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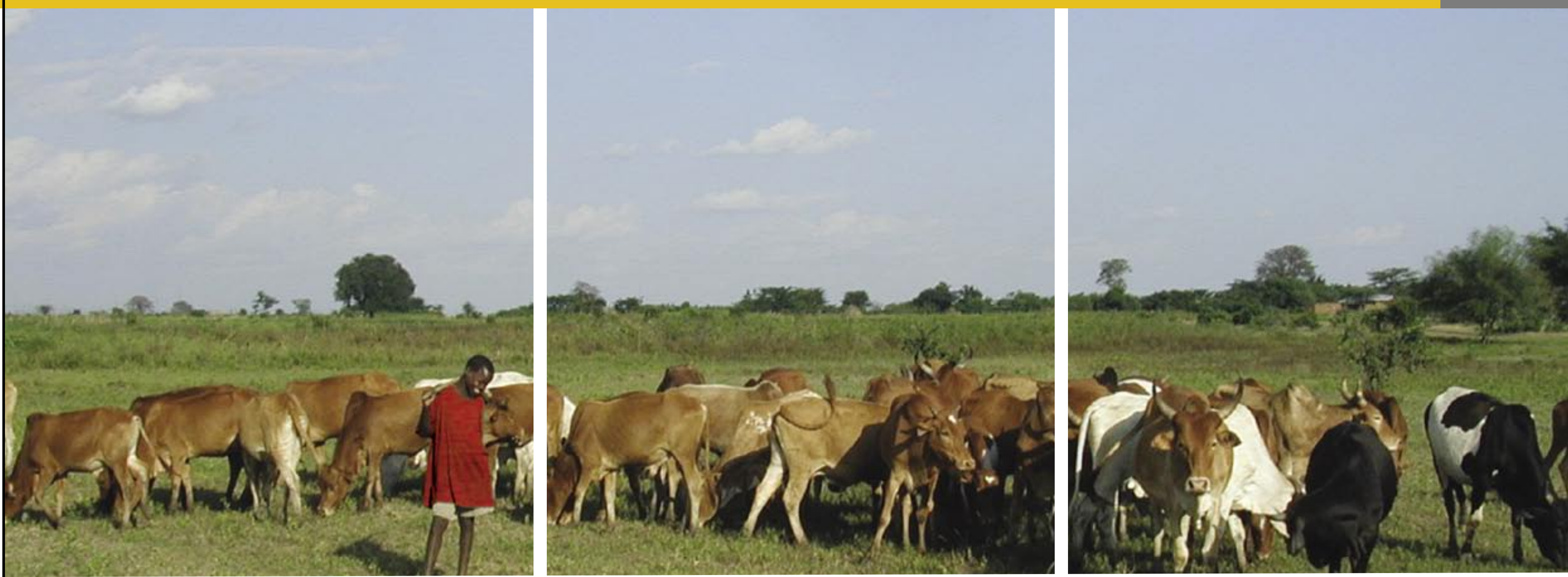

Indigenous Techniques for Assessing and Monitoring Range Resources

in East Africa

Indigenous techniques for assessing and monitoring range resources in East Africa

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Abstract

Local knowledge, which refers to a social activity that has been set up primarily as a result of local initiative, or techniques that are endogenously generated, enforced and maintained has not been mainstreamed in rangeland development programmes in the region. This paradigm unfortunately overlooks the fact that local knowledge and experiences form the basis for local-level decision making in natural resource management. Recently there has been increasing interest and understanding of traditional knowledge systems in the fields of ethno-veterinary medicine but not so in natural resource management. Consequently, the ecological integrity of the range-lands is deteriorated because of increasing population growth, cultivation, over-stocking, felling of trees, and other unsustainable resource utilization methods. In recognition of the role of traditional knowledge in natural resource management and sustainable development, case studies were conducted to document the traditional methods used to assess and monitor the condition and trend of grazing lands in East Africa by the Pokot and Il Chamus of Kenya, the Barabaig and Maasai of Tanzania, and the Bahima and Ateso of Uganda. The results of this study support the theory of the existence of complementary relationships between traditional techniques and modern scientific knowledge.

Keywords

Indigenous knowledge, Range resources, Pastoral communities, Pokot, Il Chamus, Barabaig, Maasai, Bahima, Ateso.

Foreword

The rangelands of East Africa account for 79% of the total land area, which constitutes the main source of the livelihood of its inhabitants and contributes to the national economies as well as maintenance of the ecosystem.

Despite the importance of rangelands, ecological neglect has led to economic deterioration. Solutions to the problems of economic stagnation and environmental degradation in these areas have proven elusive, partly due to the exclusion of traditional knowledge systems from the development agenda. Local knowledge of these ecosystems and the interrelations between climate and land resources should be used to complement modern scientific knowledge.

In response, a study was conducted to bring together and make available the traditional ecological knowledge of several pastoral and agropastoral communties in East Africa, namely the Il Chamus and West Pokots of Kenya, the Teso and Bahima of Uganda and the Maasai and Barabaigs of Tanzania. These perspectives were enriched by range scientists and development workers in a workshop held in Arusha Tanzania, specifically to discuss the study findings.

To forecast weather, the studied communities depend solely on local knowledge, drawn from several indicators including changes in vegetation, animal biology, astrology and animal migratory patterns. Other techniques used to monitor range resource found among the six communities was use of viscera. Such techniques could have scientific basis and could be related to modern techniques based on faecal profiling, which is currently used in early warning and monitoring system.

This report is an important tool for better understanding indigenous methods of assessing and monitoring range resources in East Africa, and will inform future research aimed at improving rangeland management through the integration of indigenous and conventional approaches.

Chin Ong

RELMA in ICRAF Project Manager

Abbreviations and acronyms

A-AARNET	ASARECA-Animal Agriculture Research Network
ACTS	African Centre for Technology Studies
AI	Artificial insemination
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
DEO	District extension officer
EASZ	East African Shorthorn Zebu
EPOS	Environmental Policy Society
EWS	Early warning system
FAO	Food and Agriculture Organization of the United Nations
FEWS	Famine early warning system
GIS	Geographic information systems
GL-CRSP	Global Livestock-Collaborative Research Support Program
GoK	Government of Kenya
GTZ	German Technical Co-operation
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
ITI	Indigenous technologies identified
KENGO	Kenya Energy Non-Governmental Organizations
LEWS	Livestock early warning systems
MAC	Ministry of Agriculture and Co-operatives
NGO	Non-governmental organization
NIRS	Near infra-red spectroscopy
NOAA	National Oceanic and Atmospheric Administration – USA
ODI	Overseas Development Institute
PINEP	Pastoral Information Network Programme
PRA	Participatory rapid appraisal
RELMA	Regional Land Management Unit
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture

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1. Introduction

To plan for rangeland management, the quality and quantity of the biological and non-biological components of rangeland ecosystems must be evaluated. These components or resources include vegetation, animal populations (livestock and wildlife), rainfall, water sources, land or soils, and climate. Thus a rangeland resource is anything on the rangeland that has a value attached to it. The range manager—be it a pastoral user or a manager trained in modern techniques—must therefore know the current status of these resources and their possible future changes in relation to variations in the natural environment and land use. To determine the current status of the range resource base involves *assessment*, while to keep track of the changes taking place in these resources over a period of time entails *monitoring*. Once this has been achieved, the data acquired are analysed to determine the direction of or trend in the change, so that, if it is downward, remedial measures can be taken. To achieve this, indigenous technical knowledge (ITK) and/or modern techniques should be used.

The pastoral groups of Africa use a wide range of ITK to manage natural resources of which to date very little is documented (Brokensha and Riley 1980; Niamir 1994; Tadingar 1994). Early modern techniques for range assessment, monitoring and condition classification had an ecological basis and were associated with different stages of secondary succession (Dyksterhuis 1949; Parker 1954; Gates 1979; Wagner 1989). The inferred range condition is based on the relationship of the present vegetation composition of the sites. Site stability, grazing value, vegetation cover, forage and carrying capacity are assumed to increase as vegetation composition nears climax state. More recently range classification and monitoring of rangelands has also been done using diagnostic surveys and geographic information system (GIS) methods. These surveys and methods are used to characterize the physical and socio-economic environment such as drainage pattern, slope, soil quality and distribution, farming systems, land tenure and social and cultural characteristics of human communities. Within East Africa, range condition classification has placed emphasis on periodic re-measurements of range condition on permanent sample transects or plots (Casebeer 1970; Skovlin 1971; Bille and Heemstra 1978; Kuchar et al. 1981; Herlocker 1994).

After almost a century of development activities in the rangelands of East Africa, there are no ready solutions to the pressing economic stagnation and environmental degradation. To varying degrees, pastoralists and agropastoralists who live in these areas have been caught in a protracted crisis as a result of increasing scarcity of natural resources and inappropriate technologies. This crisis in pastoral development led to the proposition of a closer linkage between indigenous pastoral systems and knowledge, and modern, scientific technologies to produce what Roling (1993) termed ‘coupled systems’ comprising hard ecosystem (i.e. range science) and a soft platform for making decisions about that ecosystem (i.e. pastoral organization).

The term indigenous knowledge adopts the definition of Rai and Thapa (1993) and refers to ‘an organization or social activity that has been set up primarily as a result of local initiative’. It refers to techniques that are ‘endogenously generated, enforced and maintained’ or those that result from the ‘local adaptation of methods from outside’. The term indigenous system is used as opposed to a sponsored system. A sponsored system is always initiated through an external intervention such as by government agencies and non-governmental organizations (NGOs). However, according to Woytek and Gorjestani (1998), indigenous knowledge is local knowledge that is unique to a given culture or society. It forms the basis for local-level decision making in natural resource management and a host of other activities in rural communities.

As Warren (1986) observed, indigenous knowledge is not necessarily simple. It does not exist in a cultural, economic or political vacuum but always confronts other knowledge systems. It is within the context of contestation that, through a process of dialogue and exchange, innovation and knowledge creation will always operate (Scoones and Thompson 1993). Therefore, potential disappearance of many indigenous practices could have a negative effect primarily on those who have developed them and who make a living through them.

Indigenous systems for natural resource management invariably include both biological management and the social arrangements by which access to the natural resources are regulated. A lot of indigenous knowledge is based on accurate, detailed and thoughtful observations, collected and passed on over many generations. It allows informed decisions to be made by combining information and techniques to maximize production and minimize risks (Brokensha and Riley 1980). According to Scoones and Thompson (1993), 'rural people's knowledge and agricultural science are both general and specific, theoretical and practical, value laden and context bound and influenced by relations of power'.

The understanding of pastoral ITK is gradually increasing, especially in the fields of veterinary medicine (Ole-Lengisugi 1994; Munyua et al. 1998; Mogoa and Nyangito 1999;) and livestock husbandry (Farah 1996; Kyagaba and Farah 1996; Oba 1994; Mwilawa et al. 1996; Noor et al. 1999), but is still limited for natural resource management.

It is evident, therefore, that the pastoral groups in Africa use a wide range of techniques to manage their natural resources. These techniques are quite deliberate and adapted to the vagaries of pastoral environments (Niamir 1990). In appreciation of the importance of indigenous knowledge in natural resource management, and with a view to promoting these practices and integrating them with conventional range management for better results, this study was conducted to investigate the indigenous range assessment and monitoring techniques used in East Africa—Kenya, Tanzania and Uganda. The specific objectives were to identify and document these indigenous techniques. The study findings were enriched by range scientists and development workers in a workshop held in Arusha, Tanzania, specifically to discuss the study findings (Appendix 3).

This report contains nine chapters. Chapter 1 consists of the introduction of the subject matter. It presents the descriptions and definitions of the main terms used and introduces the various chapters.

Chapter 2 provides an indication of the extent and description of the range resources in the three East African countries, while Chapter 3 discusses the main range attributes considered in the assessment and monitoring of range resources. Chapter 3 also provides a discussion of the inventory, survey and planning for range resource use.

The methods of study are discussed in Chapter 4. Studies were carried out in selected range areas among a number of pastoral communities taken as representative cases. The approaches used to evaluate indigenous knowledge in the three countries were generally the same, with minor differences depending upon the different characteristics of the selected localities and communities.

Chapters 5, 6 and 7 give the results of the studies in the three countries. The results are organized on the basis of the range attributes considered for assessment and monitoring.

Chapter 8 presents a discussion of the findings while the final chapter provides the conclusions made, offering suggestions for use of the findings. Suggestions to strengthen both the application of indigenous knowledge alongside modern techniques to enhance beneficial outcomes are given.

2. Range resources of East Africa

Extent of the rangelands

The range areas of East Africa constitute a basic resource, the use and orderly development of which demands an understanding of the nature and role of each of the components of the ecosystem. Rangelands in the three countries of East Africa cover a vast area (Table 2.1). Although most of these areas fall in the semi-arid to arid lands they contribute significantly to the national economies, supporting large proportions of human, livestock and wild life populations, and considerable amounts of biodiversity (Shayo and Turuka 1987; Kariuki and Letitiya 1996; GoK 1996; Herlocker 1999; Mugarura 2001). The rangelands in Uganda present an entirely different set of conditions and problems in the context of rangeland use and animal production than those in Kenya and Tanzania, because of higher altitude and rainfall and therefore more favourable conditions for agriculture.

Soils

The rangeland soils of East Africa are highly variable. They are generally of light to medium texture, low in organic matter (fertility) due to low density of plant life and low microbial activities. They are normally shallow and often stony and sandy. They have a low cation exchange capacity (CEC), are prone to compaction and capping, and are highly susceptible to erosion. In addition, because the soils are inherently shallow, they have a limited capacity to store water. Poor soil structure and texture combined with sparse vegetal cover at the onset of the rains, makes the soils highly erodible, thus increasing the susceptibility of the land to degradation. However, there are isolated pockets of volcanic soils (alluvial/colluvial clays) in some rangelands that can be cropped. Black cotton soils (Ferralsols) also occur in some parts, but are avoided because they are difficult to cultivate using traditional methods, and have problems of salinity and sodicity. Phosphorus is the main limiting mineral in black cotton soils due to its immobilization, rendering it unavailable to plants (Jaetzold and Schmidt 1983).

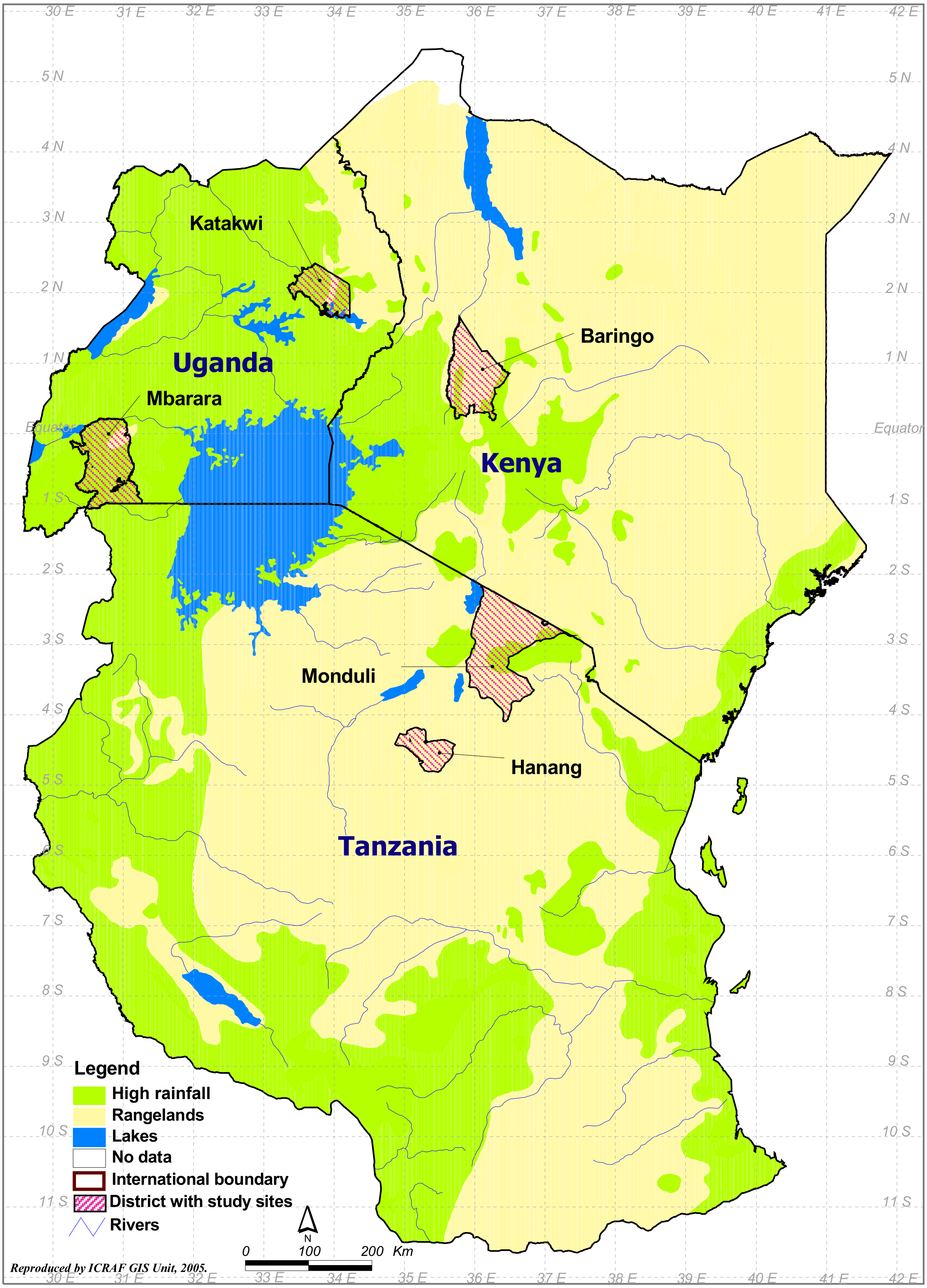
Water

Water availability in the rangelands is one of the major constraints to development. Sources include ground water from boreholes, and surface water from dams, pans and reservoirs, whose costs are a limiting factor. Vast areas of the rangelands serve as watersheds that receive precipitation that eventually drains into rivers and small streams, or sinks into the soil to replenish springs and groundwater reservoirs. For example,

Table 2.1. Rangelands of East Africa

	Total land area (‘000 km)	Proportion under rangelands (%)
Kenya	582	87
Tanzania	886	74
Uganda	208	62
Total	1,680	79

Source: Pratt and Gwynne 1977



Study sites in the three countries embedded in the eco-climatic zones map (Pratt & Gwynne 1977)

Kenya's rangelands form part of the six major water catchments: the Kerio, Ewaso Nyiro, Mara, Turkwel, Tana and Athi river systems, which originate from the highland massifs. The main rivers are subject to high and low seasonal flows that show increasingly dramatic variations and silt loads as cultivation and deforestation increase in the highland areas. The rivers are also increasingly regulated, as dams are constructed to generate hydroelectric power.

