point to the growing pressure on the pastoral system. Communities that used to be considered as nomadic are now less mobile and more likely to have settled homesteads, which brings both benefits in terms of access to services as well as challenges such as natural resource degradation and reduced economic potential (Davies et al. 2010). Less than 15% of pastoralists in West and Central Africa are now classified as nomads whilst in East Africa the figure is probably lower. The Turkana of northern Kenya are still referred to by some as nomads yet many Turkana now grow crops and have at least one foot in one of the many small towns that have grown up around food aid and development projects in their territory (Majok and Schwabe 1996).

Loss of key resource tracts and access routes have contributed to the decline in pastoral mobility whilst at the same time pressure over resources from neighbouring competitors has led many pastoralists to settle simply to protect their own land assets. Communities that used to migrate en masse with their herds now may remain divided throughout much of the year, often with women, children and some of the elders remaining in the homestead whilst younger men herd the livestock. For example, the Maasai of Kenya traditionally followed a transhumant migratory pattern returning to a home manyatta during the wet season (Majok and Schwabe 1996). However, 100 years of colonial, governmental and developmental influences have been directed at settling them and introducing the concept of private land ownership (Blewett, 1995). As a result, many Maasai have adopted permanent agricultural and ranching practices, while some of their best dry season pasture has been claimed by non–Maasai.

Ranching

The term 'ranching' has been used in African livestock development to refer to a particular brand of rangeland livestock production modeled on US (and to a lesser extent Australian) beef farming. This highly market oriented production system is largely focused on beef production and is characterized by high capital inputs, sedentary production, and often some form of private land tenure. Ranching systems have been developed on state owned rangelands as well as private and group ranches, and the system is particularly prevalent in eastern and southern Africa.

Ranching is rare in West and Central Africa, apart from a few cases where the objective is often that of developing and promoting a specific breed on behalf of the state. Examples are the Marahoué Ranch in Ivory Coast, the Madina–Diassa Ranch in Mali and the Toukounous Ranch in Niger. Some ranches seek to exploit the genetic potential of livestock such as Azawak and Gudali zebu. The ranching system was built on western (colonial) land management models by the reallocation of rangeland through nationalization and/or privatization schemes. This transformation was supported by policies that usually favored a small commercial elite at the expense of the broader community, and in much of the continent has failed to increase the quality or quantity of livestock production. Indeed, a number of studies in the 1970s and 1980s have demonstrated that traditional pastoral systems out–perform ranching systems by anything from 2 to 10 times (Scoones 1995).

Ranching has been particularly common in eastern and southern Africa, and although many ranches have failed in the east of the continent, the model remains widespread in the South—particularly private (as opposed to communal) ranches. Ranch size is often inadequate to allow management at the necessary spatial scale in highly diverse dryland environments, although communal ranches in Kenya have begun to experiment with negotiations over movement between ranches in order to combine the benefits of private land ownership with those of long–distance transhumance.

One of the major challenges that all rangeland producers face is to produce livestock at the required standard to enter international markets. Even southern African countries armed with preferential trade agreements with Europe have consistently failed to meet their export quotas, in some cases despite massive state subsidies (e.g. Botswana). Some ranchers in southern Africa have adapted to this challenge by diversifying production into game ranching, targeting markets for bush meat, game viewing and even a small but lucrative market for live wildlife sales. Though not very common, this may present an adaptation option for arid rangeland environments faced with climate change.

Mixed farming (crop–livestock) systems

It is important to distinguish here between mixed farming systems in which farmers produce both livestock and crops on fertile land, and agro–pastoral systems in which farmers herd livestock in the rangelands and also produce crops on fertile land. However, it is almost impossible to draw a line between these two production systems despite their obvious and important differences. It may be more appropriate to consider livestock and crop production as two points on a continuum, with individuals, households and communities moving along the scale according to both short–term changes and long–term trends.

There are clearly some communities who culturally define themselves according to a combination of crop and livestock production (for example the Sukhuma agro–pastoralists of Tanzania) just as certain communities define themselves, no matter how idealistically, as pastoralists. On the other hand, even members of the most conservative pastoral communities have been seen to adopt crop production temporarily as a means of re–stocking in the aftermath of a disaster, gradually re–stocking to move from crop farmer to mixed farmer to agro–pastoralist and finally to become a pure pastoralist again (Niamir–Fuller 1999). In the context of this report, mixed farming systems can be seen as important means of coping with change and may represent an important adaptation to climate change.

More and more livestock producers now also produce crops, often for subsistence purposes, just as many crop farmers keep a few livestock as a financial buffer. In West Africa cultivators and herders have a long established relationship wherein herders graze crop residues in return for tending the livestock of crop farmers. These relationships have deteriorated in recent decades, particularly as a result of land laws that favor the rights of crop farmers over livestock keepers. The outcome is that crop farmers increasingly tend their own livestock and harvest their own residues whilst some pastoralists are pushed into crop production to preserve their land rights.

Examples of livestock keepers producing fodder crops are rare in Africa, particularly in the most extensive livestock systems that ought to benefit the most from this practice. The Turkana of north–western Kenya produce low input sorghum along river banks, harvest grain when the rains allow and feed their cattle on the crop when the rains are poor. However, the commercialization of livestock production may be one factor that constrains a more intensive engagement in fodder production. Livestock production in most of Africa remains poorly capitalized with disincentives for investment such as low market access and volatile prices. In some cases where market access has improved, both livestock and crop production have benefited mutually, as in Maasailand of southern Kenya where crop production has greatly expanded over the past 20 years whilst livestock numbers have remained steady, but trade in livestock has increased dramatically.

Mixed farming and livestock systems benefit greatly from proximity to urban centres, which allows farmers to market their products and enables them to use livestock, particularly smaller stock, as a financial reserve. These systems contribute 35% of the total production of beef, 20% of goat and sheep meat, 35% of poultry, 40% of pork, 15% of milk and 10% of eggs in West Africa (OCDE 2008). According to the World Bank (2009), mixed farming systems provide about three quarters of all the meat and milk produced in the developing world, which implies that African mixed farming systems produce below the global average, perhaps reflecting the significantly higher than average proportion of rangelands in Africa.

In East Africa, mixed farming is most developed in areas of high population density where agricultural holdings have become too small to support traditional farming practices. These more intensive systems are generally based on crop growing, integrated with milk production from small herds of dairy cows or goats, and may involve some form of agro–forestry and the recycling of organic matter such as crop residues and manure. In Kenya, Sudan and Ethiopia, small–holder dairying based on small–scale irrigated pasture and crop residue together with additional feed concentrate is more profitable than many cash crops. In areas with good market access, this opportunity takes advantage of crop residues to produce animal products as a profitable complement to crops.

Mixed large–scale farming systems or ranches combined with arable production are not a major system as far as number and total production, but they have the highest livestock densities with 55 TLU/km^2 (tropical livestock units) compared to 20 TLU/km^2 and 11 TLU/km^2 respectively for mixed rain–fed agriculture and livestock dominated grazing areas. It should be noted that comparisons across Africa don't reveal much since there may be great differences in productive potential between small holdings, pastoral systems and private ranches. Irrigated mixed farming is rare in sub–Saharan Africa but can be observed in the Sudan, southern Africa and Ethiopia (Peden et al. 2006). Small–holder dairy producers in Kenya however have realized significant increases and stability in year–round income through the use of irrigation water for their livestock and in Ethiopia government irrigation schemes that have appropriated former pastoral lands may provide crop residues and water to pastoral herds during the dry season.

Integration of livestock in mixed farming systems serves several purposes:

- The manure is used as fertilizer;
- Animals are used for draught and transport;
- Crop residues are used as livestock feed;
- Animals can be sold and the revenues re–invested in agriculture or sold when the crop is failing because of weather or pests;
- Cereals and most staple foods are produced in quantities that cover the family needs, and excesses are sold.

Landless livestock production systems

Landless livestock production is largely confined to urban and peri–urban areas, although land pressure in crop farming areas may be pushing conventional land–based farmers to adopt some of the practices of landless farmers as well. The urban and certain types of peri–urban livestock system are off land or zero grazing by necessity but depend on some kind of agricultural production. Two main types of husbandry practices have been identified under urban/peri–urban production system. First, livestock is either controlled or zero grazed. Second, livestock grazing is not fully controlled, but forage under free roaming condition on vacant plots and along the roadsides or scavenge on garbage sites.

Landless livestock keepers, lacking control over and access to basic inputs, are seldom able to access support services and are often ignored by agricultural agencies. Ellis and Sumberg (1998) reviewed case–study materials on urban agriculture in sub–Saharan Africa and summarize the reasons as follows:

- It is often a means of survival for the very poor;
- It is often a strategy of women, which enables them to secure a proportion of family food;
- It is often carried out to provide security in the face of insufficient, uncertain or unstable cash;
- It is carried out primarily for food security, enabling families to withstand declining real wages, unemployment of family members, and variations in cash income from diverse other sources;
- It provides a substitute for cash purchases of food, especially for higher value items such as eggs, meat, milk, fruit and vegetables, so that cash can be used for other purposes.

However, not all landless production is purely subsistence oriented and it may also be carried out as a means of supplementing family income and achieving other objectives such as paying children's school fees. Alternatively, production may be a commercial rather than a subsistence activity, undertaken to take advantage of growing demand for high value and import–substituting food and livestock products within cities and towns.

It is not possible to generalize over livestock species kept in urban or peri–urban systems because of the great variation among cities and countries. Nairobi's urban farmers keep goats rather than chicken and ducks, whilst in Kampala cattle are preferred. In Dar es Salaam cattle, goats and sheep are kept by over half of all households and in Addis Ababa sheep are kept by a similar proportion, whereas goats are kept by only 13% of households.

Zero grazing systems are independent of any agricultural use of the land. They use only animal feeds such as cultivated fodder and agro–industrial by–products, whether concentrated or unrefined: cereals, oil seed cakes, bran, hay and straw or sometime only manufactured feed (pig fattening or pig production). These systems are found in or on the outskirts of towns, and have developed with growing urbanization and a demand for animal products that distant small farming or pastoral systems are unable to meet. They focus mainly on poultry (for eggs and meat), pig farming, and milk production to a lesser extent, generally in close association with western companies, which supply feed formulas and ready–mixed feeds, chicks or breeding animals, advice and testing. The system is growing in the coastal countries from Nigeria and Angola to Mauritania. This system faces major challenges from cheap imports of beef, pork and poultry (mainly from Europe), diseases (African swine fever, bird flu) and the high cost of staple feed such as maize that constitutes a major ingredient in feed formulations.

Free–roaming animals feed on whatever they find: on garbage, household kitchen waste, leftovers from hospitals, hotels, schools, markets and crop residues in addition to grazing on free plots of land. This type of production poses environmental and health hazards, particularly for omnivorous non–ruminants. People have started to develop informal enterprises to grow or collect grass and sell it fresh or as hay in peri–urban areas. Feed concentrates are usually affordable only by small–scale dairy producers and intensive chicken producers. Aside from feed, water can represent a significant obstacle or cost for urban and peri–urban producers since livestock and humans may compete directly for consumption. Where livestock are left to their own devices, they may consume standing water, household waste water and contaminated industrial water.

The productivity of livestock in peri–urban and urban areas is generally low and faces a number of challenges:

- animal waste disposal can cause environmental and public health hazards;
- competition for water resources with humans;
- animal health is often poor due to inadequate husbandry practice and overcrowding;
- animals often kept in a small area within a homestead;
- feed availability is a particular constraint for larger livestock species such as cattle;
- feed quality is a problem for free–roaming livestock as there is no, or very limited, control over feed sources;
- urban livestock keepers are poorly organized and their needs are poorly represented;
- access to information about and adoption of improved technologies is limited, particularly about livestock husbandry practices.

Despite the challenges, there are numerous benefits from urban and peri–urban livestock production and a number of opportunities for its development. Urban livestock keeping fits different livelihood strategies and contributes to food security, income and employment opportunities, savings, insurance and social status. It also provides easily convertible assets for covering important expenditures (school fees, health treatments and social obligations) and contributes to supporting vulnerable groups of the community). With increasing demand for land for residential purposes, urban livestock keeping provides a way to increase returns per unit of land utilized. Urban livestock keeping also provides opportunities to make use of household wastes, agro–industrial by–products such as molasses and brewery residues, weeds and grass from public land and crop residues from markets and peri–urban farmers. Vulnerable groups such as female–headed households, children, retired people, widows and people with limited formal education are particularly involved in urban livestock keeping as a social security strategy. As urbanization accelerates in Africa, demand for livestock products is projected to rise significantly, and urban and peri–urban producers are best connected to those emergent markets (Sabine 2002).

Poultry Production in Africa

In most African countries, small–scale poultry production accounts for more than 60% of the total national poultry population, which has an estimated asset value of USD 5,750 million (Sonaiya 1990). Poultry is reared for both commercial and subsistence purposes, with some export of poultry (Burkina Faso exports one third of its 15,000 tonnes of poultry meat each year at a value of USD 19.5 million). However, for most farmers chickens are reared to provide meat and eggs for home consumption. Some estimates put the contribution of poultry to meat consumption in Africa at more than double that of cattle (Forssido 1986) and poultry are the only form of livestock kept by the majority of households in countries such as Tanzania, Niger, Ghana and Mali (FAO 1998).

According to FAO (1998) three poultry management systems are found in Africa: intensive, semi–intensive and extensive/ scavenging. These systems differ according to flock size and their reliance on purchased input and intensive and semi–intensive together account for less than 30% of Africa's poultry flock. Intensive systems are mainly found in urban areas close to markets for eggs and chicken meat and tend to follow standard practice, using specialist breeds, appropriate housing and feeding, and disease control. Semi–intensive poultry production is usually practiced by family farmers, often in rural areas where access to inputs tends to be lower; this system is sometimes referred to as the 'back–yard' production system. Intensive poultry systems usually rear thousands of chickens at a time whereas semi–intensive systems generally maintain flocks of between 50 and 200 birds (Kitalyi 1998).

The abundant availability of labour in Africa may be part of the reason that semi–intensive systems have not adopted labour–saving technologies such as cage rearing; instead they opt for deep litter systems. Feed inputs can account for over 60% of the production costs in the commercial poultry sector. Rising poultry feed costs have led to the use of home–made rations whereby the concentration of commercial feed is fortified with other ingredients such as fishmeal, bone–meal, blood meal and oil seed cakes. Other ingredients used include cereal grains, cereal by–products and kitchen waste (Fanuel 1997, Kitalyi 1998). Poor infrastructure and inadequate diagnostic equipment hampers effective health and disease control, but expanding veterinary services, particularly in urban centres, is improving this situation (FAO 1998).

Extensive/scavenging poultry systems use different poultry species: in addition to chickens they may keep guinea fowl, ducks, geese and turkeys. The dominant species, chicken (Gallus domesticus) is usually maintained in small to medium sized flocks of ranging from a few to more than 100 birds. Most small–holder poultry relies on scavenging for feed rather than the purchase of expensive inputs, which makes poultry production attractive to impoverished populations in the first place. Scavenging can be improved through production of unconventional feed resources such as termites, maggots and worms or through integrating poultry and cropping. Poultry housing tends to be of rudimentary construction of boxes or baskets, sometimes with a run or perch, and occasionally with cages slung in tree branches. Poor hygiene in poultry housing leads to high parasite infestation; therefore, improving housing can lead to significantly increased productivity and a reduction in mortality.

Unconventional livestock

A number of unconventional livestock species are farmed in Africa and their variety, prominence and potential as an adaptation strategy makes them worthy of mention here: guinea fowl, pigeons, ducks, geese, turkeys, ostriches and other game birds (Koeslag 1992). In their natural habitats, these birds scavenge for food and are therefore suited to low external input production systems. In recent years cane rats (Thryonomys swinderianus) have been domesticated to reduce the poaching of a species that was en route to extinction and as a result production has flourished in Central and West Africa. Domestication of cane rats began over 25 years ago in Ghana and is now expanding in Benin (Jori and Chardonnet 2001). Its contribution to the total supply of animal products in the region is still small, but growing steadily and could help improve the supply of animal proteins to growing cities. Recently, snails have augmented the cane rat farming in Cameroon as a source of income and animal proteins that require little investment of space and minimal education.

Other species such as snails, rabbits and fish are also starting to expand in the region. Snail production is important to urban households in Cameroon, although production is still low compared to the number of those collected in the wild. In addition to local consumption, many snails are processed and exported to Europe and America. This has caused local shortages with price hikes to local consumers. Continuous harvesting of wild snails and subsistence levels of production may not be sufficient to meet the current trend of human demands. The situation can be prevented through intensive snail production using novel housing and feeding systems. Snails thrive on unconventional feeds like leaves, fruits, household and industrial by–products, thus providing the additional advantage of biodegrading waste (Etchu et al. 2008).

Government support for unconventional livestock development

Under the Ministry of Livestock, Fisheries and Animal Industries of Cameroon, the Support Project for Unconventional Animal Husbandry (PAPENOC) aims to contribute to the need for animal protein of urban populations. Major species involved are cane rats, guinea pigs, snails and frogs. PAPENOC has two broad objectives: to build the capacity of producers and to manage natural resources sustainably.

Specific objectives are:

- Develop unconventional livestock production through sensitization, information and training of producers;
- Diversify animal protein sources and increase national meat production through support to producers;
- Diversify and increase incomes through monitoring and advice to improve production techniques;
- Develop opportunities for pure African dishes in the present situation of globalization.

Climate Change in Africa

An overview of climate change[3]

According to the Intergovernmental Panel on Climate Change (Fourth Assessment Report: IPCC 2007), the term ‘climate change’ refers to ‘a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period.’ The Fourth Assessment Report states that ‘warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures’ and ‘eleven of the last twelve years (1995–2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850).’ Increases in temperature are global, but are higher in northern latitudes, and are higher on land compared to the ocean.

Climate change is characterized not only by increasing temperature, but also in a number of related climate phenomena. There has been a general increase in the frequency and intensity of some extreme weather over the last 50 years: hot spells have become more frequent; heavy precipitation events have increased over most areas and extreme tidal levels have increased. As discussed below, the variability of the climate has become more pronounced and more uncertain, and total precipitation levels have changed in many areas, increasing in some regions and declining in others.

Such climate changes are likely to affect the environment in general and there is ‘very high confidence …that recent warming is strongly affecting terrestrial biological systems.’ Changes include shifting seasonal patterns such as leaf–unfolding, bird migration and egg–laying, and latitudinal shift (particularly towards the poles) in the range of species. Climate change impacts adversely (on average) and the agricultural sector has experienced increased water stress as a result of changing patterns of run–off and shifting (and unpredictable) seasonality and changes in temperature. Run–off is projected to decline by 10 to 30% over some dry regions at mid–latitudes and in the dry tropics due to decreases in rainfall and higher rates of evapotranspiration. There is also high confidence that many semi–arid areas will suffer a decrease in water resources due to climate change. Areas affected by drought are projected to expand, whilst simultaneously there are increased risks of flood.

Climate change in Africa

On a continental scale, changes in Africa’s mean annual rainfall are projected to be modest and varied. Rainfall is projected to decline in southern Africa and the Horn of Africa by 10%, and is projected to rise by up to 16% in the Sahel (although not all models agree with this prognosis). The problem in modeling potential rainfall change in the Sahel is the large degree of natural variability in total annual rainfall that already occurs in the region and the relatively short–term records that are available (Christine 2002).

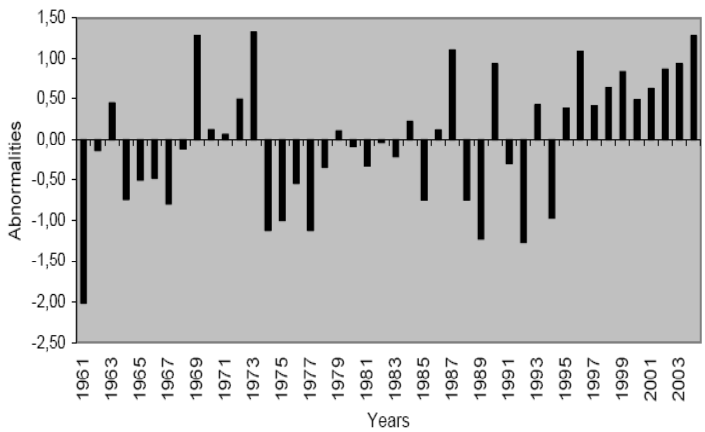

Figure 1: Annual average minimum temperature abnormalities from 1961 to 2004 in Niger (NAPA 2006).