The tributaries of the main systems used in the rangelands are ephemeral. The surface water resources are available for short periods during and after rainy seasons. Surface water can persist in natural or artificial river pans, but it is unpredictable even where seasonal river flows originate from highland rains. Groundwater potential is highly variable in both quantity and quality and is being depleted at an ever-increasing rate. The soil/vegetation complex on which precipitation falls has a major influence on the quality and quantity of water available. Land-use practices can affect the flooding of streams and rivers; silting rates of reservoirs; bacteria and sediment counts in reservoirs, streams and rivers; springs, rivers and stream flow rates; and the quality of water from overland flows that can be trapped in reservoirs. Water will continue to be a limited rangeland resource due to rapid growth in human population as well as the depletion of the groundwater reserves at an ever-increasing rate.

Vegetation

Vegetation is an important resource in the rangelands as it provides over 85% and 95% of the total feed requirements of domestic (cattle, sheep, goats and camels) and wild ruminants, respectively. The vegetation comprises grasses (both annual and perennial) and shrubs. Trees are rare and if present are often found along *laggas*, land depressions and hills.

Soon after the rains, much of the rangelands is covered with grass. Productivity varies greatly in space and time, and is dependent on rainfall. Reliable sources of high quality grass in sufficient quantities are small and widely scattered. Isolated blocks of hills and river floodplains are key areas within the annual cycle of pastoralism and wildlife migrations as dry season grazing areas. Without these high-productivity areas, many pastoral systems would not be sustainable.

Woody vegetation is less affected by rainfall variability, but the density of tree and bush cover is low. Woody vegetation is also extremely important for livestock and wildlife. For instance, strips of riverine woodland along seasonal rivers are important dry season grazing resources, and in dry years may be essential for the survival of pastoral groups. Trees and shrubs provide forage, firewood, building wood, herbal medicines and shade. Degradation of wood resources occurs locally, but elsewhere the needs of low population densities are met.

Wildlife

The rangelands provide the primary habitat for a wide range of land-dwelling wild animals highly valued for tourism (aesthetic value) and game ranching. Most wildlife is found under natural grazing conditions and includes big game, small mammals and birds. Today, most East African wildlife resources, national parks, game reserves and much of the tourist infrastructure are found in the rangelands. Adventure or ecotourism is based on the rangelands because of the spectacular scenery and panoramic wilderness in some of these areas. In many places where increasing areas are under conservation management and hunting is controlled, income from game and associated recreation facilities exceeds that from domestic animals (Nyariki and Ngugi 1999).

Unfortunately, many game species are currently endangered; they have either been decimated or eliminated by hunting or by habitat destruction due to overgrazing and other human activities. Populations of some wildlife species are at healthy levels, while others have been severely depleted by poaching.

Livestock

Livestock remain an important resource of the East African rangelands. Currently, livestock populations in Kenya are estimated at over 30 million head (WRI 1992). The rangelands support 60% of the cattle, 70% of the small stock, and 100% of the camels in the country (GoK 1996; Kariuki and Letitiya 1996; Herlocker 1999). Livestock are probably more important than any other source of livelihood because pastoralists rely on them for subsistence.

In Tanzania, most of the national herd—15.6 million cattle, 10.6 million goats and 3.5 million sheep—belongs to the pastoral/traditional livestock sector. The sector accounts for about 43.1% of the national cattle herd (6,723,600 head) and provides most of the meat and milk consumed in Tanzania (MAC 1996; Mwilawa et al. 1996). Like in Kenya, the traditional system is characterized by ownership of large stock numbers, uncontrolled livestock movement, communal grazing, traditional husbandry practices, absence of animal records, undeveloped identification methods, and continuous breeding. The system is found in the rangelands and semi-arid areas including parts of Arusha, Iringa, Shinyanga, Singida and Dodoma.

The national livestock herd in Uganda is estimated at 4.2 million cattle, 3.3 million goats and about 1 million sheep. About 700,000 cattle are kept under semi-nomadic pastoral systems in the semi-arid regions. Ankole cattle, kept by the Bahima, contribute about 23% of the total herd (Mugarura 2001).

Overgrazing in Maasai rangelands (Tanzania).

3. Conventional range resource assessment and monitoring:

key attributes and their use in planning

Basic to range resource assessment and monitoring is an understanding of the characteristic attributes of the resources. Some of these attributes are those related to soils, rainfall, landscape and vegetation. The most commonly assessed and monitored range attributes are those related to vegetation, although animal attributes are sometimes considered as well. Specifically, these include biomass, cover of the soil by plants, and height, quality, frequency and abundance of plant species.

Range vegetation attributes

Biomass

Biomass is the weight of organic matter per unit area. The organic matter normally includes the weight of herbage above ground, dead organic matter, mature trees and animals. The measurement of biomass is of great value to the range manager and may be the most important determination of biological range attribute. Usually, the unit of area in vegetation measurement is a square metre. The plants are clipped, dried to a constant weight in a laboratory and then weighed. Plant biomass for larger areas is then calculated by extrapolation.

Cover

The proportion of the soil surface covered by vegetation is referred to as cover. There are various types of cover: basal cover (per cent soil surface occupied by the bases of plants), litter/mulch cover, rock cover and tree canopy or foliage cover. Several techniques are used to measure cover. They include estimation by eye, measurement of plants intercepted along a line, point measurements, sampling in plots or transects and, in extensive areas, the step-point procedure. The relative proportion of total cover contributed by each species roughly represents their relative importance in the vegetation. The botanical composition of the different species can be assessed using these techniques. Studies have shown that species composition based on cover is similar to that based on biomass (Heady and Heady 1982). Cover also measures soil protection so that, as cover increases, there is reduced water loss, raindrop erosion and exposure to wind and runoff flow. Thus, cover is a useful attribute in rangeland assessment.

Abundance

Abundance is generally used to refer to the number of plants per unit area. However, a more specific term is density. To measure plant abundance, individual plants by species, in plots marked out in an area, are counted. Abundance can be used to show the spatial distribution of a species in time. Abundance is not closely related to biomass or cover because individual plants differ greatly in size during growth from habitat to habitat and from species to species.

Frequency

The frequency sampling method records the species present/absent in each sampled plot/quadrat. The plots/quadrats, which differ in size depending on the type of vegetation, allow for a quick survey of a large area. The main value of measuring frequency is to show the distribution of species. Species distribution can be important for the study of certain kinds of rangeland problems. The frequency of indicator species could be used to identify sites that need special attention.

Height

Plant height has ecological importance. For example, only plants below a certain height can be browsed by certain livestock and wildlife species (Schwartz and Schultka 1995). Some species, such as the giraffe and camel, can browse higher than others, such as the gazelle and goat. Tall grass may provide better cover than short grass.

Quality

On the basis of palatability, nutrient content or other attribute, plants of better quality are preferable to those of poor quality. High quality forage plants, for example, are an indication of a range of high productive potential, say in livestock production. Other quality characteristics are those related to wood density and type, translating into, say, the quality of charcoal or timber produced.

Range animal attributes

The attributes of range animals considered for assessment and monitoring are similar to those of plant/vegetation—mainly biomass, abundance or diversity, composition, distribution and productivity. For example, total biomass of large herbivores (and the biomasses of many individual species) closely reflects average annual rainfall, although this relationship may be locally modified by soil fertility, through its influence on forage quality and productivity, and the availability of surface and ground water (Herlocker 1999). The more arid the rangelands the less animal biomass they can support. Animal biomass may also be a reflection of the fertility of soil. Thus, given similar rainfall, fertile soils tend to support higher herbivore biomass than do soils of low fertility. For example, the *miombo* woodland of southern Tanzania, characterized by highly leached, infertile soils, frequent fires and limited surface water supplies, is relatively poor as a large mammal habitat. However, the *Themeda* grasslands of south-western Kenya, which are associated with more fertile soils and more evenly distributed rainfall, are noted for the abundance and diversity of wildlife supported.

Planning for range resource utilization

Inventory and planning of the utilization of range resources requires a series of decisions about measurement and analysis. Analysis involves measuring the presence or absence, number, length/height etc. of a species, for example. These measurements are used in three main stages. The first stage is estimating attributes as discussed above: biomass, cover, density, abundance, frequency, height, and number of species and others. The second stage is interpretation. This requires calculating and summarizing the raw data so that the relationships between the attributes within the plant community or ecosystem become clear. For example, the percentage species composition, usually calculated from data on mass or cover, gives a measure of relative importance of species that is not readily seen in the field data. Other second-stage (or second-order) characteristics include relative dominance, pattern of species and exclusiveness to a stand or community (fidelity). The third-order synthesis involves applying the summarized data to comparisons among plant communities, range pastures, range sites and ecosystems.

To be useful, measurement of range vegetation should be related to the location of sites. Land survey and mapping are used and involve photogrammetry. This is the use of aerial photographs, remote sensing, and interpretation of photographs taken from satellites.

Aerial photographs must be large enough (scales of between 1:10,000 and 1:50,000) to show habitats, range sites, pastures and geographical features. While this scale is possible with photographic enlargement and aerial flights close to the ground, determination of species composition, biomass etc. would require extensive ground investigation. This is where indigenous knowledge and assessment could play an important role.

The main use of aerial photographs in range resource inventory and planning is in delineating and describing range sites. These are units that respond uniformly to treatments such as seeding and bush control. For example, evaluation of range condition and range trend should be on the basis of site. Range condition is the state of health and vigour of a range in relation to its full productive potential, and range trend is the direction of change in range condition.

Resource inventory includes survey and measurement of vegetation, animal populations and geography. The information gained is transferred to maps to show distribution at a scale that can be used to plan land use. The evaluation of resources includes assessing their condition in relation to potential, improvement or deterioration, and sociological aspects (Figure 3.1).

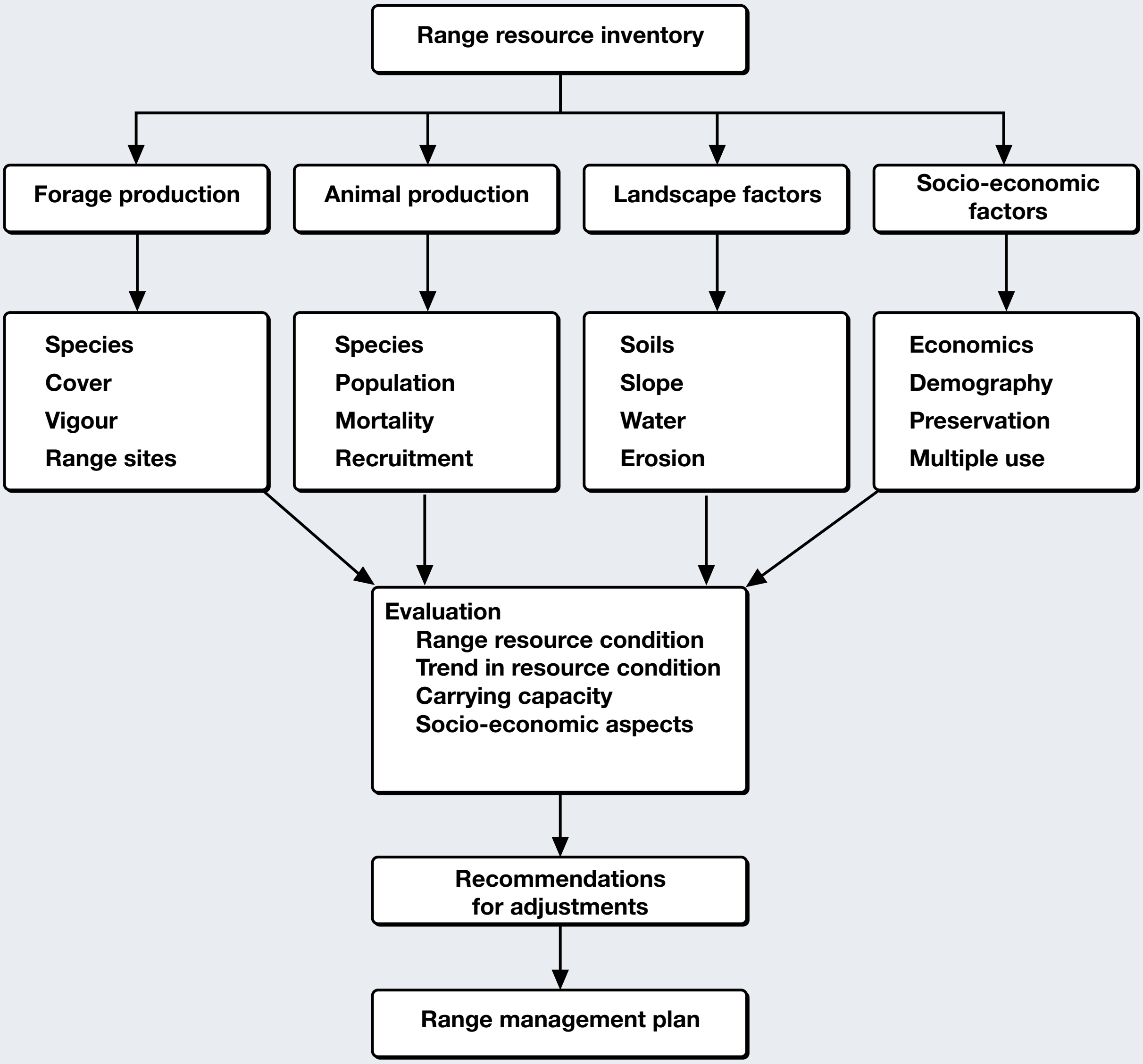


Figure 3.1. Range resources and their inventory.

Recent advances in monitoring: Early warning systems

The Global Livestock Collaborative Research Support Program (CRSP) Livestock Early Warning System (LEWS) in East Africa has developed a monitoring strategy. The strategy largely relies on the spatial extent and stratification of the region's climate based on historical weather data adjusted for elevation and proximity to bodies of water. The programme presupposes that because many areas in the world are experiencing changing drought frequencies and temporal shifts in precipitation and temperature, the traditional coping strategies for agropastoralists are not appropriate for the changing conditions. LEWS is an attempt to develop innovations to characterize, monitor, analyse and communicate the occurrence of droughts throughout the world.

While this is a good scientific innovation, there are no well-developed communication frameworks with pastoral communities that provide information valued by community leaders and individuals in a manner that would result in rational and proactive decisions. In any case this innovation cannot substitute the pastoralists' decision-making system based on farm-level observations because, like any other reconnaissance method, the finer detail on the condition of the range is achieved by looking at parameters at farm level. The ground truthing used in LEWS adopts conventional sampling and research methods, and is yet to incorporate the parameters used by the indigenous people.

The key technology in the LEWS system is near infrared reflectance spectroscopy (NIRS) which can be used to indicate the dietary protein and energy status of cattle, sheep and goats from faecal scans. This technology, combined with weather and remote sensing information from the National Oceanic and Atmospheric Administration – USA (NOAA) climate prediction centre, is used to provide information on emerging pastoral conditions six to eight weeks earlier than the monitoring system based on monitoring markets and human and livestock condition (Ndikumana et. al. 2000). The LEWS programme provides pastoral information to the monthly reports of the Intergovernmental Authority on Development (IGAD) and has developed an organizational structure to reach the grassroots. It is, however, not clear yet if the pastoral communities are able to access, interpret and make use of this information.

4. Methods of study

The approaches used to evaluate the indigenous knowledge in the three countries of East Africa were generally similar. However, there were minor adjustments in each country influenced by the uniqueness of the specific geographical areas selected and ethnic groups surveyed. Regardless of these differences, the areas and the communities studied are assumed to represent the typical rangeland attributes and pastoral communities that use range resources in the respective countries of East Africa. Thus, the results are expected to be plausible.

Table 4.1 describes the study areas in the three countries. One common characteristic of the six ethnic groups is their resistance to change and attachment to traditional livestock keeping.

Table 4.1. Study areas and ethnic groups in the three East African countries

Country	District	Ethnic group	Altitude (m)	Rainfall (mm)	Livestock species kept	Farming systems
Kenya	Baringo	Pokot and Il Chamus	900–2700	Highlands: 1200–1500 Low lands 300–700	Cattle, camels and small stock	High agricultural potential –in west and south-west. Drier east and south-eastern dominated by pastoral system.
Tanzania	Monduli	Maasai	600–2900	600–800	Cattle, sheep, goats and donkeys	Pastoral system.
	Hanang	Barabaig	1000–2000	500–900	Cattle, sheep, goats and donkeys	Large-scale farming in the highlands and pastoral farming system in the lowlands.
Uganda	Mbarara	Bahima	1210	750–1000	Ankole cattle mainly	Perennial and annual crops found in the wetter areas of the district, but the pastoral system dominates the drier areas.
	Katakwi	Teso	1000–1200	750–1000	Cattle, sheep and goats	Agropastoral system, where most of the land is still under customary communal tenure.

Data collection

The study methodology used several methods to collect information. These were extensive literature review; a semi-structured questionnaire to obtain specific information on parameters used to assess the environment; discussions with key informants to obtain a broad appreciation of range ecology and indigenous range management; and focus group discussions to assess if there was a consensus on the knowledge used. Supporting information was obtained from field observations.

A combination of methods was applied. This involved the administration of a questionnaire (quantitative methods), focus group discussions and in-depth interviews with key informants (qualitative techniques).

The unit of study in the survey was a household, used in the broad sense (i.e. homestead). Considering that homesteads in the study area were far apart, simple random sampling as a technique was very expensive. Cluster sampling was adopted using the local council as a cluster. Randomizing was then done from the selected clusters.

Quantitative data were analysed to obtain frequencies which were then used to draw conclusions. The qualitative information from focus group discussions and key informants was used to help interpret the quantitative data.

Ranking using ordinal scales was used, basing on the importance of parameters as reported by the respondents. The parameters were assigned using an average rank. When equal sums occurred, an average rank was assigned to both.

Discussion with villagers Maasai, Tanzania

5. Range assessment and monitoring in Kenya:

The case of the Pokot and Il Chamus

The Pokot and Il Chamus communities in Kenya have both similarities and differences in the way they assess and monitor the various range resources. The similarities are probably because these communities share the same home range, and therefore have a lot in common in terms of ecological experience with the range ecosystem.

Climate

The Pokot and the Il Chamus acknowledge that climate is the most important factor affecting livestock production and agriculture. They are able to monitor climatic trend, and therefore put in place adaptive survival strategies by constantly observing:

- Rainfall
- Clouds
- Temperature
- Wind

Indicators of climate change

The Pokot and the Il Chamus attribute certain ecological changes to downward trends in climate. According to them, current observations as compared to the past that indicate climate change are:

- Low and unreliable rainfall resulting in low water levels in rivers, lake and pans, and permanent rivers becoming intermittent
- Fewer and scattered clouds
- Frequent and prolonged droughts
- Increased temperatures
- Stronger winds (a lot of dust in the air)
- Invasion of grasslands by woody species
- Lack of forage
- Reduced animal and crop production

Both the Pokot and the Il Chamus regard rainfall as the most critical climatic factor, the driving force behind their daily operations, and by far the most significant constraint to life in range areas. They are able to forecast impending drought or rain using the following indicators:

- Atmospheric indicators - density of cloud and direction of wind
- Biological indicators - phenological changes in plants and behavioural changes in animals
- Astrological indicators - appearance of certain stars
- Cultural indicators - observation of the viscera of slaughtered animals

Indicators of rain

The common signs of approaching rain for both the Pokot and Il Chamus are:

- Strong winds blowing from east to west in the case of the Pokot and from west to east (Kabarnet to Laikipia) in the case of the Il Chamus
- Shedding of pods and formation of new leaf buds by *Acacia tortilis* in the case of the Pokot and shedding of leaves by *Balanites* species *(lowei)* among the Il Chamus
- Roars of the ostrich *(akales)* at night
- Bulls running excitedly, especially in the afternoons, and pointing their heads towards the direction of the on-coming rain (east for the Pokot, west for the Il Chamus)
- Sounds of excitement from the woodpecker *(tiltil)*
- The appearance of a group of four stars *(merelot)* and six stars *(remetom)*
- Forecast from the 'experts' who read the entrails (*kwanyan* in Pokot) of slaughtered animals

The Pokot use the following as signs of approaching rain in addition to those listed above:

- Formation and gathering of thick clouds
- Ripening of fruits of *Salvadora persica* (locally known as *asiokonyon*)
- Clustering of safari ants
- The reluctance of the animals to drink

In addition to the common indicators, the Il Chamus also use the following as signs of on-coming rain:

- Lightening from the south
- Flowering of *Acacia tortilis* ('iltepesi') and *Salvadora persica* ('sokotei')
- Praying zebra (ritualistic sounds of zebra)
- Croaking of frogs expecting water
- When the male *(len'goni)* and female *(lobon'g)* stars move towards each other—it rains as soon as they meet

Indicators of drought

The Pokot and the Il Chamus communities use the following signs to indicate impending drought:

- Shedding of leaves by most *Acacia* trees, including *A. mellifera* ('talamong' in Pokot and 'iti' in Il Chamus), *A. nubica* ('anyua' in Pokot), *A. tortilis* ('ses' in Pokot) and *A. reficiens* ('iljorai' in Il Chamus)
- Animal weight loss
- Reading of the entrails of slaughtered animals
- Strong winds blowing from west to east for the Pokot and from east to west for the Il Chamus
- Failure of the four stars and six stars to appear
- Clear skies or few clouds

In addition, the Pokot use the following as indicators of drought:

- Production of flowers by *A. mellifera*
- Production of green pods *(sakaram)* by *A. tortilis*
- Excretion of hard dung by the animals
- Reduced milk production, kicking and refusal of calves by their mothers

The Il Chamus use the following additional signs:

- Migration of flamingos *(roriti)* from Lake Bogoria to Lake Turkana
- Swarming of bees *(lmaren)* from the lowlands to the highlands
- Hibernation of the termites *(lan'ga)* and ants *(lasai)*
- Sounds of an owl

Drought mitigation strategies

As soon as the Pokot and the Il Chamus realize that there is impending drought, they adapt various mitigation strategies. The herds are split and dispersed into home-based (*lepon* in Pokot) and satellite herds (*sorok* in Pokot). Herding becomes a priority to ensure enough milk. Circumcised boys (*muren* in Pokot, *el moran* in Il Chamus) prepare for long distance movements and move with the satellite herds to distant dry season grazing pastures where they establish the satellite camps (*cheporiok* in Pokot). Women and children collect pods, lop trees (*yepow* in Pokot) and reserve forage supplements for the home-based herds. Sometimes young men move to towns to look for jobs and women visit their relatives to look for food.

Vegetation

Vegetation characterization

The Pokot and the Il Chamus classify the range into two broad categories—the highlands (*masop* in Pokot, *supuko* in Il Chamus) and lowlands (*keu* in Pokot, *ilpurkel* in Il Chamus). They base the eco-physiognomic classifications of the range on the following factors:

- Topography
- Climate
- Soil type
- Dominant vegetation type

Based on the physiognomic vegetation types, the Pokot and the Il Chamus further subdivide the two ecological range categories into grasslands (*kurosus* in Pokot, *ngonjin'gngelen'g* in Il Chamus) and bush lands (*kurosoko* in Pokot, *ngonjinetimbene* in Il Chamus). Grasslands are suitable for grazers while bush lands are suitable for browsers. *Ngujit* refers to grass while *mbene* means browse. The *masop* (Pokot) are lands found at higher altitudes than, and with vegetation types different from, the *keu*. *Masop* are characterized by black sticky soils as opposed to the red loamy soils found in the *keu*. The Pokot perceive *masop* as a cold place *(kornyo kakit)* that is 'not good for livestock'. Conversely, they refer to *keu* as a warm place *(kornyo layat)* which 'likes the animal' *(kornyo chameitich).* The *masop* are normally composed of *Commiphora* trees as the dominant species. Other species include Terminalia species ('koloswo') and *Dodonea viscosa* ('tapolokwa'). The *keu* are dominated by *Acacia* species and are preferred for livestock grazing. The lowlands are characterized by different grass and woody species such as *Aristida adscensionis* ('chelwowis'), *Eragrostis superba* ('chaya'), *Cynodon plectostachyus* ('seretion'), *Setaria verticellata* ('amerkwia'), *Acacia tortilis* ('ses'), *A. mellifera* ('talamong'), *Boscia salicifolia* ('likwon'), *Boscia coriacea* ('sorichon'), *Salvadora persica* ('ashokonyon') and *Balanites aegyptiaca* ('tuyunwo').

For the Il Chamus, supuko is a hilly and cold place, characterized by black loamy soils. The common woody species in the highlands include *Albizia anthelmintica* ('mukutani'), *Terminalia* species ('ilbugoi') and *Ficus thornningii* ('elngaboli'); the grasses include *Cenchrus ciliaris* ('loiupub') and *Cymbopogon* species ('ilgurume'). The *supuko* is associated with a number of deadly diseases, and is therefore not good for livestock. In contrast, *ilpurkel* is a warm place that is good for livestock. *Ilpurkel* are low-lying areas characterized by red clay and sandy soils. The common grass species found in the lowlands are *Cynodon plectostachyus* ('longeri') and *lamara*, annual herbs are *lote* and *lameruaki,* and browse species include *Acacia mellifera, A. tortilis, Salvadora persica, A. reficiens* and *Balanites aegyptiaca.*

Botanical composition

Both the Pokot and the Il Chamus perceive the knowledge of botanical composition as a vital tool for evaluating range suitability for livestock grazing. According to most, knowledge of plant species is useful for:

- Determining the dominant plant species—with respect to dietary requirements of and suitability for different animal species
- Identifying preferred and undesirable plant species—key plant species and poisonous plants
- Determining the type of range—whether annual or perennial, and therefore deciding when to graze

Identifying medicinal plants

The Pokot recognize that different animal species have different feeding habits and prefer different plant forms. Cattle and sheep, which are grazers, prefer grassland while goats and camels, which are browsers, prefer bush land. The herders are able to identify the preferred forage species and distinguish between those that fatten livestock and improve their condition (e.g. *Cynodon plectostachyus* and *Eragrostis superba*), and those that are good for milk production (e.g. *Pennisetum meziunum* ('amarkuation') and *Echinochloa haploclada* ('amaranyon')). The Pokot are also able to identify poisonous plants, e.g. *Tribulus terrestris* ('asikuruyon'). Through such knowledge herders can tell whether a given range is suitable for their herds or not. This is done through regular monitoring and judging of the changes in the composition of key plant species. The responses from the informants revealed that they have a rich knowledge of plants with medicinal and other values. Some of those with medicinal value include *Zanthoxylum chalybeum* ('songowo'), *Albizia anthelmintica* ('mukutan'), *Salvadora persica* ('asokonyon') (Appendixes 1 and 2).

The community is aware that certain grass species like *Eragrostis superba, Chloris gayana* ('amerkuan') and *Hyparrenia rufa* ('puresongolion') have either decreased in abundance or disappeared. The members of the community agree that there has been a general disappearance of perennial grasses and increased bush encroachment, thereby forcing them to keep more goats (browsers) than before.

The Il Chamus are able to recognize the key perennial grass species such as *Cynodon plectostachyus,* *Cechrus ciliaris* ('lokorengok') and *Chloris gayana* ('ilperesi') which are preferred for milk production, annuals like *Tribulus terrestris* ('lameruaki') and key browse species, for example, *Indigofera spinosa* ('atula'), *Balanites aegyptiaca* and *Acacia tortilis*. The herders can identify poisonous plant species, for example, *Datura stramineum* ('ildule') and *Tribulus terrestris*, which cause indigestion and bloat in animals.

The Pokot and Il Chamus herders take several measures when they realize that changes in plant species composition have made the range unsuitable for livestock grazing (Table 5.1).

Nutritive value of forage

The nutritive value of pasture is assessed through observations made as soon as the animals retire from grazing. According to the two communities, the indicators of good quality pasture are:

- Green, loose and big dung
- Chewing cud
- High milk production
- Deep/heavy breathing by animal at night
- Aggressive bulls and increased mating frequency
- Smooth and shiny animal coat
- Rapid animal weight gain

Plant palatability

The Pokot and the Il Chamus assess forage palatability on the basis of plant indicators and animal cues, such as:

- Forage species abundance
- Time spent by feeding animal on a given species
- Feeding speed/vigour
- Animal selectivity - animals select only preferred forage species

The herders rely to a large extent on animal signals to identify preferred forage species. They are aware that the animals heavily utilize palatable species and, therefore, these species decrease faster in abundance than the unpalatable ones. Animals also feed with more vigour and spend more time on palatable species than they do on the unpalatable ones. The responses elicited by the poor quality of pasture and an encounter with undesirable plant species are presented in Table 5.2.

Table 5.1. Decisions made when change in botanical composition is undesirable

Decision	Respondents (%)	
	Pokot	Il Chamus
Changing direction of grazing	52	57
Scouting for and moving to better pastures	48	43

Table 5.2. Decisions made when unpalatable plant species are encountered

Decision	Respondents (%)	
	Pokot	Il Chamus
Changing direction of grazing	45	45
Scouting for and moving to better pastures	32	32
Burning the pasture	23	20

Soils

Soil taxonomy

The soil classification system used by the Pokot and Il Chamus is based largely on surface and subsurface characteristics, namely:

- Colour
- Texture
- Workability/consistency

In Pokot, soil names start with *nyon'gony* (soil) while among the Il Chamus the soil names start with *ngulupo*. This is followed by adjectives describing the type of soil in terms of the properties of its top layer. On the basis of colour, both communities are able to identify four types of soil:

- Black soil (*nyon'gony cho noroyon* in Pokot, *ngulupo narok* in Il Chamus)
- Red soil (*nyon'gony cho birech* in Pokot, *ngulupo nanyuki* in Il Chamus)
- Brown soil (*nyon'gony chemelaprech* in Pokot, *ngulupo ngiro* in Il Chamus)
- White soil (*nyon'gony cho relach* in Pokot, *naibor* in Il Chamus)

Using texture as the basis of description, they classify soil into three main types:

- Sandy soil (*ngayam* in Pokot, *sunyai* in Il Chamus)
- Stony soil (*nyon'gony ngokowon* in Pokot)
- Clay soil (*nyon'gony cho topulule* in Pokot, *ngulupo nasipa* in Il Chamus)
- Loamy soil (*ngulupo* in Il Chamus)

They further classify soil into sticky and non-sticky depending on its workability.

Soil suitability for grazing, crops and other uses

Soil suitability for grazing and crops is based on:

- Colour
- Texture
- Workability
- Water retention capacity
- Slope
- Depth

Based on their knowledge of soil classes, the communities are able decide the best use of a particular soil type (Table 5.3). The Pokot recognize red loamy soil as suitable for grazing and refer to it as producing 'sweet grass'. This type of soil is also known to have good water retention capacity and can therefore sustain the growth of grass into the dry season. Black clay soil, however, is described as muddy and sticky when wet and it cracks upon drying, thereby 'choking the grass'. The herders associate the gravelly soil (*angirimition*) with paralysis in kids.

The Pokot agree that deep loamy soils are the most suitable for cultivation. They also point out that soils on flat ground are preferred because they lose less water through surface runoff than soils on the slopes. While some regard black clay soil as the best for growing crops, associating the black colour with a lot of organic matter, most believe that either red or brown loamy soils are the best for crops since they are non-sticky and easy to cultivate. The herders are aware that sandy soils lose water and become dry faster than other soil types, and are therefore not good for crops. However, some have no idea about soil for crops. Red clay soil is used for plastering the houses *(go)* because of its stickiness.

The Il Chamus decide on the best use of a particular soil based on their knowledge of the characteristics of different classes of soil as defined by colour, texture and workability. The *ngulupo ngiro* and *ngulupo nanyuki*, meaning 'soils that like grass', or *ngulupo nacham ngichu*, meaning 'soils that like livestock', are preferred for livestock grazing. The majority (70% in this study) are aware that red/brown loamy soil is the best for grazing. Some think black clay soil is best while others either have no idea or consider all types of soil suitable for grazing. Many (40% in this study) regard brown and red loamy soils as the best for growing crops; they reason that, unlike black clay soil, brown and red loamy soils are light and non-sticky and therefore easy to cultivate. Others believe black clay soil is good for crops (Table 5.3). The herders agree that whereas sandy and loamy soils are suitable for millet, cowpeas and sorghum, maize does well in clay soils. They also use both red clay soil and soil from anthills for plastering houses *(nkaji)*.

Table 5.3. Soil types suitable for grazing and crops

Use	Soil type	Respondents (%)	
		Pokot	Il Chamus
Grazing	Red loamy	62	70
	No idea	26	17
	Black clay	10	13
	Grey	2	-
Crops	Red/brown loamy	38	40
	Black clay	32	35
	No idea	30	25

Soil fertility trend

The Pokot and the Il Chamus mostly evaluate soil fertility by observing the growing plants using the following indicators:

- Water retention capacity of the soil
- Soil depth
- Colour of the soil
- Plant vigour—size and colour of the leaves, and size of the fruits and seeds
- Forage production—plant density
- Crop yield
- Presence of certain plant species

They evaluate plant vigour by observing the size and colour of the leaves, and size of the fruits and seeds. Dark green and broad leaves, and big fruits and seeds are indicators of a fertile soil. Plant density is used to indicate forage production; high grass density, meaning high forage production, indicates a fertile soil. The reverse is true for a poor soil. Black and deep soils with high water retention capacity are considered to be fertile. The presence of certain plant species such as *Cynodon plectostachyus* ('longeri' in Il Chamus), *Amaranthus thunbergii* ('kaptanya' in Pokot, 'ilkamasi' in Il Chamus) and *Solanum nigrum* ('chepkration' in Pokot) is interpreted to mean fertile soil. *Berlaria titnensis* ('lobilibili' in Il Chamus), *Cyperus rotundus*, *Grewia bicolor* ('sitet' in Pokot) and striga species are indicative of poor soil. The Il Chamus also believe that the presence of certain other plants such as *Commelina bhengalensis* ('ngaiteteia') and *Indigofera* species ('atula') is an indication of fertile soil. The mitigation measures for declining fertility are presented in Table 5.4.