Changes in temperature in Africa

Temperature across Africa has increased by 0.7ºC during the 20th century, but projections now estimate that warming across Africa will range from 0.2ºC to 0.5ºC per decade (Hulme et al. 2001; IPPC 2001a). This contrasts with an average rate of warming through the 20th century of about 0.05ºC per decade. An increase in average temperature can lengthen the growing season of crops and grasses in regions with relatively cool rainy seasons, but such regions are few in Africa. Across most of the continent, increasing temperature will adversely affect crop and grass production since high temperatures already limit growth.

[3]All data in this chapter are taken from the IPCC’s Fourth Assessment Report unless otherwise stated (IPCC 2007).

Data collected by the National Meteorological Department in Niger from 13 meteorological stations between 1961 and 2001 indicate a trend in 'average temperature abnormalities' towards a decrease from 1961 to 1986 and towards an increase from 1986 to 2001 (NAPA 2006). Namibia shows a clear trend towards increasing temperatures during the latter half of the 20th century and temperatures are now on average 1–1.2ºC warmer than they were at the beginning of the century, which is greater than the global mean temperature change (Midgley et al. 2005). In some regions, the impact of increased temperature is amplified further by land degradation, which leads to increased evaporation, reduced infiltration of water and drying up of watering points.

Changes in rainfall in Africa

Rainfall changes across Africa are projected to differ substantially, although much of Africa has seen a long–term decline in precipitation from 1900 to 2005 (the Sahel, the Mediterranean and southern Africa). There are two contrasting views regarding the impact of global warming on rainfall over the sub–Saharan Africa (Balgis 2006). The first indicates that the region might experience a precipitation deficit of up to 200 mm, whilst the second presents a wet trend that emerges in the last decade of the 20th Century and accelerates during the 21st Century in sub–Saharan Africa (SSA). Figure 2 illustrates both the inter–annual variability in rainfall and the long–term trends witnessed over the past century, factors that greatly hamper accurate predictions.

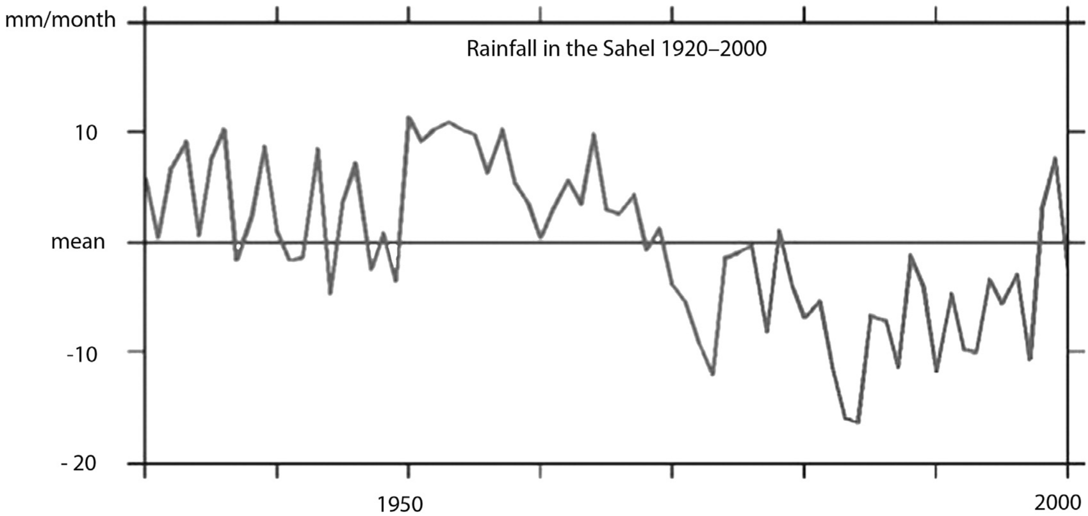

Figure 2: Annual–mean anomalies in precipitation averaged at 41 stations in the Sahel, 10N–20N across Africa, over the period 1930s to 2000 (Balgis 2006).

Rainfall declined across the Sahel during the 20th century, characterized by the great droughts of the 1970s and 1980s, but rainfall levels have begun to increase since the mid–1990s, particularly in continental Sahel (Niger, Northern Nigeria and Chad), albeit with greater inter–annual variability. Although there is uncertainty in rainfall–related climate projections for western Africa, a simple average of all the scenarios shows that the prognosis is one of slightly increased rainfall in the Sahel (particularly in the east) with no significant change along the Guinean coast. Precipitation patterns in eastern Africa are even more variable, but historical records indicate an increase in rainfall over the last century (Hulme et al. 2001; IPPC 2001).

Inundations in West and Central Africa

The 1994 wet season in West and Central Africa received the highest rainfall in 30 years, with flooding in Niger leaving more than 100,000 people homeless (UNECA, 2001). In the July to October 1999 rainy season period, heavy rains and flash floods left thousands homeless, hundreds dead, and extensive property damage. In July 2001, heavy rains in the coastal areas of Ghana, including the capital, Accra, provoked more floods. More than 139,000 people were affected and 15,000 were displaced. Roads and bridges were damaged and the lack of clean water sources posed health threats such as cholera, diarrhea and typhoid, leaving 12 people reported dead. Torrential rains in 2002 killed more than 50,000 cattle and 50,000 small ruminants in the south of Mauritania and the north of Senegal.

Despite the uncertainty, the IPCC projects that by 2020, between 75 and 250 million people will be exposed to increased water stress as a result of climate change. In some countries, yields from rain–fed agriculture could be reduced by up to 50%, which will compromise agricultural production and food security. By 2080 it is estimated that—with a high degree of confidence—arid and semi–arid land in Africa will increase by 5 to 8%.

Increased climate variability and extreme events

There are many reports that extreme events (drought, floods, disease outbreak, desert locusts, etc.) have become increasingly frequent in Africa, although often the paucity of data renders such observations anecdotal. Drought is a recurrent feature in the drylands of Africa, which cover about 65% of the continent, rather than an unexpected event and extreme climate uncertainty is normal in these regions. Nevertheless, the magnitude and intensity of droughts has increased over the last 100 years.

Under the IPCC's 'intermediate warming' scenario, parts of equatorial eastern Africa will likely experience 5–20% increased rainfall from December to February and 5–10% decreased rainfall from June to August by 2050. Extreme weather events have recently increased in frequency and intensity in southern Africa, as evidenced by increased drought, flood and unpredictable rainfall patterns in Malawi. Deforestation and degradation have exacerbated the consequences of changes in climate patterns with significant impacts on both crop and livestock production. Floods were recorded in the 1996/97 and 2000/02 growing seasons, and devastating drought occurred during the 1991/92 and 2000/01 growing seasons. Climate changes of this magnitude will have far–reaching negative impacts on the productivity of the agricultural sector.

Table 2: Recent history of meteorological disasters that occurred over the last four decades in Kenya

Year	Type of disaster	No. of people affected
2003	Flood	28,000
2002	Landslide	2,000
1999/2000	Drought	4.4 million
1997/98	El Niño floods	1.5 million
1995/96	Drought	1.41 million
1991/92	Drought	1.5 million
1985	Floods	10,000
1983/84	Drought	200,000
1982	Floods	4,000
1980	Drought	40,000
1977	Drought	20,000
1975	Drought	16,000
1971	Drought	150,000

Source: Muchemi 2003 (Kenyan Meteorological Department)

Causes of climate change: links to the African livestock sector

Climate change is widely accepted to be due, at least in part, to the heat–trapping effects of increased concentrations of atmospheric greenhouse gases (GG). Carbon dioxide (CO_2) is the principal GG by virtue of its high atmospheric concentration, which is, at the present time, about 365 ppm (parts per million (by volume)), having increased by >0.3 since circa 1750. Methane, nitrous oxide (N_2O) and halogens are the other GGs that have also increased over the same period (Hopkins and Del Prado 2007). Since 1750 and the industrial revolution, global atmospheric concentrations of CO_2, methane and N_2O have increased from 270 ppm to approximately 450 ppm as a result of human activities as determined from ice cores spanning many thousands of years (Thornton et al. 2008).

Africa's contribution to Climate Change appears to be negligible, producing around one sixth of the emissions of the USA and 4% globally. Increasing GG emissions in Africa are due to population growth, increasing consumption of fuels and use of energy–hungry agricultural inputs such as fertilizer. Grassland agriculture is often cited as a significant contributor to increased emissions of some of the GGs (Hopkins and Del Prado 2007), but there is considerable debate over the relative merits and liabilities of grassland management in regards to it as a source of GGs (primarily through rumen emissions), as a sink for atmospheric carbon and through protection of land from cultivation and the release of harmful N_2O.

Carbon dioxide

When natural vegetation is converted to agricultural land through, for example, deforestation, a large proportion of the soil carbon can be released. Such land conversion contributes approximately one third of the total CO_2 emissions globally. CO_2 is also released by burning crop residues, using fuels for agricultural production and from livestock production (Cumhur and Malcolm 2008; Hopkins and Del Prado 2007). Well–managed grasslands can sequester up to 260 tones of carbon

Grasslands potential to contribute to climate change mitigation

Carbon sequestration in soils is a major component of the global carbon cycle, with soil carbon accounting for two thirds of global organic carbon pools. Global stocks of carbon in the soil are approximately three to four times greater than in vegetation and more than double that in the atmosphere. Most global attention is focused on forests as a terrestrial Carbon sink, but whilst forests may add only about 10% to their total weight each year, savannas can reproduce 150% of their weight annually, and tropical savannas have a greater potential to store carbon below ground (in roots and soils) than any other ecosystem. Since effective herd management has been shown to increase primary productivity of the rangelands (Briske et al. 2008), and given the scale of rangelands globally, it is evident that livestock production could play a role in mitigation of climate change.

Drylands have lower mitigation potential per hectare than humid lands, but since drylands cover 65% of Africa's land surface (and 41% of Earth's) their overall contribution could be highly significant. The gross mitigation potential in the drylands is amplified by the fact that many dryland regions are affected by degradation and sub–optimally managed and can respond swiftly to management improvements (Farage et al. 2003). Globally, 36% of carbon stored in terrestrial ecosystems is stored in drylands. However, a significant amount of carbon is lost continuously from the drylands due to poor management and conversion of rangeland to arable land. In many countries drylands are associated with higher than average levels of poverty and environmental degradation, features that are strongly linked to socio–political marginalization, under–investment, weaknesses in tenure, and a general poor understanding of how to effectively promote sustainable drylands development. Global awareness of these factors in drylands degradation is steadily growing and this opens up new avenues for improving drylands management, reversing land degradation and thereby both carbon capture and averting harmful cultivation of drylands.

In addition to mitigating climate change, drylands play a crucial role in avoiding emissions of GGs. Declines in carbon stocks occur when drylands are converted from pasture to either plantation or arable land; increases in carbon stocks are seen when native forests or croplands are converted to pasture. Meta–analysis has shown that carbon capture is increased with improved grazing management of rangelands, and that high–diversity perennial grassland species have 5–6 times greater soil carbon and nitrogen than monocultures. The added advantage of improving carbon capture through improved rangeland management is that such practices also contribute significantly to improving the local and household economy. The challenge is that the factors that constrain the spontaneous adoption (or continuation) of such improved management are often at the societal level, requiring both political will and the patience to build capacity and provide resources over time to ensure results on the necessary scale.

Source: Roba and Davies 2009

per hectare while providing important benefits for climate change adaptation (Neely and Bunning 2008). Conversion from agriculture to grassland (that will carry livestock to be productive for humans) is the best way to increase the carbon sequestration rates of the land/soil (Conan et al. 2008). If Africa contributes to approx 4% of worlds GG, African agriculture contributes 12% of that and African livestock production contributes a plausible third of agriculture GG production, African livestock would be responsible for 0.16% of world's GG emission in CO_2 equivalent.

Methane

Methane (CH_4) is released within the agricultural sector from paddy fields, livestock farming and the burning of agricultural wastes. Gastro–enteric fermentation is the main agricultural source of methane in Africa, with emissions from livestock manure accounting for most agricultural CH_4. Livestock produce CH_4 through digestion of structural carbohydrates by the bacteria, fungi and protozoa contained in the rumen (Hopkins and Del Prado 2007). In general poor feed/forage leads to higher methane production by the rumen. However, higher quality feeds are responsible for GG emissions through manufacture and transport and inadequate attention has been paid to the life cycle carbon footprint of different livestock sub–sectors. The cycles of $CH_4$and CO_2 are different, depending on whether manure is concentrated on huge wet heaps in a temperate climate or scattered on the sand and baked in the sun of Sahelian or sub–Sahelian rangelands. On the other hand, the options for reducing GG emissions through capture and reuse (e.g. through bio–digesters) are higher in less extensive systems.

Nitrous oxide

Formation of N_2O in the soil is controlled by a number of factors including moisture content (De Prado et al. 2006), temperature (Hatch et al. 2005), fertilizer additions (Del Prado et al. 2006), pH (Merino et al. 2000) and organic matter content (Smith et al. 1997; Chadwick et al. 1998; Estavillo et al. 2002). Most of the agriculture–based N_2O emissions come from nitrogen fertilizer usage, legumes and animal waste, although some N_2O emissions are also released during biomass burning. Plants absorb most fertilizer nitrogen, but some leaches into surrounding surface– and ground–water and some is released into the atmosphere. Both N_2O and CO_2 are released by ploughing, which makes conservation agriculture and pastoralism strategies for mitigating as well as adapting to climate change.

Impact of climate change on the livestock sector in Africa

Livestock production depends on natural resources, which in much of Africa, primarily means pasture and water. Climate change therefore affects livestock production in myriad ways, both directly through impacts on livestock performance, and indirectly through impacts on the environment, society and economy. Impacts will be experienced on forage yield, livestock productivity, ecological processes and farm–level profitability, possibly leading to modification of regional and national food production and incomes. The impact of climate change on livestock production in Africa is also greatly influenced by the vulnerability of African livestock keepers. Therefore, understanding lower order impacts is crucial to anticipate and predict higher order effects.

The repercussions of climate change on the livestock sector will be manifest in changes in the quality and quantity of vegetation, availability of fodder and water and an increase in climate–related diseases (impacts are summarized in Table 4 and elaborated on in the following section). The aforementioned factors impact indirectly on livestock productivity parameters, such as conception and birth rates, mortality rates and meat quality. According to Moorsom and Pfouts (1993), in a period of normal rainfall, calving rates are 60% to 70%, whereas in a period of drought, this rate may fall as low as 25% to 30%. For goats the normal kidding rate is 160% and this rate falls to 50% to 80% in periods of drought.

Table 3: Effects of climate change on Livestock (Calvosa et al. 2010)

Water	Change in quantity and timing of precipitation
Feed	Land use and systems changes Changes in the primary productivity of crops, forage and rangeland Changes in species composition Quality of plant material
Biodiversity (genetics and breeding)	Loss of genetic and cultural diversity – both livestock and crops Change in ecosystem function and resilience
Livestock (and human) health	Change in pattern and range of vector–borne disease and helminth infections Loss of disease resistant livestock breeds Change in pattern of human disease, including malaria, Schistosomiasis, and filariasis Increase in heat–related mortality and morbidity

Heat stress

Livestock is a much better buffer than crops against extreme weather events such as heat and drought, but it is not certain that elevated mean temperatures and increased frequency of extreme heat stress of the coming decades are within the range that can be tolerated by existing genotypes of livestock in Africa. It is clear, however, that temperature increases above the thermal comfort zone can induce reduced growth and reproduction rates and higher mortality. The vulnerability of livestock to heat stress varies according to species, genetic potential, life stage and nutritional status. Increasing temperatures at higher altitudes are generally going to have greater impacts on livestock than at lower altitudes, where local livestock breeds are often already quite well–adapted to heat stress and drought. Most intensive dairy production systems in eastern and southern Africa use exotic breeds such as Holstein Friesian, but the use of temperate–breed genetic stock leads to greater vulnerability to heat and drought.

High temperatures reduce feed intake and thus milk production and in the tropics lead to energy deficits and decreased cow fertility, fitness and longevity (Parsons et al. 2001). Some modeling work reported by Chase (2006) using the Cornell Net Carbohydrate and Protein System model indicated that the maintenance energy requirements of a dairy cow weighing 635 kg that yields 36 kg of milk per day is increased by 22% at 32ºC compared with the energy requirement at 16ºC. For the same temperature increase, predicted dry matter intake decreases by 18% and milk yield decreases by 32% (Thronton et al. 2008).

Water availability and use

Water supply

Water use in the livestock sector includes not only the water used at a farm level for drinking and the growing of feed crops, but also for other servicing and product processing. Areas in which rainfall run–off decreases may begin to encounter watering and servicing problems, while the advantage of increased water supply in areas of increased rainfall may be offset to some extent by erosion, landslides and increased incidence of disease. Climate change will also affect groundwater recharge rates, but with much less certainty as regards to how (Thornton et al. 2008). A case–study from Botswana concludes that the key contributions of groundwater to extensive grazing systems will become even more important in the future in the face of climate change (Massike 2007) and the increased reliance on groundwater for both the cattle sector and for urban water supply could lead to unsustainable use of water resources in the country (Thornton et al. 2008).

In East Africa, projected warmer temperatures and increased rainfall, not uniformly but in sporadic and unpredictable events, will have major implications for livestock production. The increased precipitation may come in a few violent rainstorms during existing rainy seasons and cause erosion and water management problems. It is also expected that there will be less precipitation during the dry season, which may cause more frequent and severe droughts, destructive bush fires and increased desertification. Predictions for West Africa are less certain, and rainfall could increase or decrease. However, it is important to understand the dynamics of change, since increased rainfall does not automatically imply greater water availability for livestock production.

Where rainfall declines, reduction in the productivity of natural pastures is likely, and the impact of this may be profound where flood plains provide strategic dry–season fodder resources. Decline in rainfall may in some cases threaten the permanence of some water bodies (ponds, dams and lakes) with negative consequences for the watering and productivity of livestock. Reduction in these resources will impact on the population more widely than just the effects on livestock, with decreases in crop production, shortages of water, reduction in forested areas, decrease in fisheries, decrease in biological diversity (species extinction and habitats deterioration), and increase in the rate of contracted diseases such as measles, meningitis, malaria and respiratory diseases.

Water consumption

Livestock water consumption will increase with both temperature and drought. For example, the water intake of Bos indicus cattle increases from about 3 kg per kg dry matter intake at 10°C ambient temperature, to 5 kg at 30°C and to about 10 kg at 35°C (NRC 1981). For Bos taurus, intake at the same temperatures is about 3, 8 and 14 kg per kg dry matter intake, respectively. Some of this water intake comes from the forage water content itself, which also depends on climate–related factors. Forage water content may vary from about 0% to 80%, depending on the species and weather condition (Thornton et al. 2008).

Epidemiological impacts

Changes in the pattern of livestock disease will vary according to the ecosystem, the type of land use, disease–specific transmission dynamics, susceptibility of the populations at risk and sensitivity of the pathogen to temperature and humidity. All of these factors are affected by increasing temperature and fluctuating water supply. There are significant health risks associated with floods.

Effects on pathogens

Higher temperatures may increase the rate of development of pathogens or parasites that spend some of their life cycles outside their animal hosts, but high temperature and drought will also have a strong disinfecting effect. Changing wind patterns could affect the spread of certain pathogens and vectors, particularly the infective spores of anthrax and blackleg, the wind–borne peste des petits ruminants and dermatophilosis (Thornton et al. 2008; Delespaux et al. 2008). In contrast, diseases such as avian influenza, bovine tuberculosis, brucellosis, foot and mouth disease, Newcastle's disease, which are transmitted through close contact between animals, have been reported to have insignificant associations with climate (Hager 2007).

Effects on hosts

Climate change may bring about substantial shifts in diseases distribution, and outbreaks of severe diseases could occur in previously unexposed animal populations. While livestock often have evolved genetic resistance to diseases to which they are commonly exposed, they may be highly susceptible to 'new diseases'. In addition, climate change may increase stress on livestock that reduces their resistance to diseases. Heat and water stress are the obvious examples, but another example is suppression of immunity following heightened exposure to ultraviolet B radiation (an expected outcome of stratospheric ozone depletion), which means that GG emissions that affect the ozone could have an impact on susceptibility to diseases (Bayliss and Githeko 2006).