Table 5.4. Decisions made when soil fertility is declining

Type	Decision	Respondents (%)	
		Pokot	Il Chamus
Pastoralists	Moving to other pastures	100	100
Agropastoralists	Moving to virgin land	80	83
	Applying animal waste	20	17

Soil erosion

Some of the features identified by the Pokot as indicators of soil erosion include:

- Presence of rills and gullies
- Exposed stones
- Silting in pans, rivers and lakes
- A lot of dust in the air

The Il Chamus also recognize rills, gullies and high levels of dust in the air as indications of soil erosion. These communities do not usually make an effort to protect or conserve soil.

Water

Water availability and quantity

Sources of water for the Pokot and Il Chamus include rivers and streams (*lalua* in Pokot, *wuaso* in Il Chamus), pans (*loturo* in both languages), dams (*takar* in Pokot) and shallow wells (*akuicha* in Pokot, *lare* in Il Chamus). The Pokot also have access to boreholes and the Il Chamus to Lake Baringo *(mparingo)*. High variability in rainfall makes the amount of expected rain uncertain, with most rivers and streams in the region being seasonal. Surface water is only available when it rains and for a short period afterwards. Therefore water supply in these areas is limited in time and space. According to the two communities, three aspects mainly indicate the availability of water:

- The presence of big, tall and green trees
- Evergreen vegetation
- The presence of certain plants such as *Acacia xanthophloea, Ficus thornningi* ('simotwo' in Pokot, 'iln'gaboli' in Il Chamus) and evergreen *Tamarindus indica* ('oron' in Pokot), which are indicators of a high water table

Because of the scarcity of water in the Pokot and Il Chamus territories, the available water is closely monitored and managed for livestock and human consumption. The quantity of water available is monitored at source by regular assessment of:

- Level/depth
- Volume
- Extent of silting

A long stick regularly dipped into the river, dam, pan or waterhole is used to monitor the depth of water and silt. Assessing the extent of exposure of the riverbed helps assess the volume of water; silting in pans and dams is another way of monitoring the quantity of water available. The communities also make use of certain representative stones on the riverbed whose level of exposure helps to monitor both the volume of flow and the depth of water. Decisions made by stockowners when they realize water is not enough for their herds are presented in Table 5.5.

Water quality

The Pokot and the Il Chamus assess the quality of water on the basis of:

- Colour
- Turbidity
- Odour
- Taste
- Temperature
- Infestation by parasites and insect larvae

Most use unpleasant colour, bad odour, mud, bad taste and infestation by parasites such as leeches (*ilmolok* in Il Chamus), and insect larvae as indicators of bad water both for livestock and human consumption. Some of the Pokot, however, argue that there is no bad water

Table 5.5. Decisions made when water is inadequate

Decision	Respondents (%)	
	Pokot	Il Chamus
Digging more wells/water holes, looking for other sources or desilting wells	70	64
Splitting the herds	30	36

for livestock, even though they also support the idea that unpleasant odour, greenish/bluish colour, and the presence of parasites and insect larvae in water are indicators of bad quality. While cattle prefer salty and warm water, goats are very selective and take time to accept salty water.

The Il Chamus contend that livestock prefer dirty brown water, as found in rivers during the rainy season. They refer to this type of water, which they claim to contain salt *(mbolyei)*, as 'red water' *(ngare nanyuki)*. This salty water is said to be good for livestock and is described as 'water that likes livestock' *(ngare ngacham ngichu)*.

The herders believe that for human consumption, clean, clear, odourless, sweet, cold water is preferred. Taste is considered a critical attribute of water quality. Depending on taste, the Pokot classify water into three main categories:

- Salty/brackish water *(bou cho bo bartin)*
- Sour water *(bou cho mindirile)*
- Sweet water *(bou cho anyine)*

The Pokot believe that *bou cho anyine* gives livestock good health and all livestock species prefer drinking it from the dam *(takar)*. In contrast, *bou cho mindirile* is regarded as 'bad water', and is not preferred by animals. It is widely agreed in the community that salty, warm and brown water as found in rivers during floods is highly preferred by livestock; during the rainy season, river water is believed to carry a lot of minerals eroded upstream and is therefore healthy for the animals. The pastoralists make several decisions when they realize that water is of poor quality (Table 5.6). For human consumption, they purify dirty water using *Maerua subcordata* (*chepliswo* in Pokot, *lamayoki* in Il Chamus). The roots are used to stir turbid water, which is then allowed to settle, thereby obtaining clean and clear drinking water. Sometimes grass is used to sieve turbid water.

Water distribution

The indicators of poor distribution of water, according to the Pokot and the Il Chamus, are:

- Distance to water source
- Distribution of people and their livestock in relation to water source
- Condition of pasture surrounding a water source

The pastoralists dig more water holes when they realize that water is poorly distributed.

Range condition and trend

The Pokot and the Il Chamus regard animal body condition, productivity and health as perfect reflections of the range condition. They evaluate range condition on the basis of overall animal performance (rumen-fill, coat condition, milk production, weight gain, animal health and mating frequency) and ecological factors (forage availability, distance to water, disease incidences, parasite infestation and security). However, the suitability of range for grazing is evaluated on the basis of ecological factors only.

While they monitor the trend of range condition by assessing animal performance and ecological factors, most of the pastoralists use animal performance as the

Table 5.6. Decisions made when water is bad

Decision	Respondents (%)	
	Pokot	Il Chamus
Looking for other sources	52	45
Digging fresh wells/waterholes	48	55

primary factor in evaluating range condition (Table 5.7). They regard rumen-fill as a decisive feature indicating whether pasture is overgrazed or not. As long as the animals still show a full rumen, they do not consider pasture overgrazed.

Even though overall animal performance is ranked first as an indicator in the evaluation of range condition among the Pokot, rumen-fill comes first as an indicator of whether pasture is overgrazed or not; until the time a considerable reduction in rumen-fill is observed, pasture is not declared overgrazed. However, the decision to move from a poor to a better pasture is always arrived at after considering both animal performance in the current pasture and ecological factors in the next pasture. Good animal performance and favourable ecological conditions are regarded as indicative of a good range, the reverse being true for a poor range. The pastoralists use changes observed in the attributes shown in Table 5.7 to monitor range condition trend. An improvement in animal performance, increase in forage production, reduced distance to water, reduced disease incidences, and reduced parasite infestations are indicators of improved range condition. The reverse is true for a downward trend in range condition. The Pokot argue that there is no excellent range, since during the wet season when there is plenty of forage, water, milk and increased birth rates, there are also high incidences of disease, heavy infestation of parasites and many predators.

According to the Il Chamus, a full rumen is a sign of animal satisfaction and a good range. Similarly, an increase in milk production, rapid weight gain, abundance of forage, and water availability indicate an upward trend in range condition. When forage is not enough, an animal will show signs of dissatisfaction—the animal will not be willing to return home early, and once home, will want to graze at night. A drop in milk production is indicative of both poor range and poor health. Animal unrest during milking and kicking of the calf also indicate dissatisfaction and little milk. The herders also agree that an unhealthy herd implies poor range. When biting flies and other parasites are present the animals will be restless and scratching constantly; this causes a drop in milk production. The herders also know that stony, slippery, steep and rugged areas are only accessible to goats and not to cattle and sheep, and that a good range is one that is accessible to livestock. Predators like lions and leopards are a security threat and areas in which they are present are therefore avoided. The range suitability ratings were given by both communities as good, fair and poor, depending on the status of ecological factors (Table 5.8).

Table 5.7. Attributes and ecological factors considered in assessing range condition and suitability for grazing, ranked in order of importance

Decision	Attributes		Suitability for grazing	
	Pokot	Il Chamus	Pokot	Il Chamus
Animal performance	1	1	-	-
Forage availability	2	2	1	2
Plant vigour	-	2	-	-
Distance to water	3	3	2	1
Disease incidences/parasite infestation	4	4	3	3
Security	5	5	4	4
Topography/accessibility	-	5	-	4

Table 5.8. Ecological rating of range suitability for livestock grazing by the Pokot

Condition	Ecological attributes
Good	Adequate forage, short distance to water, and rare disease incidences
Fair	Adequate forage, short distance to water, and many disease incidences
Poor	Inadequate forage, long distance to water/lack of water, many disease incidences, and many predators

The pastoralists do not agree on the measures to take when pasture is poor/overgrazed (Table 5.9). Some scout for and move to better pastures; others burn the pasture to regenerate growth and kill parasites such as fleas, ticks and lice; and others split their herds to spread the grazing pressure on the range.

Animals

Animal performance

Both the Pokot and the Il Chamus monitor animal performance through regular assessment of:

- Body condition - full rumen, coat condition and weight gain
- Productivity - milk production and birth rate/mating frequency
- Health - disease incidences and parasite infestation

Good animal performance is reflected by good body condition, high productivity and good health. The factors considered by the two communities when assessing animal performance are presented in Table 5.10.

While milk production and mating frequency/birth rate are the main indicators of productivity, animal health is specifically evaluated on the basis of disease incidence and parasite infestation. The pastoralists relate good animal performance to good range condition; improvement in overall animal performance is perceived to be the result of an upward trend in range condition, and the reverse is true for a downward trend.

When the body condition of an animal is poor and productivity is low due to disease, most pastoralists treat the animal; if not, the herders scout for and move to better pastures. Others scout for and move to a better pasture immediately they notice that animal performance is poor.

Animal breeding

Breeding management among the pastoral Pokot and Il Chamus entails selection and (or) culling of breeding animals while maintaining the best male to female ratio. The bull to cow ratio among animals kept by the Pokot is normally 1:40 whilethat for animals kept by the Il Chamus is 1:50. The buck to doe ratio is 1:25 and 1:20, respectively. While all the females are allowed to breed, male animals are selected according to specific criteria, namely (in order of importance):

- Body frame/size
- Milk production of their mothers and daughters
- Strength of their calves
- Temperament
- Hide markings and colour

Table 5.9. Decisions made when pasture is poor/overgrazed

Decision	Respondents (%)	
	Pokot	Il Chamus
Scouting for and moving to better pastures	56	64
Burning pasture	28	28
Splitting herds	16	8

Table 5.10. Attributes used in evaluating livestock performance ranked (in order of importance)

Attribute	Rank	
	Pokot	Il Chamus
Rumen-fill	1	1
Coat condition	2	2
Milk production	3	3
Weight gain	4	3
Animal health	5	4
Mating frequency/birth rate	5	5

Pastoralists usually focus on the fertility of female animals as opposed to other qualities. However, the herders argue that until mating it is not possible to tell a fertile animal from an infertile one. The following observations are regarded as signs of infertility in female animals:

- Delayed conception—if a heifer conceives long after all the age mates
- Low mating frequency
- Irregular heats episodes

The Pokot control animal mating only when a male is thought to have bad traits. Such an animal is castrated. The Il Chamus usually control mating during the dry season when there is lack of forage. Bulls are separated from cows; a piece of skin called *ljoni* is tied around the reproductive organs of the rams to block mating; and goats naturally abstain from mating during drought. Both communities castrate animals after 2 to 3 years of service to avoid inbreeding. Castrated bulls and sterile cows are usually fattened and exchanged for heifers, while the castrated and infertile small stock are slaughtered to provide meat for the family. Castration is usually done to coincide with the onset of rains to ensure enough forage for the castrates.

Animal health

Through their ethnoveterinary systems, the Pokot and the Il Chamus can prevent and treat specific animal diseases. They make either one or more of the following observations to arrive at a conclusion that an animal is sick:

- Rough coat—standing hair
- Lack of appetite
- Coughing
- Frequent lying down
- Failure to chew cud
- Abnormal discharge from the eyes
- Lameness
- Running nose
- Drooping head
- Excess secretion of saliva

In the Pokot community, when an animal shows symptoms of an unknown disease *(tongunot)*, traditional herbs are administered on a trial-and-error basis. However, the herders are able to differentiate a disease from a mere condition caused by feed poisoning. According to them, foaming from the mouth and a swollen rumen indicate a condition caused by feeding poisonous plants. The most prevalent diseases in the area, according to the herders, are foot-and-mouth *(nguarian),* East Coast fever *(tilis)* and black quarter *(lukuricha)*. They had no cure for *nguarian* and *tilis* until the introduction of modern veterinary medicine. Some of the herbal remedies used by the herders are given in Appendix 1. To treat *lukuricha*, the leaves and bark of *Boscia salicifolia* ('likwon') and *Zanthoxylum chalybeum* ('songowow') are pounded and soaked in water before being orally administered to a sick animal. For fractured and dislocated limbs, rafts *(ropa)* made from the bark of *Acacia* trees are tied around the fracture *(kiil)* to keep the bones in place until they heal.

Although modern health care exists alongside the traditional medicine, the Il Chamus dichotomize illnesses into those that are handled best by traditional and by modern medicine therapy. However, the decision on whether to use the modern or traditional treatment depends on:

- Accessibility to medicine
- Cost involved
- Past experience with a similar illness

Pharmaceutical drugs are used only when they are affordable or readily available, otherwise herbal remedies are the most commonly used because they are cheap. The most common disease in Il Chamus territory is trypanosomosis *(cheptikon)*, transmitted by the tsetse fly *(lojon'goni)*. Treatment of trypanosomiasis, which is a wasting disease in cattle, involves administering a concoction of boiled roots of *lauraki* and *lemunyi* (scientific names not identified), and bleeding the affected animal at the jugular vein to drain 'bad blood'. For diarrhoea, which is common in sheep, a concoction of boiled roots of *Salvadora persica* is administered orally; and for contagious caprine pleuropneumonia *(ikipei)*, a concoction of crushed leaves of *sukuroi* (scientific name not identified) soaked in water overnight and mixed with soda ash *(sodium sequicarbonate)* is orally given to the sick animal.

The Il Chamus believe that the prevalence of diseases, presence of disease vectors, and heavy infestation by parasites such as fleas, ticks and lice are indicative of a poor range. The response from the herders is usually to scout for better pastures and escape from such risks.

Animal/land interactions

The success of the pastoralists stems from well-adapted principles and strategies designed to overcome the harsh and variable conditions dominant in arid areas. These adaptive strategies include:

- Keeping mixed-species herds
- Herd splitting, based on class and species
- Rotational grazing—division of the range into wet and dry season pastures
- Pasture deferral
- Feed supplementation (*an'gich* in Il Chamus)
- Polygamy

Keeping mixed-species herds is used to match the diversity of plant species; cattle are grazers while goats and camels are browsers that utilize browse at different heights. The Pokot also use this strategy as insurance against droughts; goats and camels are more drought resistant than cattle, and are therefore able to survive prolonged droughts.

Herders split and manage their livestock as different herding units based on animal species and class because each species and class has its own herding requirements. The herding strategy practised is carefully designed to ease pressure on the pastures around the homesteads and also to optimize the use of different ecological niches. Their livestock herds are divided into home-based herds, locally called *lepon* by the Pokot and *itelekwa* by the Il Chamus, and satellite or nomadic herds, known as *sorok* (Pokot) or *edura* (Il Chamus).

In the Pokot grazing system, the home-based herds, which include the goats, calves *(lukuyan)*, lactating cows *(oboe)*, and sick animals, are left at home during the dry season grazing movements. Besides being the main source of meat for members of the family who remain at home, the small stock have lower dietary requirements than cattle do. The small stock can therefore survive on the usually over-utilized pastures around the homestead. However, the calves and sick animals are restricted to home pastures because they are not able to walk long distances while lactating cows are left behind to provide milk for the children, women, the sick and the elderly. The *lepon* is managed by young girls between the ages of 7 and 18 years *(tibin)*. The satellite or away herd is usually composed of bulls *(kiruk)*, dry animals *(lukuyot)*, heifers *(maser)* and castrates/steers *(ein)*. Managing the satellite herd involves trekking long distances and systematic grazing movements between different pastures. This is the responsibility of uncircumcised boys between the ages of 10 and 15 years *(karachin)* and circumcised boys.

The grazing pattern and mobility among the Pokot is dependent on the location and distance between dry season and wet season grazing areas. Dry season grazing areas are perennial pastures with permanent water sources, as found on the hills. The pastoralists move to these areas as soon as the sources of surface water in the lowlands dry up and the forage is exhausted (June and January). The lowland areas usually provide wet season grazing for livestock, not far from the main camps *(kau)*. They are often overutilized and mostly dominated by annual grasses. The Pokots refer to annuals as 'weak grass', indicating that the annual grasses only last a few weeks after the onset of rains, and that such species cannot support livestock during drought. Movements from the dry season grazing areas to the wet season areas usually occur in March and October. Grazing management and control therefore involves livestock movements between the dry season *(kimei)* and wet season *(ten'get)* pastures and communal deferral *(suschokiripe)* of some pastures as insurance against drought.

Among the Pokot certain pastures, mostly on the hills, are used as traditional grazing reserves. These areas, locally referred to as *karantile*, are closed on orders from the elders *(kipsus)* who are responsible for enforcing the regulations related to the use and management of grass for drought *(suschopkemei)*. Also forming part of the management of the *karantile* are boys assigned to guard these reserves (*kirosin)*. These boys answer directly to the *kipsus* and report any herder who violates the regulations regarding the use of the deferred pastures.

The Pokot also practise feed supplementation especially during droughts when forage is inadequate. They lop trees such as *Balanites* ('tuyunwo') and *Acacia* species, collect *Acacia tortilis* pods, and cut grasses such as *Eragrostis superba* and *Cenchrus ciliaris* ('chelwowis') mostly for the home-based herds.

Pokot men marry many wives to provide herding labour. The wives of one man have their homesteads situated in different ecological niches to spread risk, expand grazing ground and achieve optimum use of the grazing resource.

The Il Chamus keep cattle, sheep and goats in the ratio of 3:5:2. This kind of herd structure ensures optimum use of different forms of plant life. Different species serve different purposes. While cattle are kept mainly for milk among other important social, cultural and economic reasons, goats and sheep are the main sources of meat for pastoral households. Mixed-species herds are also used as a risk management strategy; goats are known for their high fecundity and resistance to drought as compared to both cattle and sheep.

The nomadic herd of the Il Chamus is composed of bulls *(loingoni)*, dry cows *(konanemelopi)* and heifers *(ndawa potoro)*. The home-based herd is composed of calves *(ndawa kunyinyi)*, small stock, sick animals, lactating cows *(kelepi)* and one bull *(loingok)*. Unmarried boys of 15 years of age and above *(el muran)* are responsible for the nomadic herds. During drought *(ngolong)* the Il Chamus, just like the Pokot, make several movements with the nomadic herds across the dry season grazing reserves, sometimes as far as 50 km and beyond. Boys of 10 years and below *(el chukut)* herd the home-based animals. These herds usually move within a radius of a few kilometres from the main camps to avoid overgrazing. An area around the main camps covering up to several square metres is reserved for grazing calves, lambs and kids. They make seasonal grazing movements to ensure that different ecological niches are utilized. The grazing pattern in Il Chamus territory is divided between those areas where dry season stock movements centre on swampy *(ilmanie)* areas, and those regions where dry season movements are to the hills at the base of the Laikipia escarpment. The Il Chamus, just like the Pokot, move to dry grazing areas during the months of June and January, and return to the wet grazing areas in March and October. Their grazing pattern is influenced by:

- Forage availability
- Water availability
- Stock diseases
- Settlement patterns

During the wet season *(lari)*, grazing is limited to the areas around the homesteads *(enkang)*. The traditional pastures reserved and used during drought when there is inadequate forage are referred to as *karantili*. Deferral (*kekeringop ngujit)* is enforced by a council of elders called *elbayeni oripngujit*, who levy heavy fines on herders who defy the rules and regulations governing the use of deferred pastures.

When livestock *bomas* become heavily infested with parasites, they have to be shifted elsewhere. Such strategies also ensure optimum use of different ecological niches of the range.

Just like the Pokot, the Il Chamus supplement the diet of their animals especially during droughts. The feed supplements include:

- Lopped leaves of *Balanites* species
- Leaves, pods and flowers of *A. tortilis*
- Leaves of *Ficus* species
- *Cynodon plectostachyus*

Institutional set-up

The institutional set-up of the Pokot is one in which the household heads/elders take a central part in decision making. Women, children and unmarried men may only report certain observations, but stay at the periphery of the process of decision making. Children are mostly responsible for herding while women, apart from performing other domestic chores, are responsible for milking, taking care of young stock, treating small stock, and fetching forage for young stock and sick animals kept at the homestead. The reasons surrounding the decisions to move across grazing areas is usually entrusted to the herdsboys *(muren)* and the owners of the stock. The head of the household or the herdsboy does the ecological scouting *(karkara)* for pasture, but the decision to move is the sole responsibility of the head of the household. Decisions are always made at the household level except in the case of insecurity, when communal consent is necessary.

In the Il Chamus community, division of labour within the family is largely on the basis of sex and age. In livestock production, a woman's role, apart from doing virtually all the daily domestic chores, is milking the animals and managing the *itelekwa* herd. The *el moran* are responsible for herding the *edura* herd and also reporting any abnormal observation in range condition and animal performance. The decision on herd management is traditionally a responsibility of the head of the household who is a man (women household heads were not easily identifiable). If the herders realize that pasture is poor/overgrazed, the *el moran* scout for better grazing, an exercise they call *kebon'gatan ngujit*. The head of the household or elderly persons in the family decide on the next move after the scouts have reported their observations. Decision making, just as in the neighbouring Pokot community, is done at household level.

6. Range assessment and monitoring in Tanzania:

The case of the Barabaig and Maasai

The Barabaig and the Maasai share a common home range in the East African Rift Valley. The Maasai are found in Monduli District, Arusha Region, which stretches from the Kenya-Tanzania border, whereas the Barabaig are further south in Hanang District, Manyara Region. Though known to be traditional enemies, they form the main pastoral community of Tanzania, and the two communities have a lot in common in livestock and range management practices.

Climate

Weather forecasting

The Barabaig use clouds, temperature and winds to determine the onset of the rainy season. Heavy and black clouds, humid conditions and easterly or westerly winds are indicators of the onset of long or short rains. The weather is so important to the Barabaig that it is part of the greetings when two people meet. Apart from family matters, the Barabaig ask one another about important events related to rain, the health of animals, livestock auction prices, water and the stage of pasture development. These events change with the four Barabaig seasons, namely: early rains *(domeda)* in November to December; long rains *(muweda)* in February to April; cold season *(meahoda)* in May to July; and dry season *(geaida)* in August to November. Through the greetings, one person finds out the state of the other person's grazing areas. This helps the person decide whether to shift to the new area or not.

The Maasai also have the ability to forecast weather trends. They do this by observing the position of the stars, atmospheric temperatures and rainfall patterns. Many elderly men and the warrior *(morani)* age group share this knowledge. Sunny and hot conditions forecast heavy rains, while cloudy and cold conditions forecast little or no rains at all.

The east to west positioning of the group stars forecast the onset or end of the rainy season. The stars are positioned in the east during the dry season and in the west before the start of the rains. If no stars are sighted and the rains are sporadic, crops and pasture wither fast. The sighting of stars leads to good crops and pasture establishment even if weather fluctuations develop.

Many birds inhabit wild caves. When they start flying and circling around the caves they also signal the approach of the rainy season.

The rainfall regime is well patterned. If rains do not persist up to early April, a minor drought is predicted. This would result in animals being in poor condition. Conversely, good rains extending past the month of April are an indication of increased biomass production, and animals are expected to be in good condition. The Maasai also believe that the occurrence of drought is cyclical. In Longido area it is expected to occur once every 10 years. In the recent past serious droughts have, in fact, been experienced in this area in 1977, 1987 and 1997.

Plant and animal indicators

According to the Barabaig, the flowering of some plants (e.g. *Commiphora species* ('ishipone')) indicates the onset of the rainy season. The singing of some birds, e.g. ostriches and guinea fowls *(daemg'anda)*, and croaking of toads *(udaghambagajamu)* is also an indication of the onset of rains.

In the past, the emigration of game animals and birds in the area was used as an indicator of the onset of the rainy season. Also used is the increase in water levels in wells and springs and movement of a group of stars *(jaega)*. The Barabaig regard the establishment of *Oxagonum* species ('mbigili') as a sign of poor/low rains. Fast establishment and subsequent seeding and seed maturation is a sign of a poor rainy season. A good rainy season, however, is predicted by an outbreak of armyworms.

Among the Maasai, the extent of flowering in vegetation, especially of *Acacia* trees, reflects the amount of rainfall received and relates to the quantity of pods that would be produced in the season. Goats relish pods during the dry season and they are a valuable source of protein supplementation. Good flowering therefore indicates a good season that leads to animals in good condition.

Soils

Soil classification

The Barabaig and the Maasai classify soils on the basis of colour. The Barabaig identify the following soils on their range:

- Black
- Red
- White
- Dark
- Dark brown

These soils are found on plains *(mbugas)*, plateau, high areas and flat areas (Table 6.1). The colour of the soil informs the livestock keeper on the nature of drainage, organic matter content and productivity level.

The Maasai distinguish two soil types within their home range, closely resembling those at the soil series level. They are the red sandy loams *(orpumi/osanyai)* and black sandy loams *(engusero)*. These soils are associated with certain physical features, such as foothills *(orpumi/osanyai)* and lowlands *(engusero)* (Table 6.2). The colour of the soil depends on organic matter content of the soil.

Table 6.1. Classification of soils and their occurrence by the Barabaig

Soil class (based on colour)	Location on catena
Black *(ashangwajanda)*	Plains *(mbugas)*
Red *(segedarire)*	Plateau (flat)
White *(eshish)*	High and flat areas
Brown *(gwanyeideayi)*	High areas
Dark brown *(dushang'wajanda)*	Flat areas

Table 6.2. Classification of soils and their occurrence by the Maasai

Soil class (based on colour)	Location on catena
Red sandy loams	Foothills
Black sandy loams	Lowlands

Soil fertility

The attributes the Barabaig use to assess the fertility of soil are shown in Table 6.3. They (47% in this study) evaluate soil fertility by observing the establishment of pastures and crops. High fertility soils exhibit tall and healthy plant growth, dense cover, dark green vegetation and fast plant regeneration after a grazing cycle. Individual plants exhibit high degrees of producing suckers/tillers, and greenness of the vegetation extends well into the dry season. Some of the Barabaig (31% in this study) observe the health of animals to establish the fertility status of soils, while others use plant indicators such as the presence of *Cynodon dactylon* ('ngarojika'), *Acacia tortilis* ('rabanghaed') and a certain shrub ('sinida').

Sparse vegetation, paleness of vegetation and low regeneration ability are an indication of soils with low fertility. Such soils produce inadequate grazing and the encroachment of low feed value species such as *Aristida* species and *Chloris virgata* ('haroroid') is common.

Soil uses

Different types of soils are used in different ways to sustain the Barabaig and Maasai range and livestock productivity and subsequently their own lives over space and time. The suitability of soils for grazing and crop production is based on:

- Existing species of grasses and trees
- Distance from crop fields
- Distance from water—not more than a 3-hour grazing distance
- Whether previously burnt

All soils generally provide some form of pasture for grazing. Another major use of soil is crop production by the Barabaig agropastoralists. The black and dark brown soils are suitable for sunflower, beans, onions and maize while the red soils are suitable for maize, finger millet and sorghums. Red soils are also used for building residential houses/livestock corrals, while white soils are used to hang beehives.

Vegetation

Vegetation characterization

The pastoral Barabaig and Maasai have the ability to classify different vegetation types based on physiognomic characteristics. The knowledge enables them to effectively plan for the use of the existing vegetation by different classes of animals. They also classify vegetation on the basis of forage availability to livestock. Since forage availability is dependent on the type of soil and its inherent fertility status, the Barabaig have three types of vegetation associations:

- *Balanites-Acacia* ('sawachanda-nyashochanda') and *Pennisetum-Hyparrhenia* ('gharosk-sabaled') associations on mountain ranges
- *Commiphora-Acacia* ('ishopone-barjomoda') and *Eragrostis-Aristida* ('nyatka-hararoid') associations on *mbugas* ('tindiga')
- *Acacia* and *Cenchrus-Pennisetum* associations on the plateau

According to the Maasai, there are two vegetation associations based on soil types and physical features. One is an *Acacia drepanolobium, A. nilotica* ('olklorit'), *Pennisetum mezianum* ('asangai') and *Setaria* species association on the foothills. The second is a *Balanites aegyptiaca* ('ngosawai'), *A. robust* ('olera'), *Grewia*

Table 6.3. Evaluation of soil fertility by the Barabaig

Attribute	Respondents (%)
Establishment of pastures and crops	47
Animal health	31
Plant indicators	22

bicola ('ositeti'), *Cynodon plectostachyus* and *Setaria* species association on lowlands.

Quantity of pasture

Both the Barabaig and the Maasai assess the potential of a grazing area based on:

- Botanical composition
- Plant vigour
- Biomass
- Cover
- Growth form of the grazing areas

Once the head of the household reaches a new pasture, he looks at the height and type of plant species in the area. Particular emphasis is placed on open grazing with well-distributed tree layers, interspersed with different grass layers. He also looks at the density of the plants. The best density of the grass layer is tall to medium tall; this makes good grazing. After introducing the animals, the vigour, biomass and cover attributes are monitored through animal performance (gut-fill, milk production and productivity of grass species), height, greenness and tillering ability. The woody species are monitored by the degree of sprouting, and the production of new leaves and pods. After grazing for some days, the head of the household assesses the productivity of the pasture by monitoring animal performance. On the basis of animal performance, especially milk production, the head of the household moves the animals to new pastures when the quantity of grazing declines. Most Barabaig use stubble biomass and botanical composition (78% and 77%, respectively, in this study) to determine grazing pressure. Others use biomass, vigour and cover (Table 6.4).

The Maasai are aware that different livestock species browse shrubs and trees at a certain height. Beyond this height the branches of the trees and shrubs are harvested by chopping. The cover of different plants is observed in terms of:

- Tussock size
- Spreading ability through runners
- Seed production

The herders look for an increase in the area covered by the base of the plant, runners producing vegetative materials at short distances from the mother plant and germination of some seeds from the mother plant within the area covering the entire soil surface at peak season. For woody plants the Maasai observe pod production capacity. Early in the season, herdsboys observe the grasses, trees and shrubs that sprout with the onset of the rains. The presence of a variety of plant species (grasses and legumes) is an ideal grazing site for the Maasai.

Quality of pasture

The Barabaig and Maasai pastoralists assess the potential of a grazing area in terms of its quality—nutritive value and palatability. These methods are similar to rapid appraisal techniques and have been used for many generations by the pastoralists and have sustained their production systems. However, as they are at present, these techniques need to be improved and streamlined into conventional science.

Once livestock have entered a new grazing area, the herdsmen monitor the quality of grazing by observing the immediate responses of the animals to the pasture.

Table 6.4. Attributes used by the Barabaig to determine grazing pressure

Attribute	Respondents (%)
Stubble biomass	78
Vigour	59
Biomass	67
Cover	60
Botanical composition	77

The animal factors observed include:

- Gut-fill
- Animal activities in the morning before they are taken to pastures
- Milk production
- Smoothness of faeces

In the long term, the quality of grazing is monitored in terms of:

- Number of heifers that come on heat for the first time
- Libido in bulls
- Body condition of dry cows and calves

A change in calving intervals and the number of calves dropped on the pasture indicate the long-term quality of grazing.

During the course of grazing, plants that are grazed first are usually palatable (also referred to as desirable or decreaser plants), such as *Cenchrus ciliaris* ('erikari' in Maa), *Pennisetum mezianum* ('eruke' in Maa) and *Digitaria microphylla* ('engapuru' in Maa). Over time, the low quality (undesirable or increaser) plants, which include herbaceous and woody plants, increase. Animals rush for palatable plant species and resist any attempts to move them out. The palatable species are grazed intensively (close to the ground).

Water

Sources of water

The Barabaig and the Maasai identify water sources, their exploitation and their uses to enhance the pastoralists' ability to obtain suitable water for both livestock and human consumption. Water is obtained from one or other of the following, depending on season or availability:

- Rivers and streams (natural and seasonal)
- Natural springs (seasonal)
- Shallow wells (man-made)
- Lakes (natural)
- Springs—the main source of water
- Boreholes
- Piped water (man-made)
- Valley dams (natural)

Sources of water vary depending on the location of the village and topography.

Quality of water

The Barabaig and Maasai communities monitor the quality of water for human consumption by observing:

- Colour
- Smell
- Presence of foreign materials
- Weight of water

The Maasai have three quality classes:

- Clean water from the springs
- Water that tastes good
- Water that is polluted

In both communities, water that is clear in colour, with no smell and devoid of debris is suitable for human consumption. When the quality of water is unsuitable for human consumption, the Barabaig add ash to the water and let it stand overnight. On the next day the clear water at the top is removed leaving the dirt at the bottom. The Barabaig observe the animals to monitor the quality of water for livestock consumption. If the animals do not fall sick within a few days of drinking the water, the quality is said to be satisfactory.

Quantity of water

The Barabaig assess and monitor the quantity of water by observing the different sources in relation to the population of livestock, while the Maasai observe the degree of flow from springs and the number of animals that can be watered per day and per season. For shallow wells the Barabaig look at:

- Degree of flow
- Depth of the well
- Degree of congestion of the animals at the wells
- Number of holes that discharge water in the well

A good well should not dry out. It should be available all the year round. For rivers and streams, the following are observed:

- Rate of flow
- Size of the dam
- Area of the catchments

Continuous flow is a good indication of the quantity of water available. In addition, through experience, the Barabaig can make an eye estimate of the extent to which the dam is usually filled in bad and good years and the rate of water consumption, matching the number of livestock with the quantity and amount of precipitation received.

The decisions made by the Barabaig when the quantity of water decreases are shown in Table 6.5. Most of the herders (69% in this study) move livestock to other water sources when water is inadequate at the grazing areas. Others meet the water quantity requirements by digging shallow wells, ferrying water from distant areas and separating water sources for human use from those for livestock.

Distribution of water

The Barabaig monitor the distribution of water by assessing the sources of water in the dry and wet seasons. As the dry season sets in, the temporary water sources dry out resulting in poor distribution. Consequently, in the dry season the only water sources available are lakes and dams. Therefore livestock keepers have to trek long distances to water their livestock. Under these circumstances watering is only possible every other day. The distance to water in the dry season varies depending on the location of the villages. The range is between 2 and 3 km in Mureru and 7 and 10 km in Gehababieg villages. In bad years livestock keepers are forced to move to other areas/districts like Kondoa where there are permanent water sources and pastures. In the wet season the sources of water include lakes, natural springs, pools and seasonal streams, and therefore water is well distributed.

In the Maasai grazing areas water is generally poorly distributed. Thus, individuals have made efforts to develop private waterholes in temporary grazing areas. The major water sources for Longido Division are the natural springs, small dams and piped water.

Availability of water

The Barabaig monitor the availability of water by assessing the sources of water in the dry and wet seasons. In the rainy season, the pastoralists observe the extent of the individual lakes, and, based on their experience, determine whether the amount of water held in the lakes would be sufficient for a certain period of the season. In the dry season they observe the extent of the remaining area of the lake (water source), and can determine with some certainty the degree of water sufficiency for the season.