Effects on vectors

Changes in rainfall and temperature regimes may affect both the distribution and the abundance of livestock disease vectors, as can changes in the frequency of extreme events. The feeding frequency of arthropod vectors may also increase with temperatures rising. As many vectors must feed twice on suitable hosts before transmission is possible (to acquire and

Distribution of vector–borne disease in eastern and southern Africa

Rhipicephalus appendiculatus (the Brown Ear Tick) is the primary vector of East Coast Fever, a cattle disease caused by the protozoan parasite Theileria parva. By the 2050s, suitable habitat for these ticks is projected to have largely disappeared from the south–eastern part of its existing range (south–eastern Zimbabwe and southern Mozambique), although its range may expand in western and central areas of southern Africa (Rogers 1996). Similarly, habitat for the Tsetse Fly is projected to decrease leading to reduction in the risk of Trypanosomiasis, another protozoan disease that has particularly profound implications for livestock production in Africa (Thornton et al. 2008). Tsetse fly and tick habitats are being modified through grazing management practices, extending the grazing range for livestock. This has gradually led to natural selection and co–adaptation, to milder forms of the disease, and the development of tolerance to Trypanosomiasis amongst some zebu cattle populations (Bourn et al. 2004).

then to transmit the infection), warmer temperatures increase the likelihood of successful disease transmission. What is less certain is whether climate change will also affect the abundance or distribution of the competitors and parasites of vectors themselves, thus influencing patterns of disease.

Other climate change effects on livestock health

Changes in ecosystems, driven by climate change and other drivers that affect land use, could give rise to new strains of species, which will expose hosts to novel pathogens and vectors that cause the emergence of new diseases (WHO 1996). Droughts may cause overgrazing, mass migration and concentration around pastures and water resources leading to increased infections of diseases such as Foot and Mouth Disease and Peste de Petits Ruminants. Alternatively, high rains may increase the prevalence of dermatophytosis, anthrax and foot rot. Regions where endemic stability is prevailing could shift to epidemic status when high livestock mortality occurs. Changing international trade patterns, local animal transportation, farm size and human migrations are all factors that may be driven in part by climate change, and which may impact negatively on disease transmission.

Impacts of climate change on livestock health in West Africa

Discussions with pastoralists during this study indicated that poor quality forage, especially during periods of scarcity, causes nutritional stress and disease that undermines livestock performance. For example, nutritional stress is the cause of a supposedly new disease in cattle called Dissidimi Ban (in Bambara, Mali). This disease seems to be widespread in the semi–arid and arid zones, and is treated with mineral supplements. Another example was given in the sub–humid zone of the Adamawa in Cameroon, where scarcity of forage during transhumance in the dry season leads to increased consumption of toxic plants, which in turn causes many cases of abortion and cattle mortality.

Forage quality and quantity

Experiments on grassland productivity under elevated atmospheric CO_2 concentrations and the interaction with temperature have revealed the likelihood of a number of outcomes of climate change globally (Topp and Doyle 1996; IGER 2003; Hopkins 2004). These data apply to grasslands globally and are not specific to Africa.

1. Increased herbage growth: compared with the current atmospheric CO_2 concentrations and temperature, dry matter yield of swards cut frequently was enhanced by elevated temperatures, elevated atmospheric CO_2 concentrations and by a combination of elevated atmospheric CO_2 concentrations and temperature;
2. Increased legume development: in sown mixed pastures, elevated CO_2 increases legume development, and this also occurs in temperate semi–natural grasslands;
3. Changes in herbage quality: higher concentrations of water–soluble carbohydrates and lower concentrations of N at a given dry matter yield.

Climate change, however, will have other consequences, including:

- Greater incidence of summer drought, which will offset the advantages in dry matter yield that may arise;
- Leaching increased due to increased winter rainfall, but some potential for increases efficiency of nitrogen use by the growing sward;
- Reduced opportunities for grazing and harvesting on wetter soils and higher demand for watering.

As temperature and CO_2 levels change, optimal growth ranges for different species also change; species alter their competition dynamics and the composition of mixed grasslands changes. The amount of browse in rangeland habitats is likely to increase in the future as a result of increased growth and competition of browse species due to increased CO_2 levels (Morgan et al. 2007). Legume species will also benefit from increases in CO_2 and in tropical grasslands the mix between legumes and grasses could be altered. Average biomass generally increased for warm–season grasses and decreased for cool–season forbs and legumes as optimal grassland conditions shifted from lower to higher latitudes (Dixon et al. 2003). Other studies indicate that higher temperatures will favor forbs and legumes over grasses, but they also note that there are likely to be less significant impacts on livestock yield per se, compared with grassland biomass.

According to IPCC (2007), temperature and rainfall changes in the future will often limit the negative impacts of CO_2 on plants. The major physiological effects of higher temperatures on plant growth are generally associated with higher radiation levels and increases water use. At higher latitudes, rising temperatures may prolong the growing season. Higher temperatures in lower latitudes may result in more water stress for plants, although higher temperatures in low latitude highland areas may increase their suitability for cropping and thus increase the risk of soil erosion.

Sustained increases in mean temperature result in significant changes in rangeland species distribution, composition, patterns and biome distribution (Hanson et al. 1993). In pastures, elevated CO_2 combined with increases in temperature, precipitation and nitrogen deposition could result in increased primary productivity with changes in species distribution and litter composition. Future CO_2 levels may favor C_3 plants over C_4 plants, but the opposite is expected under associated temperature increase. Impacts on plants depend significantly on the precipitation scenario. Changes in evaporation–precipitation ratios modify ecosystem function, particularly in marginal areas, in ways that are not fully understood (IPCC 2007). There are also potential threats to many species and habitats and extinctions can be triggered by frequent extreme weather events. Species with poor capability for dispersal and restricted geographic ranges are under high risk.

A modest amount of information on the likely impacts of climate change on forage quality is relevant to tropical Africa. The modeling study of Hanson et al. (1993) indicates that mean forage digestibility decreased under all scenarios considered. The models simulated an increase in standing biomass but a considerable reduction in the nitrogen concentration of plants during the summer grazing months, large enough to bring about considerable decreases in animal performance. Higher temperature increases the growth rate and lignification of grazed plants. Other studies have shown that an increase in the legume content of swards may partially compensate for the decline in protein content of the non–fixing plant species under conditions of elevated CO_2 concentrations. At the same time, the decline of C_4 grasses (which are less nutritious than C_3 plants) may compensate for the reduced protein content under elevated CO_2. However, the opposite effect is expected under associated temperature increases (IPCC 2007).

Livestock market and exports

At face value, it is expected that a decline in the volume livestock production will lead to a decline in the number of livestock marketed. However, in reality, the scenario will be determined by a range of factors, including the fact that livestock marketing in Africa is already depressed due to structural inefficiencies and it is driven by both subsistence and profit motives. The value of cattle and small stock may drop during drought due to increased supply and deteriorating conditions of the animals, and the response of herders to these market conditions is highly varied, with some producers selling their animals before the value becomes unacceptably low, whilst others reserve higher value stock as long as possible as a back up. Marketing of livestock often declines and their price increases immediately after drought because farmers are rebuilding their herds and more likely to withhold animals from sale (Davies 2006). However, it is not clear how these short–term responses to climate events will translate into long–term adaptations in marketing practices.

Livestock prices are determined by both demand–side and supply–side factors, and climate variability and the occurrences of drought are generally classified as supply–side factors since they influence production levels. There is evidence of marginal downward pressure on domestic livestock prices during times of drought and a slight upward pressure on livestock prices in periods immediately after droughts. While prices did not fluctuate much over the years, farmers received lower total value for their cattle and small stock because of the lower average grades arising from the poor conditions of the animals (UNDP 2008).

The impact of climate change on the dairy industry in Africa is poorly understood, as is the dairy sector in general. Milk is the primary output of Africa's extensive rangelands but marketing in most areas is negligible leading to gross undervaluation in national accounts and national planning. The intensive dairy sector, which supplies a disproportionate share of the market, will largely be affected through input shortages and rising production costs. The impact on the extensive sector is likely to be similar to that of others discussed here through depressed productivity and reproductive rates. The overall impact may be a lowering of gross rangeland productivity and reduced human–carrying capacity.

Social impacts

Climate change may hasten or change the course of ongoing social transformations in sub–Saharan Africa. An observable effect of drought is the transfer of livestock ownership to crop farmers, which is partially the result of capitalization of agricultural surpluses, especially in the cotton producing areas. Herders have sought to contain the risks of increased competition in the marginal lands between pastoral and crop producing zones by diversifying into crop production themselves.

Climate change projections indicate some intriguing changes in land use options for many of the marginal lands of Africa, with shifting frontiers of production possibilities. As areas get drier, marginal crop producing lands will become unsuitable for crop production and will presumably revert to livestock production. This may also be the case in areas that receive more but less certain rainfall, unless investment is made in water harvesting. In areas where rainfall increases, crop production may encroach into grazing lands, or may be increasingly adopted by current livestock keepers (or drop–outs from livestock keeping communities). The range of outcomes is wide and the ramifications for social cohesion, environmental management and sustainable and equitable development are profound (Davies and Nori 2008).

Impacts of climate change on pastoral resource competition in Kenya

The Boran pastoralists of Garba Tula in northern Kenya follow a transhumant production pattern, using the high quality wet season pastures when they are available and retreating to other grazing areas in the dry season. Early in 2008, when disrupted rainfall was severely hampering crop production in the neighbouring Meru district, the Boran were relatively unaffected and were able to track the few unseasonal showers. Later in the year however, the dry season extended for a longer than average period and the Boran were obliged to move to traditional dry season pastures. One of the main buffer zones is the Lorian swamp, but this area has steadily become drier in recent years, in large part due to water offtake far upstream by neighbouring cultivators. As a result of this lost dry season grazing buffer, the Boran from Garba Tula sought grazing in the restricted Bisan Adhi reserve—land that has been annexed for wildlife protection by the local authorities—leading to conflict with the park authorities. Eventually the herders took their stock down to the Tana River, some 100 km further away, where they negotiated water and pasture use with similarly affected herders from many other parts of northern Kenya.

In some livestock dominated areas of Africa, insecurity is already a major threat to sustainable livelihoods. The roots of this insecurity are diverse and in some cases contested; nevertheless, changes in the pattern of resource availability as a result of shifting climate patterns will create new areas of resource competition to which livestock producers will be forced to adapt. Key buffer resources, such as riparian zones, may become of increasing value to crop producers, leading to accelerated privatization and exclusion of land. Key pasture zones may support changing population groups and may put strain on customary institutions for resource sharing and conflict management. Other resources that are crucial for healthy livestock, such as salt–pans, may similarly face new competition. These pressures are shifting at a time when the capacity of many livestock keepers to govern themselves and their resources has been eroded, and this presents conditions for conflict.

Specific impacts of climate change on rangeland livestock systems

In arid and semi–arid areas, livestock production has the greatest potential to meet the subsistence needs of humans, maintain ecosystem health and minimize the negative global impacts of climate change. However, many rangeland areas in these regions are experiencing high population growth and resource competition, both of which force expansion of grazing into areas of marginal productivity, placing extreme pressure on an already stressed ecosystem. Changes in precipitation are especially important in regions where lack of rainfall is already a limiting factor. At a regional level, alterations in rainfall patterns are likely to have a greater ecological and socio–economic impact than the direct effects of small increases in mean annual temperature. Rainfall variability coupled with overgrazing could cause severe land degradation that has the potential to lead to desertification.

Traditional pastoral systems and industrialized rangelands systems have different capacities to adapt to climate change. Pastoral systems have often been defined by their adaptive capacity and can only have survived in highly uncertain and climatically extreme environments by being very adaptive. However, recent decades have seen ‘development’ approaches that have undermined this adaptive capacity, leaving many pastoralists highly vulnerable to climate change. The key to rebuilding this capacity is to restore governance over natural resources and to build human capital (for example through education) that will enable pastoralists to make informed choices about the adaptation strategies that are at their disposal (Davies and Nori 2008).

Table 4: Possible climate change impacts on rangeland systems in eastern and southern Africa

Direct livestock impacts	Shifts in rangeland vegetation structure or boundaries Changes in forage quality and quantity Changes in length of growing season Changes in livestock productivity and health Changes in water quality and quantity
Indirect through ecological impacts	Changes in soil quality and productivity Disturbances in ecosystem function (e.g. alterations in biogeochemical cycling, incidence of wild fire, etc.) Changes in biodiversity Changes in habitat suitability for wildlife
Indirect socio–economic impacts	Changes in food production and security (locally, regionally and nationally) Changes in incomes derived from livestock production, and other rangeland inputs Changes in security and resource competition Change in land use Changes in recreational use of rangelands and alterations in scenic quality

Industrialized livestock production systems, with their financial and political resources, are more likely to make technological shifts to mitigate many of the potential negative effects of climatic change (such as changing the type or mix of feed, cross–breeding, relocating, buying coolers). Whether these will be cost–effective or ecologically sound remains uncertain, and many of the adaptive measures could increase the causes of climate change through increased energy consumption and water usage. Adjustments may also imply land–grabbing, which could, for example, produce more feed inputs that would increase conditions for conflicts.

In addition to the climatic effects on rangeland, the increase in animal numbers on a decreasing surface of pasture is overloading pastures and accelerating their degradation in some areas, as in Burkina Faso where the population of cattle has grown by 30% in 14 years. Decreases in pasture are not necessarily climate–induced; since the 1970s, pastoral resources have been lost to irrigation projects in numerous countries (such as Sudan, Ethiopia, Kenya, Mali, Benin, Niger and Senegal), as well as to conservation projects and protected areas. Furthermore, even where pastures remain available they are often rendered inaccessible due to fragmentation and privatization of land and loss of transhumant corridors, undermining one of the key adaptation mechanisms in the drylands.

Loss of pasture in Cameroon

About 42% of northern Cameroon (6,000km^2), which used to be natural grassland, receiving pastoralists from neighbouring countries (Nigeria, Chad and Central African Republic), has been classified as either national parks (Bénoué, Bouba Njida and Faro) or game reserves that attract foreign tourists. Livestock is prohibited in these areas and herders who invade such terrain fear being shot by the guards. Furthermore, the three main national parks cut Cameroon into two, from east to west, preventing livestock from moving southwards to benefit from the abundant grasslands of the Adamawa Region.

Impacts of climate change on mixed farming systems

Climate change will influence livestock production in mixed farming systems primarily due to geographical shifts and yield changes, reduction in the quantity of water available for irrigation, and loss of grazing/crop–lands through rising sea levels and associated salinization. The yields of natural pastures may be altered by changes in temperature, precipitation, cloud cover, soil moisture and increases in CO_2 concentrations. Low rainfall and high temperature could reduce soil moisture in many areas, reducing the available water for crop irrigation and natural pastures fields. The changes in soil properties such as the loss of soil organic matter, leaching of soil nutrients, salinization and erosion are likely in some climatic zones (Cumhur and Malcolm 2008). Furthermore, the pattern of weeds, insect pests and diseases may change, with increases particularly likely in the areas that are more favorable to crop production. Since agro–pastoral systems tend to use more agro–veterinary inputs, drug consumption and costs may increase.

Dairy production in mixed farming zones is likely to be most affected since it depends heavily on water supply and is most demanding in quality forage and crop. Higher temperatures would likely result in a decline in dairy production, reduced animal weight gain and reproduction and lower feed conversion efficiency (Cumhur and Malcolm, 2008). As climate changes, species niches change (plant and crop substitution) and this may modify animal diets and compromise the ability of small–holders to manage feed deficits. In parts of East Africa, maize is being substituted by crops more suited to drier environments (sorghum and millet) and in marginal arid southern Africa, systems are converting from mixed crop–livestock to pure rangeland systems.

Table 5: Summary of possible impact of climate change on crop–livestock production systems in eastern and southern Africa

Factor	*Impacts*
Feeds	Land use and systems change Changes in the primary productivity of crops, forages and rangeland Change in quantity of stover and availability of digestible energy for dry season feeding Change in quality of plant material (e.g. increased lignification if increased temperature) Interactions between primary productivity and quality of grasslands
Water	Increasing water scarcity, affecting livestock feed production systems and pasture yield as well as livestock health and productivity directly
Biodiversity: genetic and breeding	Possible loss of genetic and cultural diversity in crops as well as domestic animals (Ehrenfeld 2005) A 2.5ºC increase in global temperature above pre–industrial levels could lead to 20–30% loses of plant and animal species (IPCC, 2007).
Livestock disease	Expansion of vector populations into cooler areas; decrease in dryer/hotter areas Expansion of diseases to the north (Lancelot et al. 2008) Helminth infections are greatly influenced by changes in temperature and humidity Loss of trypanotolerance traits in sub–humid zones of west Africa Increase a heat related mortality and morbidity (Patz et al. 2005)

Impacts of climate change on landless livestock production systems

A review of available research suggests that the direct impacts of climate change on landless livestock production may be relatively minor for intensively managed livestock production systems (landless) such as confined poultry, swine and beef operations (IPCC 1996). These systems already have a great deal of built–in climate control through the use of shade and mechanical heat regulation. However, there are important indirect impacts on these systems such as the cost and availability of feed grain, water quality and quantity, and the cost, availability and types of energy sources.

Research has not shown the likely indirect impacts of demographic shift and environmental refugees, which may lead to changes in demand for livestock products (favoring peri–urban and urban production) as well as changes in production systems (increasing household production of small stock). Furthermore, no research relating to the impact of climate change on unconventional livestock production systems has been identified, but, as with other forms of small stock production, there may be increased opportunities for meat production in urban and semi–urban settings. It is uncertain where feed inputs for different forms of urban and peri–urban production will come from, but experiences in Asia highlight the value of monogastric production for consuming household and industrial waste in urban areas.

Adaptation in the African livestock sector

A community's adaptive capacity refers to its ability to adjust to climate change and to moderate or cope with the impacts, including taking advantage of opportunities that may arise with climate change. Adaptive capacity is understood in terms of basic socio–economic factors (e.g. income, access to resources and services and literacy), a community's past and current experience in managing climate stress, the feasibility of past strategies for adaptation in the face of current trends (climatic and otherwise), availability and awareness of alternative adaptation strategies and the conditions and barriers to adaptation.

Adaptive capacity, when understood in the context of the relative vulnerability of a community, is determined by exposure and sensitivity to hazards (IPCC 2001). Exposure is defined by the magnitude, character and rate of climate change in a given geographical area whilst sensitivity is the degree to which a community is adversely or beneficially affected by climate–related stimuli. Sensitivity is greatly influenced by a community's livelihood activities and by the specific natural, physical, financial, human and social resources needed to carry out these activities (Riché et al. 2009).

Maddison (2006) categorizes adaptation into 'internal' and 'external' measures (local and borrowed or adapted from elsewhere). However, the IPCC (2007) classifies adaptive responses to climate change more broadly, as behavioral/managerial or policy–oriented. According to Klein (2002), adaptation to climate change can be 'reactive' when applied to the current extreme climatic events or 'anticipatory' when implemented before the extreme events occur. This study explores adaptation measures rather than vulnerability more generally, and therefore does not discuss issues of sensitivity or exposure in detail. For deeper analysis, the CRISTAL toolkit (Community–based Risk Screening Tool—Adaptation and Livelihoods) provides an excellent approach for assessing community vulnerability and adaptive capacity (www.cristaltool.org) and the study by Riché et al. (2009) provides a good working example of this methodology amongst livestock keepers in southern Ethiopia.

Traditional adaptation strategies

Rural livestock producers have a degree of adaptive capacity and have only survived or emerged as livestock keepers due to this capacity. In some cases livestock keeping is defined by adaptability, as in the case of African pastoral systems, which have elaborate systems for managing climatically unpredictable dryland environments. In other cases, livestock production is itself an adaptation strategy that people have adopted as a means of diversifying their livelihoods, preserving assets and harnessing marginal resources. It is significant that, in the context of climate change, the combination of weakening existing adaptive capacity combines with the inadequacy of existing capacity in the face of new and severe threats.

Pastoralism as an adaptation to climate change

More than once in human history, pastoralism provided a means through which sedentary populations could adapt to survive in the face of deteriorating climatic conditions. Archaeological evidence indicates that pastoralism in Africa developed about 6,000 years ago in direct response to long–term climate change and variability, and spread throughout northern Africa as a means of coping with an increasingly arid and unpredictable climate. Current climate changes are predicted to bring rising temperatures and erratic precipitation, which increase the likelihood of both drought and flood. Traditionally, pastoralism—more than any other rural land use system—has been well–adapted to such changes.

Source: Davies and Nori 2008

Breeding locally adapted livestock species

The overwhelming majority of livestock in Africa is locally bred and kept by small–scale livestock keepers and pastoralists. These breeds may be less productive than their high–yielding 'exotic' relatives, but they are supremely adapted to the harsh environments where they dwell and they can produce under conditions where other breeds cannot survive. Indigenous breeds are more disease resistant and drought tolerant; furthermore, they are crucial to the effective management of the environments in which they were developed. Without resilient livestock that can cope with the rigors of transhumance, rangelands systems collapse and environmental degradation often ensues (WISP 2008b). In the 12,000 years since livestock were first domesticated more than 7,000 breeds have been developed, many of which have adapted to a specific habitat and shaped, often over centuries, by the cultural preferences of a particular community (FAO 2007).

Local breed Improvement

N'Dama cattle weigh about 168 kg at 36 months and about 200 kg at maturity (Bosso 2006). Because of their low body weight, pastoralists are crossing this breed with zebu cattle to improve their body–mass and walking capacity. Although a fairly short–term production strategy, this constitutes a threat to the long–term survival of the breed, which is only about three million head, but which is a valuable asset owing to its tolerance to trypanosomiasis. The International Trypanotolerence Centre, based in The Gambia, is administering a multinational project in West Africa (Gambia, Mali, Senegal and Guinea) funded by the African Development Bank to develop the breed and to increase its productivity so as to maintain its popularity and promote its use.

Examples of local adaptation are the N'Dama cattle and the West African dwarf goats, both of which have been bred in the tsetse infested zones (sub–humid and humid zones) of West and Central Africa where trypanosomiasis is prevalent (Bosso 2006). These breeds have a proven ability to survive, reproduce and remain productive without recourse to drugs. Djallonke sheep and goats in Central Africa have demonstrated similar resistance to tsetse. The raising of these indigenous, trypanotolerant livestock is one approach to control disease and reducing the risk of inducing drug resistance in trypanosome strains. It has also been reported that trypanotolerant cattle, especially the N'Dama breed, show superior heat tolerance than zebu cattle. Plus, they metabolize water with greater economy, making them better adapted to the hot and water–stressed regions of Africa, conferring obvious advantages in the face of climate change.

Diversifying livestock types

Most African pastoral systems consist of a diversity of livestock species that includes some combination goats, sheep, cattle, camels and donkeys. Maintaining a diverse herd has a number of advantages and it represents a critical adaptation measure. A diverse herd is an adaptation to a diverse ecology in which vegetation can be highly varied in both space and time. One area might be dominated by grasses whilst a neighbouring area is dominated by shrubs, or alternatively the same area may shift from one dominance to another and back over the course of time (Behnke et al. 1993). In general, cattle and sheep are better suited to grazing pasture whilst goats and camels thrive on shrub land. In addition to ecological motives, pastoralists change their stock type according to market forces, with cattle and sheep often highly saleable. Various species also have different production attributes and uses, with camels providing transport in addition to milk and meat, goats providing rapid rates of post–drought herd recovery, sheep providing seasonal income opportunities related to Islamic festivals, and camels and cattle providing prestige and social status in some communities.

Samburu and Turkana Pastoralists in northern Kenya have recently begun to increase the number of camels that they manage, substituting them for cows in order to have more drought–resilient livestock. This change of livestock species is not a new phenomenon and has been reported in the past as a periodic shift, driven by climatic factors, change in land cover (e.g. between browse and pasture) and shifting market demand. During drought periods for example, pastoralists may shift from cattle to sheep and goat husbandry, as their feed requirements are lower, feeding habitats broader and reproduction rates are higher.

Adopting livestock production as an adaptation strategy

Non–livestock farmers have often been observed to take up livestock keeping as an adaptation strategy, usually starting with small stock and often feeding them on crop production and/or household waste. The preference for different livestock types depends on the availability of fodder, the capacity to thrive on crop residues or disease resistance. For example western African farmers have begun to embrace novel livestock types, including cane rats and snails, exploiting niche markets or local production opportunities, whilst in southern African farmers have adopted game ranching in order to target emerging markets.

A more common production system is poultry, which has been touted as a key survival strategy for many Africa farmers (Alders et al. 2007). Poultry production is a well–known and proven livelihood option in most sub–Saharan countries; it is fast producing at low cost, using locally adapted species and has low medical costs with inexpensive vaccines available for the most prevalent disease (Newcastle Disease).

Poultry plays an important role in the national economies of most developing countries and is plays an equally important role in improving the nutritional status and incomes of many small farmers and landless communities (FAO1998). Studies have shown that adoption of poultry production increases food security in Africa (Mutizwa–Mangiza and Helmsing 1991) by providing readily harvestable animal protein to rural households, and providing eggs and meat that cook faster than pulses and red meat, and therefore use less fuel wood (Chale and Carloni 1982). Poultry are particularly important to women because of their comparative ease of handling and the fact that they can be reared on minimal space and using household waste, and in countries such as the Sudan women have achieved a degree of economic empowerment through the sale of eggs.

Resource management practices

Setting aside grazing areas for either seasonal use or for production of certain animals (e.g. calf–grazing paddocks) has been widespread in eastern Africa, although such practices have in many cases been lost in recent years. The loss of such resource management practices is due to a number of factors, including sub–division of land, changes in resource tenure (including nationalization of land in some cases) and the breakdown of the mechanisms for governing communal resources effectively (McGahey et al. 2008). Pastoral mobility, which is a means of reducing pressure on low–capacity grazing areas, continues in much of Africa. Although it has been widely curtailed, the practice allows domestic herds to replicate the grazing pattern of native herbivores by performing bouts of intensive grazing followed by periods of rest and recuperation.

Adaptation strategies that pastoralists apply in times of drought include the use of emergency fodder in the form of grazing enclosures, culling of weak livestock and keeping more than one species of stock. Pastoral women play a particularly important role in natural resource management, harvesting wild food during drought and harvesting other products that have market value such as honey.

Feed production technologies

Many non–rangeland livestock businesses rely on crop residues, scavenging or purchased inputs to feed livestock. The pressure for land to produce food for human consumption means that innovative ways are needed to produce feed such as agricultural by–products or household/industrial waste products. Africans have developed various techniques to produce alternative feed inputs for poultry, often on a small scale. In Togo, villagers have developed a novel system for producing eggs and larvae of termites as poultry feed. Crop residues from maize, sugar cane and millet are placed in pots on termite mounds to attract termites, which are harvested to feed poultry after 3–4 weeks (Farina et al. 1991). In Burkina Faso a similar system has been developed using maggot culture tanks filled with water, cereal stover and poultry droppings as substrate (Soukossi 1992) that produces larvae after five to ten days for feeding poultry.

Adaptation by peri–urban pastoralists in Cameroon

The Far North Region of Cameroon has a semi–arid climate with one rainy season and a highly variable temporal and spatial rainfall pattern. During the eight–month dry season, cattle lose considerable weight and become more susceptible to diseases and mortality is at its highest. The Logone floodplain in the Far North Region of Cameroon is one of the most important dry season grazing lands in the Chad Basin and each November pastoralists from Cameroon, Nigeria and Niger trek to Logone to exploit the excellent quantity and quality of the rangelands. At the start of the rainy season the Cameroonian pastoralists return to the higher elevated dunes of the Diamaré, while pastoralists from neighbouring countries return to their respective countries.

The village of Wuro Badaberniwol, located about 10 km east of the centre of Maroua in the Northern Province of Cameroon, has grown from approximately 50,000 to 400,000 inhabitants in the last 25 years. Increasing urbanization has also led to an expansion of agriculture around Maroon as many urban dwellers continue to farm. Consequently, there are practically no rangelands in the surrounding villages. The carrying capacity from March to June is extremely low and cattle in the peri–urban area cannot survive on the natural forage available. Peri–urban pastoralists have adapted to the lack of natural forage in two ways. Firstly, they entrust part of their herd, the bush herd, to nomadic pastoralists or paid herders who are permanently in transhumance between the Logone floodplain and the Mindif–Moulvoudaye region. Secondly, in the dry season, they feed the remaining animals in the village with cotton seed cakes, bran and sorghum stalks. In the rainy season, these animals are sent on transhumance to the Mindif–Moulvoudaye region. Thus, peri–urban pastoralists pursue both intensive and extensive strategies to cope with the disappearance of grazing lands in the peri–urban area.

Source: Moritz 2008.

Pastoral livestock mobility

Pastoral production is generally characterized by some form of herd movement, or transhumance, which allows herds to access seasonally available resources (e.g. wet season pastures or dry season forests) and evade seasonal stresses (such as parasites). There are other factors driving mobility such as the need to access markets or services, the need to avoid conflict and the opportunity to make political alliances or fulfill social obligations. Ecologically and economically speaking, mobility is essential for the sustainable management of rangeland resources.

Herd mobility enables pastoralists to adapt to changing vegetation patterns in environments described as 'non equilibrium': where vegetation is in constant flux and does not arrive naturally at a climax vegetation state. Climate change is likely to increase this variability among natural resources, making herd mobility an increasingly important survival strategy.

Diversification of livelihood activities

Pure livestock farmers have often turned to crop cultivation as a means of supplementing livestock incomes, and sometimes as a survival mechanism when they are attempting to re–stock after an emergency. Many former pastoralists are now mixed farmers, sometimes referred to as agro–pastoralists, combining transhumant (and in some cases sedentary) livestock keeping with crop production. The change in land use has implications for social relations between farming and herding societies that were previously mutually reliant. In the semi–arid and sub–humid zones of northern Cameroon for example, farmers are faced with a drop in crop yields due to declining fertility, and in the past they would contract pastoralists to graze crop residues and in return, to keep them at night on their farms in order to collect manure for soil fertility. This is no longer possible, as pastoralists prefer to keep animals on their own farms. Consequently, farmers harvest all crop residues for sale or to feed their own livestock in the dry season (Dongmo 2009). When livestock keepers adopt crop production they often have the advantage of copious manure, which gives them higher yields compared to non–livestock keeping farmers. This system contributes to improving soil fertility, reducing the need for expensive chemical fertilizers by poor resource farmers, increasing the productivity of food and the availability of diverse animal products.

Understanding the constraints to adaptation

Despite the many tried and tested adaptation strategies of Africa's livestock keepers, there is understandable concern about their capacity to adapt to the challenges of climate change. Respondents in Kenya cited the following constraints to their capacity to adapt in the short–term to the challenges of climate change (Table 5).

Table 6: Constraints in short–term adaptation in Kenyan households under mixed crop–livestock farming

Constraints	***% of household respondents***	
	High potential zone	Mid to low potential zone
Lack of information about short–term climate variation	7%	10%
Lack of knowledge of appropriate adaptation	16%	25%
Lack of credit or savings	56%	64%
No access to water	12%	3%
Lack of appropriate seed	4%	6%
Other constraints	12%	14%
No barriers to adaptation	9%	8%

Innovative adaptation within the livestock sector

There are many innovations and development interventions that have the potential to increase the adaptive capacity of livestock keepers, even though these innovations may not be explicitly designed with climate change in mind. These innovations—such as the vaccination of rural poultry, the development of farmers' organizations or the development of solar energy for water supply—may be social, technological, economic or environmental.

Table 7: Enabling conditions and constraints in Ethiopia

Strategy	***Enabling conditions***	***Constraints***

Migration	Young men in pastoral communities have the physical ability and willingness to move to other places within and outside internal and international boundaries to find work or better pastures	• Conflicts among tribes over pasture, water resources and new boundaries limit movement in Borana
		• Agricultural expansion limits livestock movement in some areas
		• Negative effects which may limit continued adoption of the strategy:
		  • Separation of families when men migrate
		  • Increased rural–urban migration of unskilled labour might exacerbate urban food insecurity and urban poverty

Diversification of livelihood activities	Community members have the willingness to undertake other livelihood activities Drought times are favorable for brokerage activities (undertaken by young men) as there are many livestock to sell during those times	• Limited market access and limited up–to–date market information • Limited financial support and credit access to engage in different kinds of business activities • Limited skills to engage in new income generating activities • Limited water resources available for farming and irrigation in many areas • Firewood and charcoal selling is leading to depletion of forest resources (negative effect) and, because many people are undertaking this strategy, prices are very low (disincentive) • Low or no demand for casual labour in many areas
Reducing conflicts over available resources	Awareness that conflicts makes them more vulnerable to droughts and other extreme weather events Expressed willingness to put conflict prevention and peace building strategies in place	• Regional boundaries are often changing and are not clearly defined in Borana • There are often delays in peacemaking and government interventions, which often come after human deaths and destruction of resources

Source: Riché et al. 2009

Social innovation

National and regional institutions such as CILSS (Comité Inter–Etate pour la Lutte contre la Sécheresse au Sahel) have developed ways to facilitate the movement of livestock within or outside the countries for transhumance or for markets. Empowering pastoralists to organize themselves into co–operatives, unions or associations aimed at defending and protecting their rights has been a major social innovation. Their active participation in national or regional debates is gaining ground in Africa.

Networks of livestock keepers in West Africa

Bilitaal Maroobé is a network of livestock keepers (largely pastoralists) from seven West African countries, headquartered in Burkina Faso. The name of the network, which means ‘Promotion of Livestock Keepers’ in Peul, was created in 2003 with the goal of representing livestock keepers’ rights. Bilitaal Maroobé works with livestock keepers to address their marginalization and support their sustainable development. This work includes linking herders with policy makers, securing the pastoral economy, promoting the socio–economic position of women farmers in the Sahel, promoting technical innovation and improving the ecological balance and environmental sustainability of the region.

Improving village poultry production to alleviate poverty and improve rural income in Burkina Faso

Increased human population, urbanization and economic growth increase the demand for animal protein and are driving growth in short–cycle livestock production sectors such as poultry. This sector is being strengthened in Burkina Faso by vaccinating against Newcastle Disease, which is contributing to the abundance of poultry. 'Poulet bicyclette' (so called because they are usually transported to town by bicycle) is widely available and cheap at about USD 3 per head. Some of the difficulties that hinder the development of village poultry farming include:

- Diseases such as Newcastle disease, which can easily wipe out 80–100% of poultry in a rural village.
- Poor feeding systems, for example, low protein intake in particular, where frequent use of pesticides has led to reduction in insects, which are a source of protein for rural poultry.
- Lack of access to suitable nests or incubators, poor housing and hygienic conditions and the lack of training, information and sensitization of producers.

Under the Ministry of Animal Resources, the Support Project to Village Poultry aims to reduce rural households' poverty by increasing incomes from marketing village poultry. The target beneficiaries are rural producers (men, women, and young people) who develop activities in poultry such as training farmers' organizations, implementing a health improvement program to decrease fowl mortality, increasing Newcastle disease vaccination rate, improving poultry husbandry techniques, building appropriate infrastructure and improving equipment for rural poultry farming. Poultry is now largely available and cheaper than beef and the project has created awareness of vaccination options available for rural farmers.

Farmers' organizations are important assets to the dissemination of information, building capacity of members and developing production and marketing policies. Such organizations in Burkina Faso have been involved in the preparation of the pastoral code that was recently presented to Parliament. In Cameroon, farmer associations are negotiating with the Government to declassify one national park to give livestock access to resources in the south of the country.

Technological innovations

Many farmers have developed or adopted technological innovations to increase livestock productivity whilst having less of a negative impact on the environment. Some technologies are endogenous, such as on–pasture cattle fattening in the peri–urban zone of Brazzaville before marketing by traders from Chad. Extension agents, NGOs and others have taught various technologies such as the national program for the promotion of vaccination of poultry in rural farms of Burkina Faso. Examples of technological innovations include peri–urban dairy production, intensive poultry and pig production in arid and semi–arid zones, feed preparation, hay production, crop residue conservation, irrigation, and forage seed production.

Management innovations

Fattening cattle on pastures in the peri–urban zones is an increasing phenomenon in Gabon, Cameroon and Equatorial Guinea. In the humid and sub–humid zones where plenty of good quality forage is available, developing peri–urban fattening facilities helps to regulate the supply of quality meat to the growing urban population. Pastures in the arid and semi–arid zones can therefore be used for reproduction with peri–urban zones acting as a holding and fattening ground. A similar system is evolving in Kenya where cattle from the lowlands are fattened on mid–altitude private ranches prior to sale in urban markets.

Cattle fattening in Congo

Traders in Brazzaville, Republic of Congo, fatten cattle from Chad prior to onwards sale in Congolese markets (Njoya et al. 2003). Lean cattle are fattened for periods varying from 4 to 10 months on pasture in the outskirts of Brazzaville (Kintélé, about 40 km from Brazzaville) where there is abundant fresh pasture. The only supplement given to cattle is salt and minor expenses are incurred for salaries to herdsmen, fees paid to the Local Council, and the cost of drugs to protect cattle against insect bites. Cattle that arrive in the Republic of Congo weighing 350 kg sometimes double their weight after 8 to 10 months on pasture and can be withheld from the market until prices are favorable to sales.

Developing niche markets to preserve indigenous breeds

Despite the exceptional adaptation of local livestock to local conditions, livestock experts have invested a lot of money trying to replace them with higher yielding foreign breeds that are costly to maintain due to their low adaptation and which are often rendered unproductive by environmental challenges. As a result there is a risk of losing some of the adapted local breeds that could play a significant role in future adaptation to climate change. FAO estimates that up to 11% of mammalian breeds and 2% of avian breeds have become extinct in recent years with a further 210 cattle breeds and 179 sheep breeds classified as 'critical' or 'endangered' (FAO 2007b).

Maintaining local breeds requires a multi–pronged approach, starting with respect for the rights of local custodians of these breeds and support for their production systems. Niche markets and the addition of value may provide one means of raising the returns from indigenous breeds and making them more competitive. Niche markets exist for some of the less mainstream livestock products, including camel ice cream and fine animal fibers (although not relevant in the African context). Identifying niche market opportunities is an important strategy and there are a few examples of marketing of camel milk that show promise. Desert lamb in South Africa is another example of promoting the value of less mainstream production systems by marketing their environmental credentials (WISP 2010).

In Kenya, ecotourism can play a similar role by providing significant secondary income for livestock keepers to maintain the traditional system that is more environmentally friendly than modern alternatives. A number of group ranches in the Laikipia and Samburu areas of northern Kenya have opened ecotourism ventures and manage their herds accordingly, maintaining open rangelands for the movement of wildlife as well as livestock, protecting wildlife for the additional revenue they earn, and providing buffer zones for conservation that livestock only access in times of extreme hardship (www.nrt–kenya.org).

Information technology

Mobile phones have become important tools for many pastoral livelihoods. The geographical position, the availability of forage and water resources, the conditions of the animals, the occurrence of events (births, theft, accidents or disease) is conveyed through this medium. It is also becoming a tool in the development of various warning systems to inform pastoralists of the occurrence of extreme events. NGOs in Northern Uganda have also explored opportunities for using mobile phone technology to create community security information networks.

Mobile phones also support more informed market engagement by livestock keepers and both pastoralists and livestock traders are now better–informed of market conditions and policy issues than in the past. Since livestock marketing involves a transfer of large amounts of money, traders have progressively become targets of bandit attacks and new money transfer technologies by mobile phone (e.g. M–PESA in Kenya) are transforming the ease with which traders can do business.

New energy supplies

Solar energy is becoming increasingly affordable and widespread, and in West Africa governments are exploring its potential in water supply and management. Given the amount of time spent fetching water in rural areas and the challenges of expensive and inaccessible energy supply, solar energy can be a practical solution in some cases where water pumping is required. Since 1991, West African countries, under the aegis of CILSS, have received support from the European Union to develop an extensive water supply network using solar energy. In 18 years, the project has installed 610 pumping systems to supply water in communities of 1,000 to 40,000 people, 16 pumping systems for irrigation, 155 solar refrigerators installed in community health centres for the conservation of vaccines and 477 light systems for schools, mosques or literacy centers (CILSS 2009).

Climate forecasting capacity

The National Disaster Management authority of Kenya has been created as well as a Radio Internet Project whose responsibility is to disseminate weather and climate information to vulnerable communities. There is also a mechanism for development of climate reporting in Kenya that resulted in the formation of the Kenyan Network of Journalists and Meteorologists. A strategy for enhancement of the capabilities of the Kenya Meteorological Department (KMD) to render better services has also been adopted. This includes research on how the states of the Indian, Pacific and Atlantic Oceans affect the climate of Kenya. The KMD has also taken measures that improve the quality of service in issuing flood, long–range climate and climate change forecasts. Given the enthusiasm of scientists for weather prediction, there could be value in learning more about how livestock keepers predict the weather and what sort of additional information they would value. Building capacity to use weather forecasts may also be of value.