Generally the Barabaig and the Maasai recognize the availability of water in an area by the presence of green grass during the dry season, soil moisture in the topsoil, and presence of some indicator plants, e.g. *Ficus* species (‘mkuyu’ in Maa) and *A. tortilis*. In addition, the presence of some butterflies and of natural springs, as shown by the holes dug by elephants, is indicative of the presence of water.

Table 6.5. Decisions made by the Barabaig when the quantity of water decreases

Attribute	Respondents (%)
Shift to other water sources	69
Dig shallow wells	14
Ferry water to livestock	14
Separate livestock water sources from those of the people	3

Animals

Barabaig and Maasai pastoralists use several indigenous techniques to assess and monitor herd performance. These techniques help them to identify areas for intervention. The problem associated with the use of these techniques is that they are subjective and need the experience of herdsmen to apply them effectively.

Animal productivity

The pastoralists assess the productivity of an adult animal by observing:

- Hair coat
- Feeding behaviour
- Appearance

The hair coat of a healthy animal is usually smooth and shiny and the animal is usually a good feeder and is appealing to the eye. For young animals, livestock keepers look at the size of the calves at birth. The calf is usually large and continues exhibiting such features throughout the yearling stages (for both male and female calves). It is usually long, strong, lean, with a wide frame (for heifers), and has a small head, a small hump pointed backwards, and exhibits high libido (for bull calves). For a lactating cow, it usually produces a lot of milk, has an udder with good conformation, has a complete number of teats, is appealing in appearance, has a well-built body, is very active, and comes from a reputable line. The bull is usually good looking and starts breeding at an early age, is from a reputable line, is active, has a pendulous scrotum, has two testicles, has a good appetite to ensure continued body build-up, and has no parents in the herd. For castrates, the body must be large, well structured and fast growing.

Physical condition of animals

According to the pastoralists, the physical condition of animals is assessed by generally observing:

- Hair colour
- Finish
- Neck muscles

Usually a good body condition has a shiny hair colour, well-structured body finish, and a short and stout neck. For cows the pastoralists observe the udder, legs and voluntary weaning of calves. A large, full and extended udder, strong legs, and voluntary suckling of calves exhibit good body condition in cows. Bulls and steers in good condition are aggressive, alert, wholesome and attractive. Any departure from the attributes of good body condition is usually treated as bad body condition. This is manifested in emaciation of the body, rough hair coat, dull appearance, protruding hump and horns, sharp horns at an early age, enlarged external lymph nodes, deformities (legs, eyes and limbs), poor appetite, low live weight and poor milk production.

Animal health

The Barabaig and the Maasai assess the health of their animals by observing:

- Appetite
- Feeding behaviour
- Hair density on the skin
- Animal activities
- Milk production
- Strength of the animal
- Libido

A healthy animal has a good appetite, feeds well, has shiny skin hair covering the entire body, is active, has high milk production, is well built, and has a high libido. The opposite is true for an unhealthy animal. Enlarged lymph nodes are also used to identify unhealthy animals. They lag behind other animals; they have dry muzzles, diarrhoea, anorexia leading to emaciation, laboured breathing and are unthrifty. Unhealthy animals also exhibit inflammations, coughing, fever, wounds, blood stained urine, and hard faeces that contains fibrous materials.

The combined knowledge of plants and animals has placed the pastoralists in a position to manage livestock well. They are able to diagnose diseases and treat them. For example, to treat a cough, plant liquor is administered through the mouth of the sick animal

Table 6.6. Decisions made on diagnosing sick animals by the Barabaig

Attribute	Respondents (%)
Treating sick animals using traditional methods	47
Seeking advice from veterinary officers	38
Shifting the herd to another area	6
Culling sick animals	6
Supplementing animals	3

using a guard funnel. The dosage is repeated the next day if the animal does not recover during the night. Drenching a sick animal with sour milk is used to treat cases of plant poisoning with grass species. To treat bloat, caused by a legume (*Trifolium* species), a sharp piece of metal is used to pierce the rumen.

About half of the Barabaig population (47% in this study) diagnose sick animals and treat them using traditional techniques, a figure substantially higher than that of those who seek modern veterinary treatment (38% in this study) (Table 6.6).

Selection and breeding

The two pastoral communities of Tanzania practise a continuous breeding system. For every 10 mature cows, there is a fully-grown bull to mate with the female animals as they come on heat. All the females have access to a bull all the year round.

Bulls that are retained in the herd are usually selected. Such bulls are healthier than other bulls, active since yearling and well framed (rectangular). They have short horns, tall hind and fore quarters, large testicles and a high growth rate. They are selected from a reputable line, are attractive in colour and preferably have a herding trait. If they are selected from the herd, all their parents are normally removed from the herd to avoid inbreeding.

The ability of a heifer to reproduce is monitored by assessing the number of times it is bred and how active the heifer is in the herd. The inability of the heifer to reproduce is monitored by observing how fast it is growing, how early or late it is mounted in relation to its counterparts, how often it comes on heat, how its reproductive organs are placed, and how it walks.

The Maasai choose animals based on both meat and milk production as suitable breeding stock. In addition to the above, other characteristics considered are, twinning ability, sire/dam size, posture, milk potential, size of udder and well-placed testicles. To avoid inbreeding, bulls/bucks are bought from or exchanged with neighbours' animals. It is normal practice to sell or castrate all males not selected for breeding. Infertile females once identified are culled.

Animal/land interactions

Grazing pattern

As the dry season sets in (in May), the Barabaig household head surveys for dry season grazing. The selection is based on topography, soil fertility, and the crop residues and type of pastures available. Other factors considered are suitability for the period, availability, adequacy and proximity of water to livestock, and farmers' acceptance of other livestock keepers in their areas. The area selected is usually green and consists of grasses and legume plants, has good cover and is interspersed with trees. When the head of the household is satisfied that the pasture is suitable for the animals, the herd moves into the area. Cattle (plus calves) and donkeys (for carrying luggage) go on the first trip and goats and sheep follow. Sheep and goats are not moved to new grazing areas if the grazing conditions are not suitable for them. Once on the new pasture, the quantity and quality of grazing and overall suitability of the area for livestock are monitored using livestock performance indicators—milk production, absence of diseases and other observations the livestock keepers make. Calves, small stock and sick animals are usually grazed near the homestead, under the attention of women, whereas cattle and donkeys are sent to distant pastures. The first areas to be grazed are the homestead pastures and crop residues (up to the end of June or July). In August to November, the livestock graze in any other open areas where there are pastures. When the open areas are exhausted, they move to distant areas (e.g. Balangda Lelu, Gidagamono wheat farm, Babati, Singida and Manyoni) where there is water and pastures.

Since water is scarce in the Barabaig plain, most of the permanent water is too salty for livestock and people to drink. From August to November herdsmen therefore dig wells in areas surrounding Lake Balangda Lelu. These wells draw on less salty water found below ground level. After cleaning a well for the season, a herdsman places a tree trunk that can hold his weight over the mouth of the well, draws water using a bucket and pours it into a reservoir built on the ground with mud from the well. The water then runs by gravity into a trough, which is also built from the mud from the well. Sticks are usually driven into the ground and woven together forming a low fence impervious to water and strong enough to resist use by many cattle daily throughout the dry season. In this way livestock do not pollute the water supply with their feet, dung or urine.

With the onset of short rains (November to December) the head of the household surveys for wet season grazing. Livestock keepers move away from lowlands and farming areas to avoid floods and conflicts between farmers and livestock keepers. The areas chosen for grazing are usually not far from the homestead to allow members of the family to participate in farming activities. The selection is based on topography and type of soil. Areas with red and white soils are suitable for livestock grazing in the wet season. The area selected has good cover, strong grasses and legumes with interspersed tree species.

The animals are moved to homestead pastures within one kilometre for small stocks. However, as pastures diminish near the homestead, the animals are moved to *mbugas* away from water sources until February (i.e. the start of the long rainy season).

For the Maasai, the availability of dry pastures, temporary shelter and seasonal availability of permanent water govern their dry season grazing. Movement starts in August when pastures near homesteads are already depleted. Animals move to seasonal grazing areas *(ronjo)* about 12 km away. From the camp they have a grazing range of another 10 km.

Wet season grazing is governed by permanent settlements and availability of permanent water and social amenities (schools and hospitals). Movements start in March when the Maasai return to the village. In so doing, the *ronjo* grazing unit is rested from grazing.

Table 6.7. Importance ranking of ecological and other factors by the Barabaig

Attributes	Rank
Vegetation	1
Availability of water	2
Freedom from diseases and predators	3
Availability of salt	4
Proximity to veterinary services	5

Range suitability for grazing

Among the main ecological factors—vegetation, freedom from diseases, availability of water and range suitability for animal performance—the Barabaig consider vegetation the most important, followed by the availability of water and freedom from diseases (Table 6.7).

In the Maasai community, young men *(moran)* are sent out to scout for suitable grazing areas. The criteria for suitability include availability of pasture, trees/shrubs with green leaves, fruits, flowers and pods, water and cattle dips. Once the elders confirm the area as suitable, movement begins immediately. A few milking cows are left behind, otherwise the whole herd is moved to temporary camps *(ronjo)* about 12 km from the homestead.

Range condition and trend

The assessment of range condition by the Barabaig and the Maasai is subjective. It entails assessing species composition of palatable (desirable) species, forbs (herbaceous) and woody vegetation. A rangeland in good condition has a high plant density of palatable species, minimal bare ground, good litter and good animal performance. A rangeland in fair condition has few palatable species, a declining biomass productivity and little cover. Poor rangeland is characterized by lack of palatable plants, plant cover and litter, and is dominated by woody and herbaceous plants.

Institutional set-up

The Barabaig are horizontally divided into generation sets. Every Barababanda (singular for Barabaig) is also a member of the clan that is unified by a male lineage traced to a common founding ancestor. The clan is the largest corporate body of Barabaig society. The basic social unit of the Barabaig is the polygamous family made up of a man, his wives, children and possibly some close relatives. As already shown, the head of the household determines grazing strategy and marketing. He also has authority over domestic matters and decides on household movements, labour allocation and expenditure returns from livestock sales. The clan *(hulanda)* tackles issues that are beyond the family and a council of joint members of different clans *(getabaruku)* tackles issues that are beyond the clan. A special committee screens issues that cut across different clans *(makchameda)*. High-level decisions are made unanimously and no individual is allowed to depart from other members' views.

The Maasai community is organized around the kinship-clan age set network, with self-contained ecological units with well defined boundaries called *olosho*. This is the basis for the social, political and economic decision making. Decision making in the community is linked on risk avoidance, risk spreading and mutual help. The herdsboys make daily decisions as to where the animals go while at the temporary camp coupled by the cues of the animals to decide where to graze for the day.

The role of women in the Barabaig and Maasai communities

Barabaig women are involved in herding livestock (if children have moved out), removal of dung in corrals, and diagnosis of diseases when livestock have returned home. They treat sick animals in collaboration with their husbands, collect medicinal plants, cut and haul fodder for calves and sick animals, carry out poultry husbandry, and wash kids and lambs infested with fleas. The women are responsible for milking, processing and marketing of milk products, and fetching water for sick animals, kids and lambs in the dry season. Barabaig women are also responsible for skinning carcasses, drying hides and skins, tanning leather, embroidery, and preparing hides for ropes and for family bedding. They carry household belongings when moving to new areas, collect blood after piercing animals, prepare blood meals and collect firewood.

The role of the Maasai women in the household is limited to domestic chores, milking, taking care of young stock, and fetching water and grass for calves and sick animals. Women also process milk into yoghurt and ghee. Performing these tasks entails knowledge, skills and techniques acquired over many generations under the supervision of older women. Animals are milked once a day and the milk is collected in small gourds. To give the milk a special aroma, the inside of the gourd is treated with specially incensed wood pellets. The calves are kept separately and are released during milking to suckle so as to let down milk. They are usually allowed to suck two teats while the remaining two are being milked. The milk is emptied into bigger gourds and stored as yoghurt, while the rest is processed into ghee. This is a tedious procedure where the women churn the milk in gourds for many hours before the separation of ghee takes place.

In the Maasai community, it is men who own livestock. The exception, however, is where a few milk cows are allocated to individual wives who then become responsible for the upkeep of these animals, particularly the calves. Women have little indigenous knowledge about common animal diseases. Men, however, are knowledgeable about livestock diseases such as East Coast fever *(katen)* (whose outbreak is experienced in the dry season), contagious bovine pleuropneumonia *(oremiti)*, black quarter *(emburwa)*, lumpy skin disease *(eririi)* and foot-and-mouth disease *(majive)*. Men provide clinical services while women are only supposed to report about sick animals and assist in buying medicines using money earned from the sale of milk and other products.

Men are mostly responsible for providing parental guidance to children, but women are sometimes consulted. Decisions like sending children to school is the responsibility of both parents. As mentioned above women are responsible for embroidery. Bead embroidery is a tedious technique and involves sorting out small beads and fixing them neatly in desired patterns on necklaces, bangles, ear laces, head laces and garments. Longido women have formed a handicraft organization and are part of the Longido eco-tourism circuit. This has contributed to improving the economic welfare of the members.

Animal management

In grazing management, herdsboys regulate animal movement in relation to pasture availability. The elders usually recognize and reward herdsboys who, at the end of the day, return home early with animals with full guts.

Once satisfied that the productivity of animals is low, the head of the household moves his livestock to other areas, seeks the advice of livestock officers, supplements the livestock (with salt, pods and pumpkins), sells unthrifty stock and/or buys replacement stocks with the money from stock sales. In addition, the Maasai traditionally treat the sick castrate bulls that do not qualify to remain in the herd; such animals are slaughtered for tribal ceremonies, such as weddings. Dipping is done to reduce the burden of ticks.

7. Range assessment and monitoring in Uganda:

The case of the Bahima and Ateso

The Bahima of Mbarara District, south-western Uganda and the Teso of Katakwi in north-eastern Uganda are found along what is described as the Uganda cattle corridor or the rangelands of Uganda. These rangelands are slightly wetter than those of Kenya and Tanzania and therefore the communities studied in Uganda are less nomadic than those of Kenya and Tanzania. Therefore the rate of sedentarization, which has an effect on range management, is growing faster in the Bahima and the Teso communities.

Climate

The pastoralists, especially the Ateso, observe weather patterns based on:

- Wind
- Clouds
- Animal behaviour

According to the experience of the elders of Katakwi, when the winds blow from the west to the east, they will bring rain. Farmers prepare for planting. When the winds blow from the east to the west, it means that the dry season is still on. Gentle winds usually depict a transition in weather, either from dry to wet or from wet to dry. During this transition period, the mornings also tend to be very cold.

The stars are another aspect that is closely observed and monitored and is used to determine planting time. The stars are visible at sunset and seven of them are conspicuous towards the morning during February and March. These always coincide with the planting season. The Ateso also use the colour of the moon to predict rain. When the moon appears and turns reddish brown by the time it is full, the community expects plenty of rain.

There are similarities and differences between conventional techniques and those used by the Bahima and the Ateso to assess and monitor climate (Table 7.1).

Table 7.1. Seasonality pattern indicators

Attribute	Interpretation by Bahima	Interpretation by Ateso	Conventional use
Winds	North to south bring rain; south to north bring dry spell	East to west means rain is expected; west to east means drought expected; gentle winds indicate transition in weather	Wind direction used
Temperature	–	Cold mornings indicate transition in weather pattern	–
Colour of moon	–	Brown full moon shows season with plenty of rain	Use unknown
Wild herbivores	When seen on the range shows good season	When seen on the range shows good season	Animal migrations are used in conventional science
Stars	Unrecorded	Visible at sunset shows planting time	Unknown
Birds	Hornbills vocalize just before the onset of the wet season	Birds of prey (kites and eagles) abundant in dry season, hornbills vocalize just before the onset of the wet season	No interpretation found

Vegetation

Vegetation characterization and trends

Vegetation characterization by both the Bahima and Ateso is understood more by composition than structure. They are also able to differentiate structural characteristics based on the shrub and herb layers of the vegetation. Because the Bahima traditionally rear and cherish cattle, which are grazers, they have specific preference for open grassland *(orwera)*.

The pastoralists are able to tell the trends in pasture condition. Most Bahima (64% in this study) indicate that pasture condition has declined while the majority of the Ateso (78% in this study) think that the pasture condition has improved (Table 7.2). Very few (4% in this study) have observed an increase in the prevalence of some weeds, especially striga *(emoto)*, in sorghum fields. The difference in opinion arises out of the different levels of management intervention. Some have exclusive rights to their land and have incorporated conventional management techniques on the land over a relatively long period. Those recently settled in the Bahima area, for example, assess the range as declining since they are still trying to adapt to producing from a restricted area.

According to the Bahima, weed encroachment has been observed. The following weeds, starting with the most important, are common:

- *Cymbopogon afronardus* ('omutete')
- *Acacia hockii* ('obugando')
- *Vernonia campanea* ('kyakuyambaki')
- *Lantana camara* ('ekihukye')
- *Capparis* species ('kagyenzanda')

In the Ateso area, the following grasses dominate and are used to identify the type of grassland:

- *Hyperhenis* species ('asisinit')
- *Themeda triandra* ('emaa')
- *Sporobolus pyramidalis* ('echilaboi')
- *Cynodon dactylon* ('emuria')
- *Panicum maximum* ('edinyot')

There is an increase in the relative abundance of weeds in the Bahima territory. The invasion of *Lantana camara* for instance has increased over the last decade while *Acacia hockii*, which has been a component of the range, has increased in abundance and spread. The invading grass, *Cymbopogon afronardus* ('omutete'), has proliferated in the recent past. Those who were old enough in the early 1960s remember being told by their parents that at one time this grass was so rare

Table 7.2. Assessment of pasture condition by the Bahima and Ateso

Pasture condition assessment	Respondents (%)	
	Bahima	Ateso
Improving	30	78
Declining	64	4
No change	6	18

that people would move long distances to collect it for medicinal purposes. It is now observed to be rapidly colonizing a large area.