In Namibia, early warning management, contingency and response plans are found to be inadequate, which leaves the government ill–prepared to deal with large humanitarian emergencies despite the presence of local early warning mechanisms in the form of the early warning and information systems, an Emergency Management Unit, and others in the Southern African Development Community. These units focus mainly on crop production, yet both commercial and communal livestock production are often affected by drought and diseases, which may result in the loss of income and product supply, and which could benefit from some form of early warning system.

Index–based insurance in Kenya

Index–based insurance (IBI) against climatic hazards has been successfully developed among the pastoral communities of Mongolia and this success has sparked interest in developing similar systems in East Africa, notably Kenya. These systems are designed so that groups of resource users share risks with insurance companies and government. IBI is typically designed so that small losses are borne by the client that do not significantly affect their enterprise, whilst larger losses are transferred to the private insurance industry.

IBI is being developed in northern Kenya by a consortium of partners led by the International Livestock Research Institute (ILRI) and funded by USAID and the World Bank. In principle, herders should pay a market premium rate for the base insurance product, which pays out to individual herders whenever the livestock mortality rate in a given location exceeds a defined threshold. This threshold is index–based, so it is measured based on weather data (which is related to data on the economic impact of past climate events) rather than the rate of individual losses. This is considered an attractive way to reduce the risk of moral hazard (individuals 'playing the system'), reducing costs and creating an incentive on the part of the herders to adopt effective risk management techniques.

Developing financial services

Financial services were raised as an important capacity constraint in Kenya and are an important constraint throughout much of Africa. Although examples of financial services for livestock development exist, they are few and far between and there is little penetration of private sector financial services into the most remote areas of Africa where livestock keeping predominates. Urban and peri–urban producers have greater access to financial services in most countries, and in cases where these producers provide a link between rural and urban areas, they might transfer some of the benefits of financial services to rural livestock keepers by strengthening access to markets or other (non financial) services.

The absence of financial services, or the lack of financial products that are tailored to the practical needs of livestock keepers (e.g. relevant repayment rates, types of collateral etc.), has implications for the way livestock keepers engage in markets. Livestock itself often stands in for financial services, providing a store of wealth that can reproduce itself over time and provide a cash reserve for emergencies. The outcome is that livestock is often not reared exclusively for the marketplace and is not sold according to the logic of demand. In certain countries, such as Namibia, financial services are beginning to penetrate rural areas and be of benefit to livestock keepers, which enables some to sell livestock at the most preferential time (when the animals are most healthy or when market prices are highest) and save or invest the income in the most appropriate way.

Informal financial services are beginning to be explored, such as group saving schemes or village banking, and since both communal and commercial livestock farmers increasingly use purchased inputs for livestock, the role of financial services, including insurance, is likely to rise. In the context of climate change and the already highly unpredictable nature of most livestock keeping areas, insurance is a particularly crucial gap to fill. Insurance is often hampered by the lack of trust in local legal institutions or other systems for verifying claims and traditional forms of resource sharing in which livestock is provided, with or without obligation, to households in need, are widespread, particularly in pastoral areas. Such systems of insurance are often culturally important, but they are flawed by the fact that all members of a community are likely to be impacted simultaneously by climate events, rendering these traditional systems less and less effective. The need for appropriate livestock insurance products to be developed for and provided to livestock keepers is critical.

Developing community adaptation strategies

Development agencies can support livestock keeping communities to adapt to climate change by integrating adaptation planning into ongoing community development initiatives, and a number of tools are being developed to support this process. Once such tool, 'Community–based Risk Screening Tool: Adaptation and Livelihoods' (CRiSTAL), is designed to help project planners and managers integrate climate change adaptation into community–level projects through participatory planning. CRiSTAL helps project planners and managers understand how projects influence climate–related vulnerability and adaptive capacity and the programme enables communities to adapt to the impacts of climate change through activities that restore ecosystems, strengthen local capacities for risk management and diversify livelihoods.

Increasing numbers of agencies are aware of the implications of climate change and are attempting to address the issue with livestock keeping communities. In Namibia for example, a regional awareness program in the northern part of the country that is co–ordinated by The Desert Research Foundation uses workshops, discussions, posters, booklets, brochures and radio programs to create awareness and understanding of climate change among the general public—including livestock farmers, regional and local decision makers. This project also gathers information on climatic data and makes it available to decision makers.

Integrated livelihood development for resilient livelihoods in Mali

Programme d'appui au développement durable de l'élevage au Sahel occidental (PADESO) in Mali is an example of an integrated and co–ordinated development approach with broader socio–economic goals that include education, health, resource management, tenure systems, marketing and livestock productivity PADESO was created in 1973 following the droughts of 1972–1973. The overall aim is to contribute to the improvement of the living conditions and incomes of farmers and pastoralists through sustainable development of range management. Specific objectives are to create and equip watering points, construct livestock infrastructure, build capacity of farmers and pastoralists, contribute to the security of animal production, restore and protect the ecosystem and improve the management of pastoral lands.

PADESO has developed six new perimeters equipped with six deep–boring systems that use solar energy to pump water. The project has also constructed 15 pastoral wells to supply water to livestock, seven vaccination points and three markets for livestock. Other facilities built include agricultural equipment and water pumping systems, literacy centres, training centres for women as well as health centres. Capacity building includes functional literacy, agricultural management, environment and participatory management of natural resources, computer literacy, pastoral management and animal health and production. One of the major underlying challenges for this program is to secure land for pastoralists.

Conflict management

Based on the responses given by communities that were cited earlier in this report, it appears that inadequate attention is being paid to the challenge of natural resource conflict and management—issues that are widespread but which defy technological resolution. Natural resource conflict is likely to increase with climate change, whether due to diminishing resources that lead to increased pressure, or expansion of cultivable lands and encroachment of different land use systems. A lot of strong work on conflict management and natural resource governance is carried out in Africa outside the sphere of climate change adaptation. It is important to recognize the benefits of such work to the adaptive capacities of livestock keeping communities, and in particular the importance of securing legal rights over resources and ensuring that there is effective governance, through both formal and informal institutions.

Agencies working on adaptation—research and development

Many agencies are working on community adaptation to climate change in Africa, although few focus explicitly on livestock production. Nevertheless, there is much to learn from community adaptation in general—as a suite of adaptive capabilities rather than a series of sector–specific technologies. A few examples are cited in the box below.

A number of Agencies in eastern Africa are working explicitly on adaptation to climate change in the livestock sector, although all the examples identified in this study focus on the extensive rangelands sector. Agencies working directly on livestock sector development include ILRI, who are working to reduce vulnerability of livestock–based livelihoods in pastoral and agro–pastoral areas using a trans–disciplinary research approach, and a consortium from Michigan University, ILRI, Ohio University, Virginia Tech and Dar es Salam University are working on the project East Africa Climate, People, Livestock and Savannah Ecosystems in Kenya, Uganda and Tanzania.

Agencies Developing Community Adaptation Toolkits in eastern Africa

The African Center for Technology Studies, in partnership with other organizations, is undertaking action research to test tools on community adaptation and to build the capacity of rural communities through its Community–Based Adaptation to Climate Change in Africa project, which is implemented in Kenya, Malawi, Sudan, South Africa, Tanzania, Uganda, Zambia and Zimbabwe (http://www.acts.or.ke).

CARE international uses the Climate Vulnerability and Capacity Analysis toolkit to analyze vulnerability to climate change and adaptive capacity at the community level, based on a framework of 'enabling factors' for community–based adaptation. This approach combines community knowledge and scientific data to yield greater understanding about local impacts of climate change (http://www.careclimatechange.org/cvca).

IUCN in partnership with the International Institute for sustainable Development (IISD), the Stockholm Environment Institute (SEI) and Interco–operation—Swiss Foundation for Development and International Cooperation uses the Community Based Risk Screening Tool—Adaptation and Livelihoods (CRiSTAL) to better understand linkages between livelihoods, climate and project activities, to identify livelihood resources that are most vulnerable to climate hazards or which are important for adaptation, and to assist project planners and managers in making project adjustments to improve its impact on community resilience to climate change (www.cristaltool.org).

Table 8: Livestock adaptation strategies in summary (Calvosa 2010)[4]

Production adjustments	i) Diversification intensification and / or integration of pasture management, livestock and crop production ii) Changing land use and irrigation iii) Altering the timing of operations iv) Conservation of nature and ecosystems v) Modifying stock routings and distances vi) Introducing mixed livestock farming systems such as stall–fed systems and pasture grazing
Breeding strategies	i) Identifying and strengthening local breeds that have adapted to local climatic stress and feed sources ii) Improving local genetics through cross–breeding with heat and disease–tolerant breeds
Market Responses	i) For example, promotion of interregional trade and credit schemes
Institutional and policy changes	i) Removing or introducing subsidies, insurance systems ii) Income diversification practices iii) Livestock early warning systems
Science and technology development	i) Understanding of the impacts of climate change on livestock ii) Developing new breeds and genetic types iii) Improving animal health iv) Enhancing soil and water management
Capacity building for livestock keepers	i) Understanding and awareness of climate change ii) Training in agro–ecological technologies and practices
Livestock management systems	i) Provision of shade and water to reduce heat stress from increased temperature ii) Reduction of livestock numbers in some cases iii) Changes in livestock/herd composition iv) Improved management of water resources

[4]Based on FAO 2008, Thornton et al. 2008, Sidahmed 2008.

Analysis and recommendations

Relationship between the livestock sector and climate change

The relationship between the livestock sector and climate change is likely to greatly influence the overall nature of the approach to adaptation within the livestock sector. The sector has been much maligned since the publication of 'Livestock's Long Shadow' by FAO in 2006 and the allegation that the industry contributes more to climate change than the automobile industry does. However, the real relationship between livestock and climate change is much more complex and the environmental services of extensive livestock systems have generally been overlooked. Such services could become crucial to adaptation in the sector in future.

Livestock play a critical role in rural poverty reduction; therefore, livestock development is vital for development in Africa. Development in all sectors will be increasingly scrutinized for its 'clean' credentials and it is desirable that livestock development can be carried out without significantly contributing further to climate change. Nevertheless, livestock are important to the adaptation strategies of poor people on a continent that is a major victim of, and a minor contributor to, climate change.

The livestock sector worldwide is estimated to contribute around 18% of all anthropogenic GGs. Yet Africa, where livestock is significantly widespread, contributes barely 4% of total global emissions—taking into account the digestive metabolism of its millions of cows and small ruminants—yet the region is continent is highly susceptible to the effects of climate change because of limited resources and capacity to mitigate the effects of extreme weather. Climate–related disasters and diseases are on the increase and the impacts of drought, flooding and disease have brought starvation, internal displacement and death to millions of people. For many Africans coping with climate change–induced poverty, livestock keeping offers one of the few options for rebuilding a livelihood.

Implications of climate change for development of Africa's livestock sector

Climate change is becoming a major threat to the most vulnerable populations in Africa. This situation requires urgent and co–operative action. Various studies describe different scenarios of climate change: drought, extreme weather (floods, storms) and average warming are a constant feature of the forecasts, but not everywhere. It is important therefore that local predictions are used appropriately and that generalizations are avoided. Furthermore, given the degree of uncertainty in predictions, it is important to develop adaptive capacities across the board that enable livestock keepers to adapt to all eventualities, rather than to focus on specific expectations.

In summary, Africa's livestock sector is likely to be affected by climate changes as follows:

- Rainfall quantity and patterns will change; areas may get wetter or drier. In most places rainfall is likely to become erratic with more sudden, destructive heavy downpours.
- Temperature will increase. There are few places in Africa that will benefit from temperature increase (a phenomenon that will be felt in colder climes) and the average temperature will generally amplify heat stress on animals and on rangeland/fodder production.
- Winds will change, exacerbating heat stress and the risk of dehydration and contributing to the damage caused by heavy precipitation.
- Seasonal climate patterns will change. For livestock keepers this is less severe than for crop farmers who face challenges in knowing when to plant or harvest a crop. Adapting to changing seasonal patterns will hinge on the freedom of herders to move among seasonal resource patches at appropriate times.
- Catastrophic events such as droughts, floods and periodic storms will increase. Hail storms have been known to cause dramatic overnight loss of entire herds.
- Feed/fodder production will decrease but prices may increase as pressure for land to produce crops for human consumption rises. Small–holders and urban/peri–urban producers are particularly vulnerable to this scenario. Higher CO2 levels may have a positive effect on production of forage, but unlikely to outweigh the negative impacts of heat and water stress, and outcomes will vary according to altitude, latitude and local type of climate change. Plant species distribution in the rangelands will be modified to an uncertain extent.
- Water availability will increase or decrease according to location and seasons, possibly in correlation with heat. However, competition for water will increase where surface water is captured for irrigation by crop farmers, with potentially adverse consequences for rangeland production. Irrigated fodder/feed production could provide an option for increasing resilience of the livestock sector, depending on competition with other uses.
- Disease prevalence and distribution will change, driven by location, hosts and type of disease. Most diseases prefer warm and humid environments, but the distribution of vector–borne diseases will be determined by complex interactions among the environment, vectors and the hosts. Heat and water stresses will generally increase susceptibility to disease, but this may not be the predominant factor in changing patterns.

- Changes in marketing and prices will occur in response to increased urbanization, but the outcome in terms of demand for livestock products is unclear. Supply of livestock products will be affected by the factors outlined above and is likely to become restricted, which could raise prices. The impact of global environmental tariffs like carbon taxes could affect livestock exports, which could promote the domestic livestock sector and potentially benefit Africans.

Linking climate change to other threats to the livestock sector

It is crucial that climate change does not become a scapegoat for the myriad of threats that oppose the livelihoods of livestock keepers in Africa, who are usually among the poorest people in their countries. Climate change is forcing the debate about adaptive capacity onto the development agenda, but if the debate stops with adaptation to climate change then the rural poor will lose out because the underlying causes of lost adaptive capacity will be overlooked. The current attention to climate change globally should not mean that climate change is automatically assumed to be the priority of the rural poor.

Important pre–existing threats to livestock keeping populations include:

- Population pressure, from both external encroachers and internal demographic growth;
- Insecure tenure and weakening/breakdown of customary governance institutions;
- Loss of land, particularly key resource pockets;
- Restriction of transhumance and loss of access to key resources;
- Sedenterization policies leading to land degradation and severely reduced carrying capacity;
- Conflicts among pastoral groups and crop farmers (linked to weakening governance);
- Market failures, entry barriers and national policies that exclude small–holders and pastoralists who comprise the bulk of Africa's livestock keepers;
- Inequity in global livestock trade (subsidies and concessions) undercutting local markets;
- Poor access to foreign markets, partly due to strict hygiene standards and even more stringent consumer standards.

Adaptation and resilience

Livestock keepers have many adaptive mechanisms and livestock keeping can itself be an adaptation. Nevertheless, adaptive capacity does not hinge entirely on a selection of options or a portfolio of management decisions. Such adaptation mechanisms imply managing foreseen eventualities and cannot be assumed to be effective in dealing with unforeseen events. This 'unknown–unknown' is perhaps the most significant challenge of climate change.

In order to genuinely strengthen the adaptive capacities of livestock keepers it is necessary to take a more proactive approach and address the fundamental determinants of capacity. This depends on at least the following four capacities:

1. The ability to make an informed assessment of the threat to which they must adapt;
2. The ability to make informed choices from a range of options, about the best response measures;
3. The capability to deploy their preferred options (skills, money and infrastructure);
4. The freedom to implement such options (policy, governance and rights).

In general, there appears to be a dominant focus amongst scientists on developing adaptive technologies whilst development agents focus more on building the capacity of communities to assess and make decisions about adaptation options. Greater effort to bring these two approaches together could significantly address the first two capacities outlined above; scientists can help to make data available to improve climate threat assessment and to analyze different options, whilst NGOs can work with communities to build their capacity to make sense of and to use such information. The third capacity listed above requires support in public and private investment, market development and training, which are instrumental in enabling people to empower themselves. The freedoms necessary to deploy preferred adaptation options are largely addressed by governments (from local to federal) and relate to the legal and policy environment.

Strengthening the assessment of climate change threats

The first step in raising adaptive capacities, at local and national levels, may be to improve the assessment of the threat of climate change to enable planners and farmers to react appropriately. Improving informed decision–making requires strengthening of the knowledge base and building awareness to make use of that knowledge. At the local level this may require greater emphasis on raising awareness of the implications of climate change, although this is challenging considering the uncertainties in climate change predictions using local experiences and existing understanding. At the national level the focus should be on both improving meteorological data collection and also making that information available regularly and reliably across each country.

Improved forecasting and warning

Meteorological data in all countries studied in this report, which are weak and often incomplete, compromise the ability to determine trends and to develop models in support of early warning systems. Early warning systems and climate information has an important role to play in promoting adaptation if people are able to use the information effectively. Support to improve climate forecasting should focus on improved distribution of data collection combined with refined processing and analysis of existing historical data to allow improvement of the local forecasting capacities.

Based on improved weather forecasting and analysis, early warning systems could be developed that address practical needs, which should be ascertained in advance, of livestock farmers. Communication of forecasting information should also be developed in consultation with livestock keepers in order to understand the most appropriate means of communication, such as radio and/or mobile telephone.

Forecasting should not aim only at short and mid–term forecasting for the sake of reactive adaptation, but should also be used to support long–term forecasting with a view to influencing proactive adaptation. The capacity or willingness of livestock keepers to take such measures may be a constraint, but the information could inform envisioning exercises linked to understanding the implications of climate change. At the national level such forecasts could be useful for policy development in support of national and regional disaster preparedness and mitigation strategies.

Building awareness of climate change and its consequences

Providing forecasting is not enough to equip either livestock keepers or extension agents to adapt more effectively to climate change and support is also needed to build the capacity of all stakeholders to make sense and use of climate information (measures to enable farmers to use the information more effectively are discussed below under the section entitled Capabilities). Building understanding of climate information should go hand in hand with understanding what information is relevant and useable by livestock keepers and prior assumptions about which data are relevant should be made cautiously. Institutionalizing the capacity for interpreting climate information should be explored at different levels: with community based organizations (CBOs), including co–operatives, as well as national and local government.

There are a number of options for raising awareness at the community level of the possible outcomes of climate change, but given the uncertainty of predictions, it would be prudent to build consensus initially through participatory learning and action with selected communities to learn how they currently experience climate change, how they perceive future changes impacting on their livelihood, and how they propose to respond to that. To have a meaningful impact, this information needs to be disseminate further, and a number of communication approaches can be used, including through mass media, through local government and through grassroots organizations.

Existing networks could also be used to promote learning and exchange of ideas on climate change and livestock production between producers and advisors. For example, the project work of CBOs and these networks can be harnessed effectively to provide the information on climate change and the livestock sector is reliable. Similarly, climate change issues could be integrated into school curricula with development of appropriate teaching materials.

Enabling informed choice of adaptation strategy

When livestock keepers and development planners are aware of the threats of climate change they then need to understand the options at their disposal for adapting. This includes existing adaptation strategies, over which there is still a lack of consensus and significant misunderstanding, as well as novel adaptation strategies. To reach consensus over the merits of endogenous and exogenous adaptation options requires a much higher degree of collaboration and respect between livestock keepers and planners. One of the key lessons from past failures in livestock development has been that changes will be rejected, regardless of their technical merits, if they are imposed by outsiders without consultation and without a good understanding of the local situation. The livestock sector (along with many natural resource sectors) is still characterized by a general contempt for local knowledge and skill on the part of extension workers and a tendency to come up with advice for farmers in isolation from them.

Improving informed choice requires not only coming up with information, but also ensuring that decision makers (farmers and planners) can both make sense of and use such information; in other words, an effort is needed to ensure that information is transformed into knowledge. At a community level this requires building basic human capabilities. General basic education remains neglected in many countries, although other forms of public awareness should also be used. In addition to providing people with information, information needs to be made more generally available on demand through better access to libraries and Internet resources, which implies a role for local governments and CBOs. In order to make informed choices, people need access to the full range of options at their disposal rather than a selection of options that has been determined by other people.

At a national level, greater emphasis should be placed on building the capacity of extension workers to understand local experiences and knowledge, which implies modification of university and technical training curricula. Collaborative research is also needed into different adaptation options, both endogenous and exogenous, to broaden the array of options that decision makers can select from.

Raise awareness of the value of different livestock breeds

The value of indigenous breeds need to be better understood by extension agents, and in some cases local communities, and a better balancing of the merits of disease and climate resilience against the cost of lower production and marketability is needed. Where drug supply is a constraint, trypanotolerence and tick resistance (as well as resistance to other diseases, should be seen as favorable traits that often outweigh the costs of lower productivity and lower consumer satisfaction. With increasing risk of drought, hardy livestock that can cope with the rigors of water shortage and long–range transhumance will also attain higher value and these important survivability traits need to be much better understood and valued.

The role of 'exotic' breeds needs to be explored more deeply, but with particular attention to the variety of breeds found around Africa and a reduced enthusiasm for fast growing but highly vulnerable and costly European breeds. In southern Kenya, Maasai farmers have begun to shift production from the indigenous Maasai red Sheep towards the South African Dorper breed, which is a larger and faster growing animal that is nevertheless well suited to the dry climate of Maasailand. This transition is facilitated by the relative ease of access to anthelmintics (de–worming drugs) that renders the high worm–resistant characteristic of the Maasai red sheep redundant.

Breeds such as the N'Dama cattle, the Djallonke sheep and the West African Dwarf goat have particular disease resistance and this feature may make them more desirable in the face of shifting disease patterns, or less desirable in the face of expanding drug markets. In general there is inadequate information on the potential of the different indigenous breeds, management advice is poorly adjusted to fit with these local characteristics, and local breeds are poorly traded around the continent to exchange genetic traits between comparable environments.

Raise awareness of the value of different management strategies

Misunderstanding over the rationale of different livestock management strategies is a major cause of underdevelopment of the livestock sector in Africa. This is particularly the case in pastoral systems that deploy transhumance of varying extremes, which have been portrayed as anarchic and irrational on the basis of this important management technique. Range scientists themselves remain at odds over the value of different forms of herd mobility, with major recent studies showing no evidence for the value of rotational grazing systems: one of the key pieces of advice given to farmers by extension agents. However, there is growing consensus over the importance of intelligent rangelands management in which herds are used as a tool for manipulating pasture species through bouts of intensive periodic grazing followed by appropriate periods of pasture recovery. Work is urgently needed to understand planned grazing, as practiced by herders and as advocated by some researchers, and this knowledge needs to be made much more practicable in the field.

At the same time as building awareness on the value of livestock mobility, greater understanding is needed of the benefits of sedenterization, with a growing number of pastoral households embracing a degree of settlement. Benefits include greater access to public services, such as schools or health services, greater access to markets and market information, opportunities to engage in alternative livelihoods, and opportunities to strengthen security over tenure. All these benefits can theoretically be attained without sedenterization of part of the household, although success to date has been limited (in Africa at least). However, there is no denying that pastoralists are benefiting in some ways from sedenterization and development assistance needs to reflect this transition, particularly given the important gender differences in the patterns of settlement.

Many livestock keepers are poorly connected to markets and are unable to take advantage of markets as a management tool. There is rich research on meat markets in particular in Africa, and livestock keepers are increasingly integrated with and dependent on markets, but many farmers find themselves disadvantaged in the marketplace: unable to negotiate satisfactory prices or unable to sell their stock at the most suitable time. As producers become more integrated with markets there is evidence that they modify their production system and attempt to meet consumer demand, for example selling livestock at more appropriate live weight or age, or rearing breeds with higher demand (for example, rearing fat tailed sheep to sell at Ramadan). Market distortions are common however, for example in pastoral areas where markets for meat are much more available than markets for milk, despite milk having significantly higher latent market potential, and these distortions have implications for the way livestock keepers develop their system. Finally, the low access to financial services such as banking has implications for the way many livestock trade, since livestock play the role of bank meaning that withdrawals (i.e. sales) may be made during times of stress (when markets are depressed) rather than times of plenty.

Build capacity for integrated land use planning

Improved land use planning is needed to enable livestock keepers to take greater advantage of the range of natural resources at their disposal and to diversify their livelihood portfolio as a hedge against risk. Planning capacities need to be improved to reflect the importance of livestock production in mixed farming systems, which may increase if crop farmers are forced to shift steadily from crops to livestock production as climate deteriorates. Similarly, planning capacities need to be built on communal rangeland where the scale of landscape management is large and the range of resources is wide.

Participatory planning tools are highly suitable for land use planning and are consistent with a broader approach to empower livestock keepers. Natural resource maps provide an excellent planning and management tool, and capacities of local government to conduct genuine participatory planning need to be built.

Build knowledge on fodder production and conservation

Given the value of livestock for many rural small–holders, greater investment is required in developing fodder crops and more digestible crop residues and in promoting and expanding these technologies. Suitable fodder crops may include those cultivated with almost zero input on marginal land or field boundaries, or with increasing commercialization of the livestock sector they may include specialized forage species. With growing pressure on water and increasing risk of drought, emphasis should probably be placed on the development and spread of improved dryland forage species. Livestock keepers need to have better access to information regarding the variety of plants that are available to them, and availability of seeds needs to be increased through market development or through extension projects. Livestock keepers can also benefit from learning different techniques for forage conservation and identifying solutions that fit with the production system, although the most mobile herders who could benefit most from forage conservation may find the technique the least convenient.

Fodder production in most cases will rely on relatively secure land tenure to ensure that farmers who invest effort in cultivating a crop retain the right to exclude others from harvesting the crop. As obvious as this may sound, it is a major constraint to forage development in many livestock systems, and one of the most difficult obstacles to overcome. Tenure and governance are addressed in a subsequent section.

Strengthen herd health and reduce mortality

Significant gains have been made in recent years in provision of veterinary services to pastoralists, particularly with the privatization of the veterinary drug sector in many countries and the expansion of community–based animal health service providers. Nevertheless, a great deal more can be done to ensure that drug supply is consistent in quality and availability, and ongoing training is required to maintain standards to improve disease surveillance. Simultaneously, veterinary services need to keep pace with shifting disease patterns that result from climate change.
Build understanding on the additional values of different livestock systems

Improved choice is not only needed by livestock farmers, but by government planners who are often poorly informed of the value of different livestock systems, and who often promote management systems that are inferior to those already in existence. Two angles in particular need to be looked at: the economic value of different systems and the environmental value. These are not entirely distinct and the environmental value of some extensive systems may increasingly confer economic value with the growth of different forms of Payment for Environmental Services.

At a national level, better data is needed on the production value of traditional livestock systems. Data is typically collected only at the marketplace, yet many livestock systems are, to a significant extent, subsistence oriented; in other words, the marketplace does not provide an adequate source of production data. A good example is in pastoral systems that produce milk that can be 2–4 times the value of meat, but where milk is scarcely marketed at all. The result is that investment and research, based on market data, is disproportionately made in the meat sector despite meat being a secondary product of the system.

The environmental values and costs of different livestock systems need much more detailed investigation, both to mitigate the negative externalities of livestock keeping as well as to enable farmers to promote (and market) the positive externalities. Many rangeland managers gain secondary incomes based on the environmental benefits of their system, including those outside Africa who brand products according to environmental characteristics, and a growing number of farmers in eastern and southern Africa who capture ecotourism income to supplement pastoral activities. Other environmental services could be marketable in future, including protection of rangelands from ploughing (a REDD for grasslands), restoration of healthy water cycling to mitigate flash floods and drought, and capture of carbon in the soil which is already eligible for carbon finance. Understanding of these services, of how they are provided and how they can be boosted, needs to be developed in order to secure the services and to identify complementary sources of income for livestock keepers.

Strengthen understanding of the carbon cycle in livestock systems

Related to the environmental services and costs mentioned above, greater understanding is needed on the total lifecycle emission of greenhouse gasses in different livestock systems. All livestock systems release harmful GG, largely through release of rumen methane, but various livestock systems have opportunities for either reducing rumen emissions or promoting the capture of greenhouse gasses.

Strategies to reduce the emission of greenhouses gasses include increasing the proportion of consumption of legumes, which yield less methane during digestion than lignified grasses, and increasing the ratio of energy to fiber intake. Increasing feed quality has been shown to significantly reduce methane emission by cattle, although the total methane production by cattle grazing in tropical pastures actually increases with pasture quality. Certain feed additives are also available that could reduce methanogenesis without reducing the digestive capacity for grass and straw.

Increasing the capture of greenhouse gasses can be done in indoor systems through improved manure management, and in outdoor systems through improved biomass production. For indoor systems, biogas energy production using waste fermentation has been developed at both large and small scales, although is not widespread yet in Africa. However, this approach has the dual benefit of reducing methane emissions and reducing reliance on wood fuel. In extensive systems, significant improvements in rangeland productivity have been demonstrated through improved grazing management, indicating that livestock can be used as a tool for promoting biomass and thereby increasing carbon capture in the open rangelands.

Strengthening capabilities to act

Understanding climate change and its threats, and knowing the options for adaptation, will enable stakeholders in the livestock sector to make informed choices. However, many actors lack the basic capabilities to act on those choices. In the language of the widely understood 'livelihoods framework', these capabilities relate to the core livelihood assets—namely human, social, physical, financial and natural capital. In more practical terms, to be capable of deploying the preferred adaptation option, people need the skills, resources and infrastructure. It should be noted that the capability to act on a given choice does not have to be choice–specific; many of the capabilities that are discussed below are not unique to the climate change debate. However, many of the basic capabilities of livestock keepers are weak, leading to their underdevelopment and contributing to their vulnerability to climate change as well as other threats.

Developing skills in the livestock sector

Livestock breeding skills can be developed at a community level, to both conserve and develop locally–adapted breeds, and to introduce new breeds where appropriate. Breed development can be based on simple record–keeping and should build on existing knowledge, which is rich in many communities. Breed development must be carried out by local communities in order to be compatible with their production and livelihood objectives and their environmental and socio–cultural demands.

Livestock breeds can be diversified at a local level to broaden the diversity of species and the range of market opportunities generated by variety. For example, novelty breeds may have value in some urban settings and new breed combinations may be of value in some areas like some dryland communities that may be interested in adopting camel husbandry.

Crop–livestock systems can be further developed and promoted, where feasible to promote the inter–relationship between the two practices, through transmission of best practices in terms of agricultural sustainability, labour efficiency, animal husbandry and healthcare (of both animals and humans). Fodder production should be considered in different livestock systems, including forage and cover crops, introduction of legume forages (with appropriate prior environmental evaluation), and distribution of fodder trees.

The management and governance skills of local institutions need to be developed, particularly where traditional institutions and government institutions are at odds. In communal rangelands, traditional institutions have capacity to manage resources effectively, but they often need support to adapt to new legal and political arrangements and to harmonize them with the local government. The role of institutions that impose management rules over natural resources, including grasslands and water sources, should be established through appropriate training and reinforced by provision of relevant legal and security support.

The capacity of farmers can be built through support for farmers' organizations and other types of grassroots initiatives. Such organizations can provide a platform for debating new ideas, sharing experiences, linking producers with markets, raising policy concerns and training. Farmers' organizations can also assist their members in accessing financial and other services, thereby facilitating a range of adaptive measures.

Farmer Field Schools

The Farmer Field School (FFS) learning process, which was originally developed to help Asian rice farmers improve the nutritional value and increase crop yields, combines community development, agricultural ecology and education. FFSs play an important role in boosting skills in African agriculture and assisting participants to attain more resilient livelihoods. Innovative systems need to be developed to educate farmers, building on their perceptions and knowledge using the following principles:

- Exercising a farmers' knowledge and practical experience to adapt to climate change, for example by reducing dependence on industrial inputs and favouring low external inputs among poor farmers;
- Developing curricula to train farmers on alternative and scientific strategies for managing climate change;
- Promoting participation in policy dialogue, research and development processes.

Source: IVO 2009

Whilst developing skills in the livestock sector, it is critical to accommodate the roles of women, which are generally differentiated from those of men. In urban settings, women are often the principle livestock keepers and they may face particular challenges in accessing the financial assets to buy livestock services or inputs. In pastoral settings, women may be responsible for a particular type of livestock (e.g. small or young stock) or for a particular product (such as milk), and therefore their training and support needs often differ from those of men.

Developing resources in the livestock sector

Whilst local communities can develop skills to conserve and develop livestock breeds, institutions at the national level can also play a vital role in breed development and exchange of adapted breeds. Although emphasis has often been placed on increasing productivity, other traits are important, and may be of increasing importance as a result of climate change: traits such as disease resistance and drought tolerance, as discussed above. Breed development however must go hand in hand with development of other services such as ensuring the supply of veterinary inputs for breeds that are less disease tolerant, and general economic development to ensure that farmers are ready to shift from a labour–intensive to a capital–intensive production system.

The livestock sector's natural resource base can be developed through supporting the rehabilitation of degraded lands, restoration of forest areas that often provide a fodder bank and protection of natural water points such as ponds and streams. Protection and rehabilitation typically requires support to restore or establish governance over resources that are typically managed communally.

The poor penetration of financial services in livestock keeping areas is a major disadvantage for the sector. Banking, credit and insurance are three areas of particular importance for building resilience within the livestock sector. These services will help to reduce marketplace risks yet enable livestock keepers to exert control over when and where they buy and sell livestock and associated products. Financial services will also assist livestock keepers to invest in their production systems and to become more market–oriented.

Many livestock farmers have poor access to microfinance—often because the microfinance institutions have not developed products that are tailored to the seasonality of livestock production, those institutions do not trust livestock keepers or there is a widespread notion that livestock keepers are not interested in financial services. The mobility of pastoral communities discourages some microfinance companies from providing loans and few companies accept livestock as collateral.

Insurance, such as weather index–based insurance, is increasingly being tested as an adaptation technology, although—as with many recommendations in this report—its application is not limited only to climate change. Livestock keepers face two major types of risk to their livestock: individual (e.g. accidents, theft, predation and some diseases) and covariant (e.g. drought, rustling and epizootic diseases). Covariant risks are generally much more damaging than individual ones and can be devastating to a community. Unlike agricultural groups, pastoralists have implicit insurance arrangements from extended families, clans and ethnic groups, which helps them cope in times of crisis. However, the effectiveness of this traditional form of insurance has declined over time as pastoral production systems have been weakened, creating a growing need for an alternative form of insurance.

Developing infrastructure

Infrastructural development supports rural development by increasing communities' access to markets, government services and indeed to government itself. In the case of public services, providing infrastructure implies not only constructing premises but also providing resources for staff and equipment and there are many examples, particularly from pastoral areas, of schools and hospitals being erected but left unused and unstaffed.

Many livestock keepers have access to marketplaces, particularly those in urban and peri–urban areas. However, in the more remote rural areas, market access can be a major obstacle to livestock development and to constructing resilient livestock–based livelihoods. Construction of roads can have a dramatic impact on livestock markets, both enabling livestock to be taken to urban centres more rapidly and cheaply and by enabling greater supply of household goods and productive inputs. Informal markets can be formalized as a result of infrastructure improvements. Experience outside Africa demonstrates that producers in remote rangeland areas often cultivate low–input grain because grain in the marketplace is too expensive, but with infrastructure improvements, the cost of supplying grain falls and livestock producers switch crop production from grain to fodder, thereby investing directly in improved livestock keeping.

Water development is critically important to the agricultural sector in the face of climate change, and there is likely to be growing competition over water resources, with increasing offtake for upstream irrigation having adverse consequences for downstream users. Urban livestock keepers already struggle to provide water for livestock, and livestock keepers in the lowlands are increasingly finding that rivers are running dry, with consequences not only for water supply but also for the natural irrigation of dry season pastures. Other water development, such as installing boreholes and valley dams, could play a part in increasing resilience among the livestock sector, providing that planners are adequately informed and identify the appropriate locations for these resources. Significant rangeland degradation can be traced to inappropriate citing of water resources, which can cause conflict over water and adjacent resources. Integrating water development with a wider agenda of empowering livestock keepers and giving them a pivotal role in development planning can ensure more appropriate water development.

Related to the installation of water resources, governments can often do more to facilitate transhumance by providing appropriate services and infrastructure in the right locations. Water points in particular can facilitate stock movements, and in some countries where livestock keepers migrate over crop–land, migration corridors can be demarcated. Mobile services may be required in some instances (for example mobile schools) but innovative and more cost–effective models for service delivery should be considered. Training community members as front line services providers (e.g. nomadic teachers, para–veterinary professionals and community midwives) is a proven means of boosting access services in a cost–effective and culturally sensitive manner. Many innovative forms of mobile services have been tested and shown to be viable, such as mobile health and education that is adapted to pastoral epidemiology and epistemology, mobile veterinary services and seasonal mobile markets. Efforts are being made to integrate service delivery, with for example combinations of veterinary and human health services.

Local government offices often have the role of providing key agricultural services, such as technical advice, marketing and funding of new initiatives. This service provision needs greater investment, but it also requires technical overhaul in many cases where advice is inappropriate or inappropriately given. In tandem with building extension services, there needs to be investment in improved research into adaptation in the livestock sector and an effort to integrate more appropriate extension techniques (particularly empowering approaches and participatory techniques) into training programs and academic curricula. Greater investment may be needed in collaborative research, which will bring communities and governments together with scientists.

Creating an enabling environment for adaptation

Livestock keepers need to understand the threats that they are facing the options that are at their disposal to adapt to the threat and they need to have the wherewithal to implement the options of their choice. However, livestock keepers may still come up against significant challenges if the policy and legal environments are not conducive to adaptation. For example, a farmer may know that climate change is going to lead to high risk of trypanosomiasis, she may know that the best option for her is to switch from a local breed of goat to the West African Dwarf goat, and she may have the financial resources to do this, but if her government's policy does not support the importation of live goats—or if her community will not allow her to introduce the new breed—then she is still unable to adapt appropriately.

The freedom to choose appropriate adaptation measures cuts across policy, governance and rights. At a local level, farmers need secure land rights, strong and equitable local institutions, and functioning legal instruments. They also need government to put in place supportive policies, or more importantly to relax policy disincentives.

Policy engagement

An important way of both ensuring the relevance of policy to livestock keepers is to promote their engagement in national policy dialogue and formulation. The role of livestock keepers' organizations is discussed below, but specific attention should be paid to consulting livestock keepers in the formulation of national policies, both in the livestock sector and in other sectors that impact on them.

The livestock sector is notorious for pursuing high–level policy goals that are largely incongruent with the requirements of livestock keepers. Livestock policy may be driven by the desire for foreign exchange, demanding production for export markets, whilst livestock keepers may be producing with the objective of minimizing risk and storing assets in the form of cattle. Greater attention is required for policies that support the fundamental goals of livestock keepers. In some cases this implies a focus on optimizing production across a range of outputs from the systems rather than maximization of one or other commodity. In other cases it may imply supporting livestock keepers to raise their guaranteed minimum output rather than boost their potential maximum yield.

Livestock keepers should also be given greater voice in supra–national policy debates, and in the creation of policy frameworks at national, regional and global levels. This will give greater relevance to agreements that are designed to promote international trade and greater opportunity to domesticate conventions and other agreements. It will also enable implementation of regional programs already adopted by member countries of regional organizations such as the Economic Community Of West African States on sustainable management of pastoral resources and monitoring transhumance.

In the context of climate change and adaptation, livestock keepers and their representatives require greater input to global debates, and through this they can assist in mobilizing political support for stronger action on climate change, and to examine how the international framework could facilitate such an action. This should be guided by a shared vision for a long–term co–operative action. Such an engagement in most cases requires capacity building for international negotiations on climate change issues in relevant forums, including joint initiatives and advocacy in the respective regions.

Strengthening markets

More informed engagement in markets is crucial for the resilience of the livestock sector and government can play a role in boosting private engagement in the livestock sector, promoting private enterprises for the supply of goods and services and enabling the sale of produce and livestock. Government policy can constrain the livestock sector by imposing unattainable standards on livestock production, imposing taxes and levies that discourage trade or providing incentives for capital inputs when the sector is dominated by labour investment.

Market failures are prevalent in the livestock sector, and not only in terms of livestock markets. A strong case has been made for marketing the environmental services of livestock production in order to optimize production and diversify the sources of income to livestock keepers. However, markets for environmental services are currently weak, information about such services is scarce and livestock keepers are often unaware of the existence of these markets.

This report has not discussed global markets and export markets in detail, although they could play an important role in the future of Africa's livestock sector. Exports from East Africa to the Arabian Peninsula are significant although they are vulnerable to restrictions every time there is an outbreak of Rift Valley fever in eastern Africa. Southern Africa countries have preferential trade agreements with Europe for the export of livestock, although few countries ever meet their export quotas. This trade is more vulnerable to livestock disease than the trade from East Africa, and countries overcome this through construction of elaborate veterinary cordons, which are technically effective. In southern Africa, trade to South Africa itself dominates export trade and there are many options for trade within the African continent to explore before committing to the highly demanding and fickle European and North American markets.