The Bahima appreciate the seasonality pattern in pasture condition. During the dry season the condition deteriorates rapidly and the pastoralists have adapted by reducing the herd size. This is a recent practice because, until recently, the pastoralists used to migrate with their herds either southwards into the Kagera Region of Tanzania or shift northwards, sometimes as far north as Lake Kyoga. To date some of these pastoralists move their herds into Lake Mburo National Park when the available grazing is depleted and the water sources have dried up. A few still move southwards towards the Tanzanian border. A respondent who had moved with a herd from a neighbouring district and opted to settle said, "I avoided the flat areas because I knew they were likely to flood during the wet season and the good pasture would get spoilt. So my land had to have a gentle slope. The areas in the steep slopes dry very fast after the onset of the rainy season. I opted for open grassland because the thickets do not allow much grass. Our grazing land has only recently been invaded by woody species."

The dominant plant species are used by the Ateso to identify the type of grassland. Trees and shrubs within the rangeland are also used to classify the range. The most common woody species in the area include:

- *Acacia hockii* ('ekisim')
- *Acacia siberiana* ('etirir' *or* 'etirok')
- *Albizia coriaria* ('etekwa')
- *Annona senegalensis* ('ebolo')
- *Butyrospermum paradoxicum* ('ekungur')
- *Combretum collinum* ('ekuloin')
- *Dichrostachys cineria* ('etira')
- *Diospyros mespiliformis* ('ekum')
- *Euphorbia candelabrum* ('epopong')
- *Ficus glumusa* ('ebiyong')
- *Ficus sur* ('edurukoi')
- *Ficus sycomorus* ('eborborei')
- *Grewia mollis* ('eparis')
- *Lannea barteri* ('etit')
- *Mumusopis kummel* ('elepolepo')
- *Pilostigma thorningii* ('epapai')
- *Sapium ellipticum* ('elipilepo')
- *Sclerocarya birrea* ('ekajikaj')
- *Tamarindus indica* ('epeduru')
- *Ximeria americana* ('elamai')
- *Zizyphus abyssinica* ('esilang')

The Ateso closely follow the trends in the relative abundance of *Combretum collinum, Acacia hockii, Butyrospermum paradoxicum* and *Euphorbia candelabrum*. They assess the botanical composition from their knowledge of the various plant species in the range.

Vegetation palatability and value

The Bahima are able to keep track of the good pasture species on the range. Most (68% in this study) observe the readiness with which livestock accept a given species. However, the rest contend that palatability is relative and depends on season. The palatable species during the wet season, starting with the most palatable, are:

- *Brachiaria* species ('ejubwe')
- *Chloris gayana* ('orunyankokori')
- *Hyparrhenia* species ('emburara')
- *Themeda triandra* ('emburara')
- *Loudetia kagerensis* ('eyojwa')
- *Sporobolus pyramidalis* ('ekasi')

The Ateso agropastoralists assess the palatable plant species and observe livestock preferences. Animals spend more time feeding on palatable species than on the unpalatable ones. The palatable species decrease faster in abundance than the unpalatable ones. Others use a combination of both animal cues and relative species abundance. The Ateso consider the following among the top palatable species:

- *Hyparrhenia* species ('asisinit')
- *Chloris gayana* ('ekode')
- *Panicum maximum* ('edinyot')
- *Pennisetum mezianum* ('esirito')
- *Cynodon dactylon* ('emuria')
- *Themeda triandra* ('emaa')

The Ateso agropastoralists know that *Sporobolus pyramidalis (echilaboi)* has very low palatability. When the palatable species on the range decline, the pastoralists generally shift to other areas. Both groups of pastoralists think that *Brachiaria* species and *Chloris gayana* are the most palatable and these plants are mainly abundant during the wet season. According to the pastoralists, there are species that are only grazed when the palatable species have reduced. These include *Loudetia kagerensis* and *Sporobolus pyramidalis*. *Cymbopogon afronardus* is grazed when there is extreme herbage shortage. Some pasture species that were once abundant have declined in relative abundance, especially *Themeda triandra* and *L. kagerensis*. These species are valued not only for grazing but also as bedding for the pastoralists and calves and snuff for fumigating utensils and repelling flies.

Plant biomass estimates

Most Bahima and Ateso pastoralists use stubble height to assess vegetation biomass in the herb layer. A few use a combination of both stubble height and bare patches to assess forage amount. In Nyabushozi, where communal land holdings have tremendously diminished, the Bahima pastoral community is able to differentiate pasture condition in relation to levels of management. They are, for instance, able to use stubble height to assess forage quantity. Both the Bahima and Ateso are equally able to assess vegetation cover according to the number and size of bare patches on the range. When the grass has been grazed to a certain low level, the animals are moved to a different part of the range.

Soils

Soil classification

The pastoral group in Nyabushozi characterizes soils according to texture and colour. Sandy soils *(orushenyi)* and clay soils *(kabumba)* form the extremes of the classification. Clay soils are regarded as inappropriate for pasture growth because they are prone to water logging in the wet season and caking in the dry season. Sandy soils in the lower slope are preferred for grazing. The sandy loam soils and clay loam soils are used for crops.

The Ateso of Katakwi believe that soils are generally uniform except around termite mounds, cattle bomas, and in the swamps. They also classify soils according to texture. The major categories are sandy soils, loam soils and clay soils. Clay soils are mainly found in the swamps. According to the focus group discussions, both good pastures and crops are produced in the loam soils, while sandy soils are of low productivity. Dark humic soils near the swamps are also regarded as fertile.

Use of plant indicators to assess soil fertility

Native plants are used by the Bahima to identify the suitability of soils for pasture and other crops. Various plants are used but the most common ones are:

- *Acacia hockii* and *A. gerradii*—used to determine where to establish banana plantations
- *Combretum* species—indicate where it is not possible to grow bananas
- *Themeda triandra*—good for annual crops especially cereals (millet)

In the Ateso area, certain plants indicate soils that are not fertile and therefore not good for crops. For example, striga is an invader (weed) that destroys sorghum. *Combretum collinum, Acacia hockii,* and *Butyrospermum paradoxicum* indicate areas that are good for crops and pasture. The vigour of herbs is the first consideration when assessing soil fertility. The amount of forage produced and the level of crop yield are also considered in assessing the fertility.

Soil colour as fertility indicator

Some of the soil fertility indicators used by the Bahima, mainly based on colour, are:

- Dark well-drained soils are regarded as good for perennials
- Brown soils with no clods are regarded as good for annuals, especially cereals
- Sandy soils are good for root crops

Dark soils are preferred for perennial crops, especially bananas, which are a recent introduction in the area. The dark soils in the slopes are very good for bananas, while the brown soils are used for annual crops, especially cereals. Millet grows very well and the yields are good. Perennial crops are usually preferred in areas close to permanent water sources, mainly permanent swamps and streams. The Ateso agree that soils near permanent water sources have a higher potential for crop production. These are mainly the dark humic soils.

Soil suitability for grazing

The Bahima prefer the lower slope for grazing in the terrain with undulating slopes, while they reserve the middle slope for crop production. The upper slope is regarded as unsuitable for crops and grazing.

However, most Ateso use the season to judge suitability for grazing. During the wet season, (April to September) animals graze on the plains and as the dry season advances (October to March), the grazing extends to the swamps.

Soil erosion

The Bahima and the Ateso notice and are quite aware of soil erosion. Natural erosion is recognized by a fairly large cross-section of the Bahima (48% in this study) and is explained by the deep valleys *(enssa)* along the hill slopes. The community agrees that erosion has increased; this is attributed to population increase. Recent gullies *(empazo)* form along cattle trails *(ebihandagazi)* on steep slopes. However, most of the Ateso (66% in this study) do not think that soil erosion is a big problem. Sheet erosion occurs in cropland and minimal erosion takes place along animal tracks near settlements.

Water

Water availability

The Bahima used to move in search of pasture and water but this movement pattern is no longer possible. They have now adopted water-harvesting techniques mainly based on excavating valley tanks and farm ponds, and use of boreholes. They are able to select sites for locating water points by considering the soils, topography and the general drainage pattern of the area.

The pastoralists can tell the type of soil that retains water. They select clay soils because there is minimum loss of water through seepage. The sandy soils allow water loss *(ekimizi)*. The quality of water is judged by the colour and smell. Bad odour usually comes from decomposing organic matter. This is repulsive to livestock and ultimately leads to vegetation growth in water.

In the Ateso area the sources of water are:

- Rain
- Swamps
- Shallow wells
- Valley dams

During the rainy season, rainwater collects in some depressions. The small depressions *(aipwor)* last a short time while the big ones *(apucat)* keep water well into the dry season. The most common water sources are the shallow wells *(ecol)* and temporary springs around swamps *(ekucoi)*, on which they depend during the rainy season. Boreholes, where available, are used around settlements.

Water quality

The readiness with which livestock (cattle in particular) accept water is associated with several factors, such as salinity and temperature. The Bahima pastoralists believe that cattle are attracted to water that tastes salty *(amanure)*. They also believe that when water is very cool, especially in the wells that are under a shade, cattle will not readily drink it. The herders prefer water points that are exposed to the sun. According to one herder their water is generally bad. The colour is never clear and when ponds are dug they easily fill with silt and dry early in the dry season. When cattle drink this water, they get infected with flukes. The pastoralists are now aware that when they put blocks of rock salt *(rwabareire)* in the water the 'worms' die and the animals are safe.

The Ateso use the following parameters to assess water quality for livestock:

- Salinity
- Turbidity
- Oiliness

During the dry season water reduces and swamp water becomes muddy and turbid. Some of the swamp water has an oily layer with a bad odour. Livestock will, however, take whatever water is available, especially during the dry season. Borehole water is regarded as the only clean water source for human consumption.

Animals

Animal performance

The pastoral Bahima and Ateso assess and monitor the range condition by using indicators of animal performance (Table 7.3). The Ateso keep mainly the short East African Zebu cattle, local goats and sheep of unknown breeds while the Bahima mainly keep the Ankole long horned cattle. The Ateso also consider a range that is full of biting flies as being in poor condition.

Animal/land interactions

The Bahima and Ateso can assess the impact of grazing pressure on the range and the environment in general. In the case of the Bahima, overgrazing *(okukunduza)* is recognized. The Bahima assess overgrazing by observing the height of pasture, number of cattle trails *(ebihandagazi)*, and occurrence of bare patches *(emparamata)*. These are attributed, in order of importance, to:

- Overstocking
- Drought
- Population increase
- Reduced grazing land

The Bahima pastoralists (58% in this study) consider animal body condition an important indicator in assessing the range. However, a decline in animal body condition is observed in advanced stages of declining condition of the range if the animals still have access to drinking water. Overgrazing is largely blamed on drought. As long as there is no prolonged drought, the pasture remains sufficient.

The Bahima believe that when wild herbivores—especially the zebra, eland, and impala—move close to where cattle graze it is a sign that the quality and value of grass is good. It is an indication that there will be enough pasture and water. When the wildlife migrate back to Lake Mburo National Park, the herders know they are likely to move their herds as well.

In the Ateso area, the reduction in livestock numbers has led to an increase in the amount of herbaceous biomass and an increase in palatable species. Where the people and livestock have been forced to stay

Table 7.3. Assessment of the range by the Bahima and Ateso based on animal performance

Pasture condition assessment	Rank	
	Bahima	Ateso
Milk production	1	4
Rumen-fill	2	2
Weight gain	3	1
Coat condition	4	3
Mating frequency	5	5

in restricted areas due to insecurity, overgrazing is noticed and the decision taken to change the grazing area is based on the concern for the declining range and animal performance. Before insecurity set in, the decision to move was greatly influenced by seasonal patterns, with clearly preferred areas for grazing during the dry and wet seasons. Like in the case of the Bahima, the presence or absence of wild animals also tells the Ateso a lot about the condition of the range. According to the Ateso community, the large mammals are now rare. When antelopes come from the swamps to the open grassland, it implies a good season. When birds (kites and eagles) soar high in the skies, then the dry season will persist. The presence of certain birds, especially the hornbill *(achabi)*, implies the onset of the wet season.

Institutional set-up

The traditional mechanisms for making decisions among the Bahima have changed greatly over the years. All the Bahima now privately own land and therefore decision making beyond the household level is not applicable. The Ateso, however, use a large part of the range communally and therefore have some communal decision-making structures. The decision-making mechanism has an age-set structure with the elderly men (40 years and above) taking the lead. However, the decision on where the animals should be taken for grazing mainly depends on the herdsboys who follow both animal cues and proximity to water for that decision. The issue of security has now become very important and herdsmen have to minimize the risks of being attacked by raiders.

Summary comparison of assessment and monitoring techniques

A comparison of a number of assessment and monitoring techniques used by the Bahima and the Ateso with conventional ones, with respect to vegetation, soils, water and animals is given in Table 7.4.

Mitigation measures

Various mitigation traditional techniques used by the Bahima and the Ateso as mitigation measures are compared with conventional methods in Table 7.5.

Table 7.4. Comparison of techniques—The Bahima and Ateso vs. conventional methods

Resource type	Technique among the Bahima	Technique among the Ateso	Conventional technique
Vegetation type	Structure, composition	Structure, composition	Structure, composition
Vegetation value	Milk yield, weight gain	Weight gain	Chemical composition
Plant palatability	Livestock preference	Livestock preference	Livestock preference
Plant biomass	Stubble height	Stubble height	Dry matter production
Vegetation trends	Weeds, stubble height	Weeds, stubble height	Composition, cover, vigour
Soil classification	Colour, texture	Colour and texture	Texture, structure, colour
Soil fertility	Indicator plants, plant vigour	Indicator plants and plant vigour	Chemical analysis, plant vigour
Water quality	Turbidity, odour, flukes	Turbidity, odour	pH, conductivity, turbidity, odour
Water availability	Surface water and flow	Surface water	Surface and ground water recharge
Animal productivity	Milk production, weight gain	Weight gain, milk productivity	Milk production, weight gain
Animal condition	Rumen-fill, coat condition	Rumen-fill, coat condition	Rumen-fill, coat condition
Animal fertility	Mating frequency	Libido or mating frequency	Calving intervals and percentages

Table 7.5. Comparison of mitigation measures used by the Bahima and Ateso, and conventional methods

Deficit	Bahima	Ateso	Conventional
Vegetation biomass	Migrate, destock, separate herds	Migrate	Destock, supplementary feeding
Vegetation value	Migrate	Migrate	Supplementary feeding
Vegetation palatability	Migrate, night grazing, sprinkle salt on pasture	Migrate	Species introduction, supplementing
Soil fertility decline	Shifting cultivation, animal manure	Shifting cultivation	Rotation, natural and artificial fertilizer
Water shortage	Excavate tanks, move herds	Move herds, dig shallow wells	Surface storage, boreholes
Water quality—flukes	Add rock salt	-	Anthelmintic drugs
Water quality—turbidity	None	None	Filtration
Animal performance—low productivity	Separate herds, give local medication	Use reserve pasture, give native medication	Various nutritional, breeding and medical intervention

8. General discussion of findings

The three East African studies gathered information on indigenous range assessment and monitoring techniques used by the Pokot, Il Chamus, Barabaig, Maasai, Bahima and Ateso communities with respect to climate, soils, vegetation, water, animal factors, animal-land interactions, and suitability ratings. Other aspects considered included range condition and trend, preferential grazing areas, institutional set-up in decision-making, and the role of women.

Kenyan study

This study indicated that pastoralists make use of several indicator signs to forecast impending drought or rain. These indicators can be categorized into four groups: *biological indicators*—phenological and behavioural changes in plants and animals, respectively; *astrological indicators*—movements and position of stars; *atmospheric indicators*—density of cloud and direction of wind; and *cultural indicators*—observation of the viscera of slaughtered animals.

The pastoralists use their knowledge of their environment to follow changes in climate and to make weather forecasts. The focus of monitoring the climatic trend recorded in this study is based on familiar, observable environmental changes that are nearest in time, space and relationship to the pastoralists. Using this method gives the pastoralists a much shorter warning time (that may not allow for timely response to drought) than does the conventional early warning systems (EWS) currently used in the region. While the focus of monitoring among the pastoralists has only up to a maximum of three weeks lead time, the livestock early warning system (LEWS) in conjunction with the famine early warning system (FEWS) is capable of giving 6 to 8 weeks warning. This allows the pastoralists to adequately prepare for impending drought and to recover rapidly from the effects of the disaster. Therefore, developing an integrated approach that incorporates the additive effects of the two systems would be appropriate and beneficial to the pastoral systems.

The LEWS project in the five countries of eastern Africa (Eritrea, Ethiopia, Kenya, Tanzania and Uganda) addresses risk by adapting the already successful technologies from the USA to the situation in East Africa. The project is aimed at increasing the response time on the forecast of drought and famine and allowing policy makers to visualize the impact of their interventions on food crises. The project has integrated a series of tools developed at the Texas Agricultural Experiment Station into existing early warning systems to provide more timely and better information to pastoralists, action agencies, researchers and policy makers.