Organizations

Organizations of livestock keepers at different levels provide an important opportunity for building solidarity between livestock keepers by connecting them with markets, providing them with political representation and enabling them to access information and resources. In particular, these institutions can play a role in enabling livestock keepers to meet the quality and safety standards demanded by overseas markets and in vertical market integration.

The nature of these organizations will likely differ according to each society's needs and the state of existing institutions. Urban livestock keepers, mixed farmers and pastoralists have different priorities that will be reflected in their organizations. These associations will allow livestock keepers to strengthen their livelihood they could also be useful for raising confidence among communities that are often marginalized locally or nationally.

Land and resource tenure

Land tenure insecurity is a problem for many pastoral livestock keepers. Most pastoralists manage their land communally, which presents challenges for legally protecting land and other resource rights. Traditional rules over natural resources sometimes fail to prevent misuse of resources, and ambiguities between the customary and the state systems of governance allow individuals to exploit 'legal' loopholes—choosing the institution (state or tribal) that suits them in any given transaction. The result is that valuable resources are often easily alienated and the pastoral system breaks down. Many countries provide legal opportunities to secure communal and customary tenure and the challenge often lies in a combination of the weak legal awareness and financial capacity of farmers and poor legal institutions. Greater support is required to overcome these barriers if pastoralists are to secure their most basic resources and use pastoralism as a platform for other development.

Stronger regulation or legal support may be required to protect non–land resources for use by livestock keepers, including water. Currently, priority tends to be given to water infrastructure development for irrigation by crop farmers with little regard for the downstream impacts on the health pastoral rangelands. The share of water withdrawal and depletion by the livestock sector is generally low (World Bank 2009) and opportunities for developing livestock–centred irrigation (i.e. for fodder crop production) should be further explored.

Transhumance

One successful adaptation method of pastoralists is transhumance; the erosion of this mobility is at the heart of the lost adaptive capacity and the impoverishment of pastoralists. A growing number of African countries are also legislating for transhumance, which is supported in some countries. In Sudan several thousand kilometers of livestock corridor have been demarcated in South Darfur as a result of a Presidential Decree, although the success of these routes has been compromised by the lack of funding for associated amenities such as water points. In West Africa efforts have been made to legislate for cross–border migrations and to regulate transhumance between pasture zones.

Strengthening women livestock keepers' rights

Since women and men engage in the livestock sector differently, and since they frequently rely on different natural resources, the opportunities and challenges of climate change will be experienced distinctly. The roles and the rights of women livestock keepers are often overlooked and development is frequently skewed towards the interest of men, yet women are responsible for most sedentary care of livestock and play an active role in on–farm livestock duties. Women in some communities who herd the majority of small and young livestock are usually responsible for poultry and play an important role in the marketing of products—particularly eggs and milk.

Policies in the livestock sector have to be examined for their specific impacts on women and men, but so too do customary rules and regulations. Traditional institutions have a major role to play in sustainable natural resource management and in enabling communities to adapt, but these institutions may sideline women in decision–making, and thereby compound their marginalization and poverty. Customary rules over land and natural resources are usually highly gendered and female–headed households often face major obstacles in using these resources to maintain their livelihood.

The same constraints that confront livestock keepers in general—such as low education, low access to financial services and weak resource rights—burden women livestock keepers to a greater extent. Efforts to build resilience in livestock keeping communities therefore requires particular emphasis on building the resilience of women and enabling them to adapt to climate change.

Pastoral codes and ministries

There is a growing call for governments to recognize the dignity and rights of pastoral peoples to adopt a comprehensive agenda of supporting pastoralism. Pastoral systems require support for education, health and financial service sectors, and the policy solutions do not lie in the livestock or the natural resources sectors alone. In West Africa, governments have experimented with 'pastoral codes' as a means of satisfying the rights of pastoral communities, although these experiments have been only partially successful due to inadequate participation of pastoral communities in their formulation.

Pastoral codes are a way of ensuring broad–based support for the development of pastoralists (as opposed to development of the pastoral sector). They provide guidance on socio–economic and market development through technical assistance, participatory approaches and market integration. They should also provide a platform for raising pastoralist voices and giving pastoral communities stronger representation in government. These codes lend could themselves to cross–border policy harmonization and they are particularly attractive in West Africa where cross–border livestock migration is extremely widespread.

Kenya's recently created Ministry for Development of Northern Kenya and Other Arid Regions fills a similar role to the pastoral codes of West Africa, but with the potential to carry more political weight. Other countries also have pastoral departments, but these are usually subsumed within a livestock ministry and thereby fail to achieve the necessary broad–based approach.

Mitigation of climate change by the livestock sector

Given the small contribution that the African livestock sector makes to climate change, the ethical obligation to contribute to the mitigation of climate change can be debated, but there are some pragmatic reasons for considering mitigation activities. For example, some livestock development interventions could be eligible for funding through carbon finance.

Livestock provides a means of producing food on approximately one third of the earth's land surface, and perhaps over a half of the African land–mass (where no other form of food production is feasible). Ruminants transform rangeland plants that are useless to other livestock and humans into food for human consumption and for people living on marginal or infertile land; livestock keeping may be the only livelihood option for some people.

Options for mitigating climate change, which are subject to local context, include the following:

- Eliminating unproductive animals and increasing the overall efficiency of livestock production;
- Selection of more productive livestock breeds where conditions allow;
- Improving rangelands through improved pasture management;
- Enabling of transhumance and effective communal pasture management;
- Reforestation and tree protection in pasture lands;

Carbon finance for livestock keepers

Farmers need to identify ways to access compensation for activities that boost carbon capture and biodiversity through ‘carbon funding’ or ‘green funding’. The Clean Development Mechanism (CDM), set down in the Kyoto Protocol, allows developed countries to meet the reduction of their greenhouse gas emissions in part by investing in projects that reduce the quantity of CO_2 and other greenhouse gas emissions produced by other (i.e. developing) countries. Each quantity of non–emitted gas, by a project approved within the framework of the CDM in a developing country, is credited with a Certified Emissions Reduction credit, called simply a ‘carbon credit’. Carbon credits can then be purchased and sold and can be used by developed countries to meet their emissions reduction target. Among the reasons that have made it difficult for Africa to attract investors interested in CDM are limited financial and economic resources and a shortage of trained personnel with technical and management skills to set up projects that meet CDM standards.

- Restoration of degraded lands;
- Improved waste management, including efficient use of manure as fertilizer;
- Improved use of low fiber feed additives;
- Improved energy/feed efficiency;
- Breeding for improved productivity and efficiency in greenhouse gas emissions.

Although some of these strategies remain contentious and there is disagreement over the relative benefits to climate change and costs to livestock production, a number of the options in this report represent adaptation options that could also help to mitigate climate change. Such options ought to be a priority for livestock development since they could become self–financing. However, donor support may be needed during the initial stages to build the capacity of agencies so they can, for example, secure finance.

General principles for promoting adaptation in the livestock sector

The following key elements should be taken into account to support the design of livestock development interventions. These general principles are relevant to most of the other recommendations in this report.

Collaborative management of natural resources

Participatory approaches for sustainable management of land, forest and other natural resources are essential to develop long–term sustainable strategies. Decision–making processes should be designed to include all concerned stakeholders (farmers, pastoralists and others).

Community involvement in adaptation strategies

Successful adaptation strategies cannot be developed in isolation. Community involvement in the identification of new solutions is key to ensure the long–term sustainability of interventions. At the same time, adaptation strategies need to take into account encompassing issues such as environment, health, social change and conflict.

Risk management mechanisms

Proper risk management mechanisms and preparedness measures will need to be put in place to cope with the impacts of more frequent and extreme climatic events, especially in the Sahel. Preparedness measures, early warning systems and other risk mitigation activities (i.e. strengthening infrastructure and forecasting) will be needed to reduce impacts of severe weather events to prevent loss of livestock.

Awareness and education

Efforts should be made to ensure that knowledge about climate change is shared with local communities. Understanding the patterns of variability of current and projected climate and seasonal forecasts is crucial to anticipate losses and to enable external agencies to provide targeted assistance to herders.

Gender

Adaptation and mitigation strategies should take into account the distinct roles of women and men and how differently each will be impacted by climate change. Climate change clearly offers an opportunity to rethink gender inequities and to involve both women and men in finding innovative solutions to respond to common environmental challenges.

Indigenous knowledge

The in–depth understanding of the environments that local communities and indigenous peoples have, and their experience in adapting to climate variability, can contribute to adaptation and mitigation strategies.

General Recommendations

1. Invest in research and communication to improve understanding of the complex relationship between livestock and climate change, the potential environmental services of different livestock systems, and the opportunities for mitigating the impacts of the livestock sector on climate change.
2. Promote understanding of the importance of the livestock sector to the adaptation strategies of poor people in Africa.
3. Treat adaptation as a generic capacity rather than specific only to climate change, focusing on building adaptive capacities of stakeholders in the livestock sector, and fitting climate–specific adaptive strategies within this broader framework.
4. Avoid over–generalization of climate change projections and the risk of only equipping livestock keepers to adapt to specific scenarios, by developing broad–based (as opposed to technology–specific) adaptive capacity in the livestock sector to prepare for all eventualities.
5. Build adaptive capacity of different stakeholder groups in the livestock sector, from local farmers to national planners, keeping in mind that adaptive capacity consists at least of four distinct dimensions:
    a. Making an informed assessment of threats;
    b. Making informed choices about response measures from a range of options;
    c. Deploying the preferred response measure;
    d. An enabling environment to implement this measure.
6. Build capacities locally and nationally for improved climate forecasting and warning and improved communication, and increase awareness of climate change and its consequences, in order to strengthen the capacity to make an informed assessment of the threat of climate change.
7. Strengthen human capital through general basic education and other forms of public awareness and make information on adaptation options widely available to all stakeholders, and particularly livestock farmers, in order to strengthen the capacity to make informed choices over adaptation strategies.
8. Support informed choice through capacity building of extension workers in community–based and participatory processes and through more collaborative research into endogenous and exogenous adaptation options, ensuring that appropriate capacity and knowledge building is targeted at different groups of stakeholders (farmers, extension agents, policy makers).
9. Develop the skills, resources and infrastructure in the livestock sector that are needed to enable different stakeholders to act on the information available to them, including strengthened skills to use complementary and alternative livestock technologies, improved capacity for natural resource management and governance, stronger representation of different farmer groups, improved access to financial services, greater penetration of public services, markets and roads, improved extension services, and increased public and private investment in productive infrastructure such as water points and transhumance corridors.
10. Promote a more conducive policy and legal environment for adaptation by increasing the quality of engagement of livestock keepers in policy processes and ensuring that policy dialogue for the livestock sector focuses beyond the confines of the sector itself, recognizing the importance of all sectors for enabling livestock production. Policy support should particularly focus on strengthening markets, promoting international trade, strengthening land tenure, promoting organizations, building human capital, and upholding the rights of different livestock keeping populations.
11. Options for mitigating climate change and other environmental risk through livestock sector development should be promoted as a way of harnessing new sources of funds for development, but such options should only be explored in full consultation with livestock keepers in order to avoid harmful interventions that expose livestock keepers to greater vulnerability or poverty. Options could include improving the overall efficiency of livestock production, investing in improved pasture management, enhancing transhumance strategies, reforestation and tree protection in pasture lands, restoration of degraded lands, and improved manure management.

Recommendations for livestock research & development

Livestock research and development in Africa can be geared towards building the options for adapting to the most likely climate scenarios and reinforcing the capacity to make informed choices over those options. To recap from above, the most likely scenarios are increased temperature, increased uncertainty of rainfall leading to water stress, and more extreme weather events. The outcomes of these scenarios are likely to be reduced production of fodder, disrupted availability of water, increased incidence of disease and greater physical stress on livestock. Specific recommendations to address these outcomes are detailed below. However, it remains crucial that the principles outlined above, which can also be related to a simplified framework of "Knowledge, Governance and Empowerment", underpin all research and development in the livestock sector: research and development needs to be made more cognizant of the fact that in the absence of these principles it can contribute to undermining adaptive capacity.

1. Strengthen forecasting abilities in the livestock sector, through increased understanding of the impact of climate fluctuations on provision of productive inputs (fodder and water), greater predictions of extreme weather events, improved disease monitoring, and increased information exchange and overall awareness at all levels of the implications of these forecasts.
2. Strengthen the relevance of research and development to the explicit needs of livestock farmers by conducting research through knowledge partnerships and more genuinely participatory approaches, and building on the local knowledge of livestock keepers in the first instance.
3. Strengthen farmers' access to and understanding of information, through improved communication approaches and stronger extension services, including improved extension methodologies and practices based on farmer participation and expanded farmer field schools (and "pastoralist field schools").
4. Promote innovative approaches to local breed development that are driven by the environmental exigencies of livestock keeping groups, focusing on development of local breeds as well as promotion of 'exotic' breeds from comparable environments that display more locally–appropriate attributes such as drought survival and disease resistance.
5. Strengthen understanding of appropriate approaches to improved pasture management that accommodate climatic flux, based on the principles of mobility, fluctuating herd sizes, and diverse livestock species, and identify technological options, such as satellite imagery, for regulation of transhumance and landscape–scale seasonal resource management.
6. Based on improved understanding of pasture management, identify opportunities for livestock keepers to secure carbon credits for improved rangelands management.
7. Increase research into the specific roles of women in the livestock sector, including their role in processing and value addition (e.g. dairy processing) and product marketing, and target specific participatory research at boosting their capacities and security.
8. Develop financial products that are adapted to the production cycle of rural livestock enterprises, addressing appropriate repayment terms and collateral for loans, appropriate insurance products and relevant banking services, for example make use of new mobile telephone payment options.
9. Research and capacity building for landscape–scale rangelands management, integrating multiple land uses including livestock production and biodiversity enterprises (e.g. harvesting wild products or eco tourism), and building understanding of how to optimize production across a range of products rather than maximize production of a single commodity.
10. Continue to support development of the private veterinary sector in most countries, where models for training Community Animal Health Workers are proving successful, but where national level policy and private (and public) sector support are lagging behind, and ensure these approaches adapt to new disease risks associated with climate change.
11. Develop fodder production and conservation extension services, recognizing that in many cases these are tried and tested technologies that have historically been practiced by many livestock keepers, and focusing on addressing the structural/institutional barriers that have led to the loss of such practices.
12. Improve awareness of the shifting relationship between the crop and livestock sectors and identify synergies in mixed farming systems, for example through conservation agriculture or low external input agriculture, or improved adoption of agro–forestry and silvo–pastoral practices.
13. In water scarce areas, work closely with a wide stakeholder group of natural resource managers to identify safe options for improving water availability (options that do not exaggerate conflict or lead to serious resource degradation).
14. Increased support is needed to secure natural resource tenure and strengthen governance of natural resources, particularly in communal systems, to create a more stable foundation for livestock sector resilience.
15. Explore the options and benefits for mitigation strategies in the livestock sector, particularly where there are opportunities to access carbon finance payments, and identifying synergies between productivity and environmental benefits, for example through reduced methanogenesis (lower methane reduction leading to increased fed conversion efficiency), reforestation of rangelands, manure management, or restoration of degraded rangelands.

Bibliography

Alders R, Bagnol B, Harun M, Young M. 2007. Village poultry, food security and HIV/AIDS mitigation. LEISA. September 23.3 pp. 20–21

Baylis N, Githeko AK. The effects of climate change on infectious diseases of animals. T7.3. Foresight. Infectious diseases: preparing for the future. Office of Science and Innovation. http://www.foresight.gov.uk/ Infectious%20Diseases/t7_3.pdf.

Behnke R, Scoones I, Kerven C. 1993. Range ecology at disequilibrium: New models of natural variability and pastoral adaptation in African Savannas. London, Overseas Development Institute.

Blewett R. 1995. Property rights as a cause of the Tragedy of the Commons: Institutional Change and the Pastoral Maasai of Kenya. Eastern Economic Journal. (21)94:477–490.

Bolling, M, Schulte A. 1999. Environmental change and pastoral perceptions: Degradation and indigenous knowledge in two African communities. Human Ecology. 27 (3):493–514.

Bossche Van Den P, Coetzer JAW. 2007. Climate change and animal health in Africa; Rev. sci. tech. Off. int. Epiz., 2008, 27 (2), 551–562.

Bosso NA. 2006. Genetic improvement of livestock in tsetse infected areas in West Africa, Doctoral thesis, Wageningen University, The Netherlands.

Bourn D, Wint W. Blench R, Woolley E. 2004. Nigerian Livestock Resources Survey Resource Inventory and Management Limited and Environmental Research Group Oxford Limited, Federal Government of Nigeria and the World Bank.

Calvosa, C., Chuluunbaatar, D., and Fara, K. 2010. Livestock and Climate Change. Livestock Thematic Papers. www.ifad.org/lrkm/index.htm

Chadwick DR, van der Weerden T, Martinez J, Pain BF. 1998. Nitrogen transformations and losses following pig slurry applications to a natural soil filter system (Solepur process) in Brittany, France. Journal of Agricultural Engineering Research. 69:85–93.

Chase LE. 2006. Climate change impacts on dairy cattle. Fact sheet, Climate Change and Agriculture: Promoting Practical and Profitable Responses. http://climateandfarming.org/pdfs/FactSheets/III.3Cattle.pdf.

Christeli, G. Struckmeier W. 2001. Groundwater in Namibia: an explanation to hydrological map. Hydrological Map of Namibia Project, MAWRD: Namibia.

Christensen JH et al. 2007. Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of The Intergovernmental Panel on Climate Change, S Solomon et al. (eds.) Cambridge University Press.

Christine J. 2002. Facilitating the survival of African pastoralism in the Face of Climate Change: Looking back to move forward. MA thesis, Tufts University.

CILSS, 2009. L'énergie solaire pour la maîtrise de l'eau. Publication trimestrielle Reflets Sahéliens, N° 48.

CILSS, SWAC, FAO. 2008. Climate and Climate Change. Atlas on Regional Integration in West Africa, SWAC/OECD, ECOWAS.

CLIP. 2008. Implication of climate change on rangeland productivity in Kenya. CLIP Policy Workshop, 26 June 2008, Nairobi, Kenya.

Conant RT, Paustian K, Elliott ET. 2008. Grassland Management and Conversion into Grassland: Effects on Soil Carbon NREL, Colorado State University: Fort Collins, Colorado USA.

CPP/ISLM. 2005. The Namibian Country Pilot Partnership Program For Integrated Sustainable Land Management. Country Report.

CRA. 2007. Projet d'appui aux capacités d'adaptation aux changements climatiques au Sahel. Centre Régional Agrhymet, CRA/CILSS, Niamey.

Cumhur A, Malcolm SC. 2008. The Effects of Global Climate Change on Agriculture. American–Eurasian Journal of Agriculture. 3(5):672–676.

Davies J. 2006. Capitalisation, Commoditisation and Obligation among Ethiopia's Afar Pastoralists. Nomadic Peoples Volume 10(1):pp. 29–52.

Davies J, Nori M. 2008. Managing and mitigating climate change through pastoralism. Climate Change, Energy Change and Conservation. Policy Matters 16, October 2008.

Davies J, Niamir–Fuller M, Kerven K, Bauer K. 2010. Extensive livestock production in transition: the future of sustainable pastoralism. In: Steinfeld H, Mooney HA, Schneider F, Neville LE. eds. Livestock in a Changing Landscape, Volume 1, Drivers, Consequences, and Responses. Washington DC: Island Press.

De Klerk J. 2004. Bush encroachment in Namibia. Report on Phase 1 of the bush encroachment research. Monitoring and Management Project, Windhoek, MET.

Del Prado A, Merino P, Estavillo JM, Pinto M, González–Murura C. 2006. Nitrous and Nitric oxide emissions from different N sources and under a range of soil water contents. Nutrient Cycling in Agroecosystems. 74:229–243.

Dixon J, Gulliver A, Gibbon D. 2001. Farming Systems and Poverty. Improving Farmers' Livelihoods in a Changing World. FAO and World Bank. Rome and Washington DC.

Dixon RK, Smith J. Guill S. 2003. Life on edge: vulnerability and adaptation of African ecosystems to global climate change. Mitigation and Adaptation strategies for Global Change. 8:93–113.

Dodman D, Ayers J, Huq S. 2009. Building resilience. State of the World. Into a warming world. Chapter 5, pp. 151–168.

DONGMO A. L. 2009. Territoires, troupeaux et biomasses: Enjeux de gestion pour un usage durable des ressources au Nord–Cameroun. Thèse pour obtenir le grade de Docteur (PhD) 258.

Dowsett–Lemaire, F. 2001. A synopsis of the vegetation of Malawi. In: White F, Dowsett–Lemaire F, Chapman JD. (Eds.) Evergreen Forest Flora of Malawi. Royal Botanic Gardens Kew. UK.

Ellis F, Sumberg J. 1998. Food production, urban areas and policy responses. World Development. 26(2):213–225.

Ellis JE, Swift DM. 1988. Stability of African pastoral eco–systems: Alternate paradigms and implications for development. Journal of Range Management. 41:450–459.

Estavillo JM, Merino P, Pinto M, Yamulki S, Gebauer G, Sapek A, Corre W. 2002. Short–term effect of ploughing a permanent pasture on N2O production from nitrification and denitrification. Plant and Soil. 239:253–265.

Etchu KA, Mafeni JM, Ngenwi AA. 2008. Comparative performance of three edible snail species under an intensive cage system in Cameroon. In: Proceedings—International Workshop: Experts on Health and Human Well–being in Africa. Pretoria, South Africa, 25–27 August.

Fanuel J. 1997. A survey on the status of local chicken and the unconventional poultry species in Morogoro urban area. MSc Thesis, Sokoine University of Agriculture, Morogoro, Tanzania.

FAO. 1998. Village chicken production system in rural Africa—household food security and gender issues. FAO Animal Production and Health Paper.

FAO. 2007a. Climate Change and Food Security: a Framework for Action. Rome.

FAO 2007b. Global action plan for animal genetic resources. Interlaken, Switzerland, 3–7 September.

FAO 2008. Climate related Transboundary Pests and Diseases including Relevant Aquatic Species. Expert Meeting FAO. February 2008.

FARA (Forum for Agricultural Research in Africa). 2003. Securing the future for Africa's children: Building sustainable livestock through integrated agricultural research for development. Sub–Saharan Africa. Challenge Program Proposal. Johannesburg: FARA, http://www.fara.africa..org/files/SSA%20CP%203.pdf

Farina L, Demey F, Hardouin J. 1991. Production of termites for poultry in villages in Togo. Tropicultura. 9(4): 181–187.

Few R, Ahern M, Matthies F, Kovats S. 2004. Floods, health and climate change: A strategic review. Tyndall Centre Working Paper 63.

Forssido T. 1986. Studies on the meat production potential of some local strains of chickens in Ethiopia. PhD dissertation. Giessen Germany: Justus–Liebig University.

Getahun T. 2008. Climate changes posing danger on pastoralist: How to manage excess of its adversity. Pastoralist Forum Ethiopia. http://www.pfe–ethiopia.org/pub_files/

Climate%20changes%20posing%20danger%20on%20pastoralist.pdf.

Granli T, Bockman OC. 1994. Nitrous oxide from agriculture. Norwegian Journal of Agricultural Sciences, Supplement No. 12.

GTZ. 2008. The Livestock Dilemma: Whose Reality Counts? Why we should engage with livestock issues in development co–operation, in times of climate change, food and financial market turmoil. Messages for the 21st Century. Prepared by GTZ—Germany for ELIDEV–EU–DGDev communication strategy. Draft version 2.0. p. 19.

Hager AL. 2007. Discussion on possible impact of climate change on livestock production in Namibia.

Hanson JG, Baker BB, Bourdon RM. 1993. Comparison of the effects of different climate change scenarios on rangeland livestock production. Agricultural Systems. 41: 487–502.

Hatch, D., Trindade, H., Cardenas, L., Carneiro, J., Hawkins, J., Scholefield, D. and Chadwick, D. 2005. Laboratory study of the effects of two nitrification ibhibitors on greenhouse gas emissions from a slurry–treated arable soil: impact of diurnal temperature cycle. Biology and Fertility of soils. 41: 225–232.

Hesse C, Macgregor J. 2009. Arid waste? Reassessing the value of dryland pastoralim. IIED Breifing.

Hesse C, Cotula L. 2006. Climate change and pastoralism: Investing in people to respond to adversity. Sustainable Development Opinion Papers, IIED.

Hesse C. Macgregor J, 2009. Arid waste? Reassessing the value of dryland pastoralism. The International Institute for Environment and Development IIED Briefieng.

Hill H, Schahczenski, J. 2008. Agriculture, Climate Change, and Carbon Sequestration. http://attra.ncat.org/attra–pub/PDF/carbonsequestration.pdf

Hoffman MT, Voge C. 2008. Climate change impacts on African rangelands. School of Geography, Archeology and Environmental Studies, University of Witwatersrand, South Africa. Pp 14.

Hokins A. 2004. Impacts of climate change on the Agricultural Industry: a review of research outputs from Defra's CC03 and related research programmes. Final report to DEFRA (UK) on project CC0366. Nort Wyke, Devon, UK: IGER. http://www.defra.gov.uk/science/project_data/DocumentLibrary/CC0366/CC0366_2120_FRA.doc.

Hokins A, Del Prado A. 2007. Implications of climate change for grassland in Europe: impacts, adaptations and mitigation options: a review. Grass and Forage Science. 62: 118–126.

Hulme M, Dougherty R, Ngara T, New M, Lister D. 2001. African climate change: 1900–2100. In: Desanker, P. (ed.) Africa and global climate change. CR Special 8. Clim Res. 17: 145–168.

Huq S, Reid H. 2005. Climate change and development: consultation on key researchable issues. IIED, London, UK. http://www.iied.org/CC/projects/ccdevconsultation.html.

IECN. 2008. Dealing with climate change: A community information toolkit on adaptation. A resource package developed for farmers in North–Central Regions, Namibia.

IFAD. 2009. Livestock and climate change. Draft thematic paper. January12–13, 2009. Rome, Italy.

IGER. 2003. Influence of climate change on the sustainability of grassland systems in England and Wales. Final Report to DEFRA (UK) on project CC0359 by IGER/GEH/SAC. North Wyke, Devon, UK: IGER. http://www.defra.gov.uk/science/project_data/DocumentLibrary/CC0359/

IIED. 2006. Climate change and pastoralists: Investing in people to respond to adversity. Sustainable Development Opinion Papers. http://www.iied.org/pubs/display.php?o=11059IIED.

ILCA. 1987. ILCA's strategy and long–term plan. Addis Ababa, Ethiopia: ILCA.

ILRI. Undated. Small Ruminant Production Techniques. ILRI Training Manual 3. ILRI.

IPCC. 2007. Climate Change 2007. Fourth Assessment Report (AR4).

IPPC. 1996. Climate Change 1995. Impacts, adaptations and mitigation of climate change: Scientific–Technical Analysis. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Watson, R.T., Zinyowera, M.C. and Noss, R.H. (eds). Cambridge University Press, Cambridge.

IPPC. 2001a. Climate change 2001, The Scientific Basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

IPPC. 2001b. Climate change 2001, Impacts, Adaptation and Vulnerability. Contribution of Working Group 2 to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

IPPC. 2007. Climate change 2007: Impacts, adaptation and vulnerability. Summary for policy makers. (http://www.ipcc.cg/SPM13apr07.pdf)

Ivo AM. 2009. Farmer Field Schools; an unavoidable path for Africa. African Centre for Community and Development. http://community.eldis.org/falcazo/Blog/Farmer–Field–Schools––an–unavoidable–path–for–Africa––By–Arrey–Mbongaya–Ivo.

Jane KM. 2008. The economic impact of global warming on livestock husbandry in Kenya. Paper prepared for African Economic Conference on Globalization, Institutions and Economic Development of Africa. Tunis, 12–14 November 2008.

Jenny BL, Rust JM, Fourie HJ. 2001. The Nguni: A case–study. Managing biodiversity in agricultural ecosystems. Montreal, Canada.

Kitalyi AJ. 1998. Village–chicken production systems in rural Africa: Household food security and gender focus. FAO Animal Health and Production Series.

Kitalyi AJ. 2010. The Scope and Effect of Family Poultry Research and Development Family poultry management systems in Africa. http://www.fao.org/ag/againfo/themes/en/infpd/documents/econf_scope/paper3.html accessed 07/01/2010.

Klein R. 2002. Adaptation to climate variability and change: What is optimal and appropriate? In: Giupponi and Schecter, M (eds). Climate change and Mediterranean region: Socio–economics of impacts. Vulnerability and adaptation. Edward Elgar.

Koeslag G. 1992. The role of poultry in the rural areas. Proceedings of the Introductory Seminar on Poultry Development Policy, Barneveld College, 7 to 16 September 1992.

Krätli S. 2008. Cattle Breeding, Complexity and Mobility in a Structurally Unpredictable Environment: The Wodaabe Herders Of Niger. Nomadic Peoples 12(1):11–41.

Kurukulasuriya P, Rosental S. 2003. Climate change and agriculture: a review of impacts and adaptations. Climate Change Series Paper No. 91, Word Bank, Washington DC.

Stringer LC, Dyer JC, Reed MS, Dougill AJ, Twyman C, Mkwambisi M 2009 Adaptations to climate change, drought and desertification: local insights to enhance policy in southern Africa. Environmental Science and Policy. 12(7):748–765.

Muchemi SW. 2003. Adaptation Lessons Learnt in Kenya on Climate Variability and Change. http://climateadaptation.net/docs/papers/muchemi.pdf.

Maddison D. 2006. The perception of and adaptation to climate change in Africa. CEEPA discussion paper No 10. Special series on climate change and Agriculture in Africa.

Nassef M, Anderson S, Hesse S. 2009. (HPG, ODI), RPLAP Reg. Pastoral Levelihood Advocacy Group. Pastoralism and climate change.

Majok AA, Schwabe CW. 1996. Development among Africa's Migratory Pastoralists. WestPort, CT: Bergin and Garvey.

Moritz M. 2008. Competing Paradigms in Pastoral Development? A Perspective from the Far North of Cameroon. World Development. 36(11):2243–2254.

Masike S. 2007. The impacts of climate change on cattle water demand and supply in Khurutshe, Botswana. PhD thesis. Hamilton, New Zealand: University of Waikato.

Mendelsohn J. 2006. Farming systems in Namibia. NNFY, Windhoek, Namibia.

Mendelsohn J, El Obeid, S. 2005. Forests and woodlands of Namibia. MAWF, Namibia.

Merion P, Yamulki S, Pinto M, Del Prado A, Sapek B, Pietrzak S. 2000. Effects of liming and nitrogen fertilizer application on soil acidity and gaseous nitrogen oxide emissions in grassland systems. In: Oenema O, Sapek, A (eds.) Polanad agriculture and water quality protection, pp. 45–53. Falenty, Poland: Institute for Land and Reclamation and Grassland Famring (IMUZ).

Midgley G, Hughes G, Thuiller W. 2005. Assessment of potential climate change impacts on Namibia's floristic diversity, ecosystem structure and function. Cape Town, South Africa: South African National Biodiversity Institute, Kirstenbosch.

Ministry of Energy, Mines and Natural Recourses. 2003. Malawi's Initial National Communication under The United Nations Framework Convention on Climate Change. 1st edition. Malawi governmant.

Ministry of Energy, Mines and Natural Recourses. 2006. National Biodiversity and Action Plan. Malawi government.

Ministry of Livestock And Fisheries Development. 2008. Draft sessional paper no. 2 of 2008 on national livestock policy, Narobi, Kenya.

Moorsom R, Pfouts A. 1993. Drought impacts and preparedness in Namibia. Windhoek, Namibia: NEPRU.

Mtambanengwe F, Kosina P. Jones J. 2007. Crop–livestock system–examples of southern Africa. IRRI–CIMMYT Alliance Cereal Knowledge Bank Fact Sheet.

Mutizwa–Mangiza NT, Helmsing AHJ. 1991. Rural development and planning in Zimbabwe. Aldershot, UK: Avebury.

Neely C. Bunning S. 2008. Review of Evidence on Dryland Pastoral Systems and Climate Change: Implications and opportunities for mitigation and adaptation. FAO—NRL Working Paper. Rome, Italy.

Niamir–Fuller M. (ed.). 1999. Managing Mobility: The Legitimization of Transhumance. ITDG/FAO.

Njoya A, Engol Oyep J, Ndong R. 2003. Etude sur la commercialisation des bovins et de la viande bovine dans la région. CEMAC.

NRC. 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. Subcommittee on Environmental Stress, National Research Council. Washington DC: National Academy Press.

Osman–Elasha B. 2006. Environmental Strategies to Increase Human Resilience to Climate Change: Lessons for Eastern and Northern Africa. A Final Report Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. AF 1.

Oxfam. 2008. Survival of the Fittest: Pastoralism and Climate Change in East Africa. http://www.oxfam.org/policy/bp116–pastoralism–climate–change–0808.

Parons DJ, Armstron AC, Turnpenny JR, Matthews AM, Cooper K, Clark JA. 2001. Integrated models of livestock systems for climate change studies. Global Change Biology. 7:93–112.

Paul EA, Clark FE. 1996. Soil Microbiology and Biochemistry 2nd edition. New York, NY: Academic Press.

Peden D, Freeman A, Astatke A, Notenbaer A. 2006. Investment options for integrated water–livestock crop production in sub–Saharan Africa. Working Paper 1, ILRI.

Phiri IMG, Saka AR, Phoya RKD. 2005. National Adaptation Programme of Acion For Malawi.

Republic of Kenya. 2008. Ministry of livestock and fisheries development. Draft Sessional Paper no. 2 of 2008 on National Livestock Policy.

Republic of Niger. 2006. National adaptation Program of action (NAPA).

Riché B, Hachileka E, Awuor C, Hammill A. 2009. Climate–related vulnerability and adaptive–capacity in Ethiopia's Borana and Somali communities. IISD. http://www.iisd.org/adaptation.

Roba G, Davies J. 2009. Compilation of experiences in the field of climate change mitigation and adaptation, soil management and pastoralism in dry and sub–humid lands. Report to the UNCBD. Nairobi, Kenya: IUCN Eastern and southern Africa Regional Office.

Rogers DJ. 1996. Changes in disease vector distributions. In: Hulme M. (ed.) Climate change and southern Africa: an exploration of some potential impacts and implications in the SADC region. Norwich Climate Research Unit, University of East Anglia. 49–55.

Sabine G. 2002. Peri–urban and urban livestock keeping in East Africa: A coping strategy for the poor? Study commissioned by the Livestock Production Program. DFID, UK.

Schwennesen E. 2005. Overgrazing: the crux of pastoralist controversy. http://www.managingwholes.com/downloads/overgrazing.pdf.

Sebastian KS. SPE–IC prog. 2008. Kerala. India. Innovation for local reliance and sustainability: community insurance for goats.

Send a Cow. 2008. PreParing to climate proof: the next challenge for Africa's rural poor. http://www.sendacow.org.uk/assets/files/Related–downloads/Foundation_Series_Climate_Proof.pdf

Seré C, Steinfeld H. 1996. World livestock production systems: Current status, issues and trends. Rome, Italy: FAO Animal Production and Health Paper 127. FAO.

Sidahmed A. 2008. Livestock and Climate Change: coping and risk mgt strategies for a sustainable future. In Livestock and Global Climate Change Conference Proceedings, May 2008. Tunisia

Siri E, Karren O, Lynn R. 2008. Climate Change in Eastern and Southern Africa: Imapcts, Vulnerability and Adaptation. Global Environmental Change and Security. Report 2. University of Oslo.

Smith KA, McTaggart IP, Tsuruta H. 1997. Emissions of N2O and NO associated with nitrogen fertilization in intensive agriculture, and the potential for mitigation. Soil Use and Management 13:296–304.

Sombroek WC, Braun HMH, van der Pour BJA. 1982. Explanatory Soil Map and Agro–climatic Zone Map of Kenya. Report E1. Nairobi, Kenya: National Agricultural Laboratories, Soil Survey Unit.

Sonaiya EB. 1990. The context and prospects for development of small–holder rural poultry production in Africa. In: Proceedings, CTA Seminar on Small–holder Rural Poultry Production, Thessaloniki, Greece, 9–13 October 1990, Vol. 1, p. 35–52.

Soukossi A. 1992. Maggot production for fish and poultry production. L'aigle de Songhai: Bulletin d'information trimestriel. 9:9–10.

Sperling L, Galaty JG. 1990. Cattle, culture and economy. In: Dynamics in East Africa Pastoralism. In: Galaty JG, Johnson DL (Eds.) The World of Pastoralism. New York, USA: The Guilford Press, pp 63–95.

Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, de Haan C. 2006. Livestock's long shadow: environmental issues and options. Rome, Italy: FAO.

Swanepoel FJC, Setshwaelo L. 1995. The role of indigenous cattle breeds: Adaption and productive traits. Harrare, Zimbabwe: International Symposium on Livestock Production Through Animal Breeding and Genetics.

Thornton PK, Jones PG, Owiyo T, Kruska RL, Herrero M, Kristjanson P, Notenbaert A, Bekele N and Omolo A, with contributions from Orindi V, Otiende B, Ochieng A, Bhadwal S, Anantram K, Nair S, Kumar V and Kulkar U (2006). Mapping climate vulnerability and poverty in Africa. Report to the Department for International Development, Nairobi, Kenya: ILRI.

Thornton PK, Robinson TP, Kruska RL, Jones PG, McDermott J, Reid RS. 2006. Cattle Trypanosomosis in Africa to 2030. Report for the Foresight Project of Detection of Infectious Diseases, Department of Trade and Industry, UK Government.

Thornton PK, van de Steeg J, Notenbaert A, Herrero M. 2008. The Livestock–climate–poverty nexus. A discussion paper on ILRI research in relation to climate change. Discussion paper No. 11.

Tiedje JM. 1998. Ecology of denitrification and dissimilatory nitrate reduction to ammonium. In: Zehnder, A.J.B. (ed.). Environmental microbiology of anaerobes, pp. 179–244. New York, NY: John Wiley and Sons.

Topp CFE, Doyle CJ. 1996. Simulating the impact of global warming on milk and forage production in Scotland: 2. Effects of milk yields and grazing management of dairy herds. Journal of Agricultural Systems 52:243–270.

UNDP. 2008. Climate Change vulnerability and Adaptation assessment, Namibia.

UN Economic Commission for Africa. 2001. State of the environment in Africa.

UN Economic Commission for Africa. 2008. Biofuels: What strategies for developing the sector in West Africa?

Van Aalst, M. 2006. Managing climate risk. Integrating adaptation into World Bank group operations. Global Environment Facility Program, World bank, Washington DC.

Van't Hooft K. 2009. Livestock: friend or foe? The need to look at production systems in the debate about livestock & climate change. http://eldev.net/docs/Livestock_Friend_or_Foe–KHO–20091201.pdf.

Watson C, Catley A. 2008. Network papers HPN. Livelihood livestock and humanitarian response: the livestock emergency guidelines and standards.

WHO. 1996. Climate change and human health. Geneva, Switzerland: WHO.

Wilby R. 2007. Decadal forecasting techniques for adaptation and development planning. Report to DFID.

WISP. 2008a. GLOBAL PERSPECTIVE ON THE TOTAL ECONOMIC VALUE OF PASTORALISM: Global synthesis report based on six country valuations. http://cmsdata.iucn.org/downloads/tev_report.pdf

WISP. 2008b Policy Note 8. Forgotten Services, Diminished Goods: understanding the agroecosystem of pastoralism. http://cmsdata.iucn.org/downloads/forgotten_services__diminshed_goods_understanding_

the_agroecosysem_of_pastoralism.pdf.

WISP. 2010. Adding Value to Livestock Diversity: The Promise of Indigenous Breeds for Niche–Marketing and Rural Development. http://cmsdata.iucn.org/downloads/tev_report.pdf.

World Bank.1995. Malawi agricultural Sector Memorandum; Vols. 1 and 2, Lilongwe, Malawi.

World bank. 2004. African development indicators. Washington: World Bank.

World Bank 2009. Minding the Stock: bringing public policy to bear on livestock sector development: Washington: World Bank.

Young A. 1972, Soils. In: Agnew S, Stubbs M. (eds.) Malawi in Maps. London, UK: University of London Press.

Websites of interest

Atlas on Regional Integration in West Africa	http://atlas–ouestafrique.org
Centre Régional Agrhymet (CRA)	http://agrhymet.ne
FAO (Climate Change Website)	http://www.fao.org/climatechange/en/
FAO (High–level Conference on World Food Security)	http://www.fao.org/foodclimate/hlc–home/en/
be–Troplive	http://be–troplive.be
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