The LEWS is based on near infrared spectroscopy (NIRS) faecal profiling technology with advanced grazing land and crop models. NIRS is used to scan faecal samples to predict the diet of free-ranging livestock. This tool provides an objective and reliable indicator with an early warning capability when interfaced with a geographic information system. NIRS faecal profiling has potential for compatibility with pastoral communities since the indicator (livestock faeces) is one for which an indigenous knowledge system is already in existence (Ndikumana et al. 2000). In this system, weather data from the FEWS data dissemination system, along with *El Niño* and southern oscillation (ENSO) data from the NOAA Climate Prediction Centre, are spatially linked with PHYGROW and the agricultural policy environment extender (APEX) model. PHYGROW is a hydrologic-based model that predicts rangeland forage production, runoff and herbivore grazing in rangeland ecosystems. APEX predicts crop yields, runoff and erosion from cropland models to predict emerging forage/crop conditions and likely future conditions of forage supply and grain yields relative to known livestock density and planting dates within monitoring areas. The model is sensitive to animal selectivity of plant species and translates these processes into animal production in terms of stocking rates. The information obtained is validated through intensive and frequent monitoring of vegetation and livestock responses on validation sites established in the five countries.

Adaptation of these technologies is aimed at providing high quality information that will significantly increase response time to emerging crises and the capacity of the regional institutions to respond. The advantages of LEWS over the traditional systems are:

- It has the ability to predict responses such as impending livestock mortality by kind and class of animal, losses in forage supply and decline in milk production. This allows more flexibility in decision-making from the household level to the policy maker.
- It provides more response time for drought forecasting.
- It has the capacity to detect changes in the well being of free-ranging livestock earlier than normally detected by pastoralists or crisis monitoring organizations.

The eco-physiognomic classification of the range used by the Pokot and the Il Chamus communities is closely comparable to the approach used in conventional range science. They classify range on the basis of climatic factors, topography, dominant plant species and soil type. Areas with different soil, topography and climate are likely to have different vegetation, which would support different species of animals depending on dietary requirements. They also respond differently to management practices. This criterion is similar to that used by the Ariaal of northern Kenya (Oba 1994), who also classify range into two main categories—the highlands and lowlands—which are perceived to be different in topography, climate, soil and vegetation types. Based on these eco-physiognomic classes, the pastoralists make decisions pertaining to range suitability for a given livestock species. The pastoralists further sub-divide these categories into grassland and bush land, referring to a range dominated by grass and browse species, respectively, and which is preferred by and suitable for cattle (grazers) and goats (browsers), respectively.

Modern range scientists closely link the knowledge of plant species composition to vegetation succession and the climax concept as used to explain range condition rating. Conversely, this study reveals that pastoralists perceive the knowledge of botanical composition in more practically applicable and interpretable terms. They use such knowledge to evaluate range suitability for livestock grazing with regard to the knowledge of dietary requirements of different animal species, preferred plant species, and poisonous and medicinal plants. These findings are comparable to those of Sindiga (1994) and Makokha et al. (1999), who reported that the Maasai and the Pokot have an extensive knowledge of range plants and the species that are preferred by livestock and which are undesirable. However, the pastoralists depend primarily on animal wisdom and cues to make certain judgments, such as those pertaining to forage palatability, where the decision on the direction of grazing relies on the animals. This leads the herders to areas of palatable and preferred forage species.

The assessment and monitoring of soil fertility status among the Pokot and the Il Chamus is based on both soil and plant attributes. The soil classification system used is similar to that of the Iraqw of Mbulu and Karatu districts of Tanzania (Msanya and Mwaseba 2000). In contrast to the conventional soil classification system, this indigenous system makes use of observable surface and sub-surface physical soil features. It is quicker and easier to use than the usually complicated conventional soil taxonomy criteria which include a description of the whole soil profile and its chemical properties. The suitability of soil for a particular use is also decided on the basis of the surface characteristics. This indigenous approach, however, overlooks some of the important chemical and physical soil properties such as pH, structure and bulk density that are equally and sometimes more crucial than just the surface attributes. Unlike the conventional criteria, the Pokot and the Il Chamus, apart from considering a few physical surface and sub-surface attributes, assess soil fertility indirectly through plant indicators such as vigour, productivity and presence of certain plant species. The conventional and indigenous techniques can therefore complement each other.

The findings of this study indicated that there is little effort to improve soil fertility among the pastoralists with the exception of a few agropastoralists who sometimes apply animal manure to the exhausted fields instead of shifting to virgin lands. However, this apparent lack of incentive to conserve soil could be due to the communal land tenure system which tends to create an attitude of maximizing individual gains at the expense of conservation, a phenomenon described as the 'tragedy of the commons' (Sandford 1983).

Water is a major constraint to both livestock and crop production in the semi-arid rangelands. Water management is, therefore, crucial in these areas which receive no rainfall for a greater part of the year. The focus of monitoring the quantity, quality and distribution of water is fairly comparable to the conventional approach except for the method used. While the quantity of water at source is conventionally assessed by taking accurate measurements using calibrated instruments, the pastoralists make use of less exact visual estimations such as the extent of exposure of the riverbed to measure volume, and unmarked sticks to measure depth of water and the level of silting. The quality is assessed on the ability of human senses to judge the colour, turbidity, odour, taste, temperature and presence of parasites. The traditional assessment of water quality overlooks the presence of certain chemical properties that cannot be detected in this way but could render water unfit for both animal and human consumption. Responses received in this study reveal that quality assessment would only be meaningful when there is plenty of water and there is freedom of choice. During droughts quantity is given priority over quality.

Most responses indicated that water was inadequate and of poor quality the pastoralists dig more or fresh wells/waterholes. These waterholes are carefully dug at specific sites and intervals to avoid the concentration of people and animals at such points. Land degradation at key sites has been as a result of the creation of many concentration points (open-access areas) such as water sources provided by the government and NGOs in areas that used to be wet season grazing areas. This attracts livestock from water deficient areas and increases pressure on the pastures. The pastoralists argue that this has led to the resource being overexploited and the pasture being unable to regenerate; this was ensured formerly through seasonal rotation of the herds.

The Pokot and the Il Chamus monitor animal performance through regular assessment of animal body condition, productivity and health. These indicators are known by the pastoralists to be sensitive to ecological and biological changes. This approach of evaluating animal performance is comparable to that used by the Rendille, Ariaal and Samburu of northern Kenya (Oba 1994).

While conventional breeding management takes into account the selection of both female and male animals for breeding, the Pokot and the Il Chamus select only male animals for breeding while all the females are allowed to mate. The females are evaluated after mating on the basis of fertility. Male animals are selected according to specific criteria including physical and genetic qualities. However, they are also subjected to post-mating evaluation depending on the qualities of their offspring. These findings agree with those of Noor et al. (1999) who found a similar practice among the Somali and Borana of Moyale District, Kenya.

The most critical aspect of food security in pastoral systems is that of keeping livestock healthy to sustain people who are dependent on them. The pastoralists face the problems of livestock health including general diseases, ectoparasites and helminths. The findings of this study are in agreement with those of Ole-Lengisugi (1994) with the Maasai of Tanzania, Kaendi (1997) with the Tugen in Kenya and Noor et al. (1999) with the Somali and Borana of Kenya. The extensive knowledge of animal disease symptoms among the pastoralists is matched with equally good knowledge of plants with medicinal value. Through this wealth of knowledge, the Pokot and the Il Chamus manage livestock diseases without complete dependence on pharmaceutical medicines. Although conventional medicine exists alongside traditional health care, the Pokot and the Il Chamus rely mainly on herbal remedies to treat sick animals. This is similar to what was reported by Wanyama (1997) about the Samburu of Kenya. The decision on whether to use the modern or traditional medicine depends on the accessibility of medicine, the cost involved and past experience with similar illnesses. In most cases, modern health care is sought only when the disease is unfamiliar. However, it is also clear that, apart from the common diseases whose symptoms are known, traditional medicine is sometimes used on a trial-and-error basis.

As observed by Farah (1996), the intimate knowledge of the environment common to many pastoralists allows a great flexibility in decision-making and an enhanced ability to utilize all resources available. The findings of this study indicate that traditional assessment and monitoring of grazing resources is, to a great extent, dependent on the concept of spatial and temporal heterogeneity of rangelands, where the use of pasture by livestock is designed in a way that ensures use of different ecological sites at the peak of their forage production. The use of pasture by livestock is monitored and balanced with the productivity and potential of the ecosystem. This occasions grazing movements that are aimed at achieving optimum use of different ecological niches. Unlike the conventional approach, indigenous range management takes into account the daily variability and spatial heterogeneity at the micro-level when matching range potential to livestock use.

The results of the survey showed that pastoralists concentrate their management efforts at key sites such as dry season grazing reserves (swamps and hills) and areas with special palatable species. The beneficial effects of management of such small but crucial sites are believed to eventually trickle down to the larger ecosystem.

In conventional range science evaluation of range condition is almost entirely based on the plant and soil attributes—plant vigour, plant species composition, plant and litter cover and erodibility. Conversely, animal performance (rumen-fill, coat condition, weight gain, milk production, health and mating frequency/birth rate) is the main focus of assessing range condition among pastoralists. However, while the decision to move from a given pasture to another is dependent on animal performance in the current pasture, the choice on the next pasture depends on its ecological condition. These findings concur with those of Oba (1994), who reported the same kind of approach of evaluating the range among the Rendille, Ariaal and Samburu of northern Kenya. The Pokot and the Il Chamus use rumen-fill to tell whether pasture is overgrazed or not; as long as the animals still show a full rumen, the herders feel the pasture is not overgrazed. However, over-reliance on rumen-fill as an indicator of range condition could result in misleading judgments; an animal's rumen could be full, sometimes, regardless of obvious observable ecological deterioration.

Women and children, despite forming only 11% and 12% of the respondents, respectively, in this study, play a central role in the management of natural resources. Although they are not allowed to make decisions *per se*, they are seen to hold very crucial positions in the process of decision making. Besides performing pivotal domestic roles, women and girls manage the home-based herds. They milk the animals, feed and treat the sick animals and also suggest measures to be taken depending on their observations on the grazing resource and animal performance. Boys are responsible for the management of the satellite herds and scouting for pasture. Therefore, both women and herdsboys provide crucial information to the decision makers (heads of households, usually elderly men). It is also clear from this study that women and children play an important role in managing part of the pastoral herds (the young, sick and milking animals) and should therefore be allowed to participate, especially in decision-making processes in livestock management.

Tanzanian study

The findings of the Tanzanian study show that the Barabaig and the Maasai use a number of indigenous technologies. For example, the use of soil colour to classify soils is explained by the fact that the attribute is observable and has been established over many years. Colour suggests to the livestock keeper the prevailing condition of pasture. USDA (1957) also found that the colour of soil informs on drainage, the amount of organic matter in the soil and the general level of productivity. These communities therefore use different soils for different activities on the basis of colour.

The vegetation existing on the Barabaig and Maasai plains forms the bulk of the feed for the ruminants. Herlocker (1999) reported that indigenous grasses and other plant species have contributed greatly to improving livestock, crops and rangeland forage production in East Africa and elsewhere in the world. This knowledge can be expanded to broaden the scope and understanding of conventional range and animal husbandry science. Herbage quantity and quality plays a vital part in providing sufficient carbohydrates, and in the efficiency and profitability of livestock enterprises. Vegetation is intimately involved in the management of soil by changing the microclimate near the surface of the soil. To ensure that animals are healthy and productive, efforts are made to ensure that they have access to different pastures at different periods (Lane 1996).

Areas of intervention aimed at improving fodder quality (nutritive value) like planting leguminous and fodder tree species are likely to be adapted easily since they increase biomass, cover, nutritive value and eventually animal performance. Herdsboys or herdsmen are actually range resource managers since they plan, monitor and evaluate its use. Herding is the art of guiding and conducting livestock (Niamir 1991). Training the herdsboys in conventional range management technologies may enhance their ability to manage their resources.

Sources of water are exploited in terms of quality, distribution, availability and quantity because water is needed for efficient use of the range and for the health of the animals. Under conventional range management practices, water is used as a technique to distribute livestock over the range. Water comprises 70% to 90% of animal body weight (Reaves and Henderson 1963). The importance of water to livestock has been reported by Stoddart et al. (1975) who indicated that forage intake in sheep in Australia declined in the second day after watering. Therefore, wherever possible water is provided daily for livestock (Stoddart et al. 1975; Lane 1996).

The Barabaig and the Maasai use the dual purpose East African Shorthorn Zebu cattle in their livestock production economy. The pastoralists have come up with a breed that is adapted to environmental conditions in Hanang District and Longido by selecting bulls and females over the years. The breed survives on coarse feed that other types of cattle would not survive on. The breed is also capable of walking long distances without water. The use of individual animal performance to assess the quantity and quality of pastures is in line with the conventional range management methods of measuring animal performance (Launchbaug and Owensby 1978). Cattle require that both quantity and quality of grazing be adequate to meet their maintenance and reproduction (Lugenja 1982). The components of greatest importance in grazing behaviour include time spent grazing, the rate of biting during grazing and the size of the individual bites of herbage, all of which combine to determine herbage intake. Generally, beef cattle graze for 7 to 14 hours a day and when it is hot the time spent grazing is reduced drastically (Weaver and Tomaneck 1951; Dwyer 1961; Zemo 1968; Stricklin et al. 1976).

The abundant grazing resources in terms of herbaceous and woody species have enhanced the grazing rotation practised by the Barabaig and the Maasai. These resources are of high feed value and their diversity in space and time has made it necessary for the pastoralists to practise transhumance. This system maximizes the production potential of the various plant species at different stages of vegetative growth (Lane 1996).

The wet areas and lowlands are used in the dry season because they are not accessible in the rains. These areas are therefore partly reserved for dry season grazing. Animals graze in all other areas because of the suitability of the soils, availability of forage and water, and freedom from disease.

The use of animal performance and suitability of a grazing area by the Barabaig and the Maasai is similar to what is practised by their Kenyan and Ugandan pastoral counterparts. It is also in line with the observation made by Morley (1978), who supported the idea that many attributes of pastures, animals and those of animal products should be taken into account.

Grazing animals affect pasture by trampling and fouling and this results in patches. The relationship between the amount of pasture present and animal performance probably varies between the species and seasons of the year. However, Morley (1978) noted that pasture available reflected palatability rather than pasture growth, so that at times the more herbage there is the lower the performance of the animals that graze it.

Herd splitting is a common feature in pastoral communities in East Africa. In Tanzania it is shown to improve the utilization of the range resource by different classes of livestock. The technique can be assimilated into specialized production systems like cow-calf, weaners and fatteners depending on management objectives, since these are practices that are relevant to modern beef ranching.

Transhumance defers the use of certain blocks of pastures under two rainfall regimes. Research is needed on this technique to determine its merits so that it may be integrated into conventional range practices. This is important because a considerable amount of ecological and socio-economic information is still lacking (Herlocker 1999). The reasons for deferment should particularly be explicitly understood and more sophisticated rotational grazing systems developed and incorporated into the indigenous grazing systems. Information on how much stubble height should be left on deferred pasture, percentage cover and condition rating criteria are the expected outputs from the research studies which would provide guidance to range scientists designing grazing resource utilization.

The Barabaig and the Maasai, just like the other four pastoral communities studied, believe vegetation is the most important factor when assessing the suitability of grazing because it is a reflection of the suitability of the environment as a whole. Oba (1994), in a study in northern Kenya, noted that pastoralists considered water the most important factor when ranking ecological factors with respect to range suitability. However, the final suitability rating was based on livestock performance (Oba 1994). This concurs with the perceptions held by the Barabaig of high milk production on the first day of grazing on a new pasture.

The Barabaig and the Maasai use vegetation, soil, water and animal resources in different combinations to decide on the range suitability for animal performance. This was slightly different from what Oba (1994) observed in northern Kenya where the pastoralists used common indicators for animal body condition. Favourable rating was based on high milk production, full rumen, increased mating frequency and rapid weight gain. The pastoralists moved when the rating of animal performance was unsuitable.

The most import range resource in determining range condition and trend among the Barabaig is vegetation, followed by water, animal and soil resources. However, under conventional range management, all components of range condition classification (soils and vegetation) are considered simultaneously (Stoddart et al. 1975).

Institutional set-up and the organizational hierarchy of decision making of the Maasai, as observed by Massaro (1989), sets a precedent for organized farmer groups/associations. This is a focus area for formulating, planning and implementing range resource management plans. Territorial organization encompassing geographically bounded sections, which are self-contained ecological units with well-defined boundaries *(olosho)*, is an element that can be used to promote an attitude of land ownership among the Maasai.

The decision by pastoralists to move animals to new grazing areas when the current grazing area is not suitable for animal production in terms of stubble biomass, plant vigour, biomass production, cover, botanical composition and nutritive value is in line with Launchbaug and Owensby (1978). The quality of the new grazing area is considered suitable if it is uniformly covered with dense and adequate pastures and if it can maintain the health of the grazing animals.

Ugandan study

The Bahima and the Ateso agropastoral communities of Uganda have developed in-depth knowledge of their range resources. These communities can identify which type of vegetation is best for livestock and which areas are suited for one type of livestock and not another. Both communities monitor the availability and distribution of the palatable and nutritious plants species on the range.

The communities are aware of the distribution of the various vegetation types and the type of crops and livestock that are favoured by these soils. Both the Ateso and the Bahima classify the soils according to texture and colour. Although the classification lacks the finer detail used in conventional classification, the decisions on land utilization are based on a clear consideration of the potential of the various soil types in time and space. The mitigation measures taken as a response to changes in the given indicators are definitely influenced by other factors such as land tenure. Destocking is, for instance, one of the measures taken in response to pasture shortage in the Nyabushozi study area. This decision is easier taken where there are exclusive land tenure rights. In the Ateso community, where land is still communally managed, the immediate response is to shift to another area of pasture, leaving the other to regenerate.

The agropastoral communities know that there are native plants that have similar nutrient requirements as crops. These are used as indicators of soil fertility and various crops are selected based on the performance or occurrence of some of these native plants. The impact of the various land use practices on the soil is also well understood. The communities appreciate the erodibility of land but go further to assert that natural erosion has occurred over the years even without human interference in the areas. The Bahima, because of grazing in undulating terrain, recognize that some of the deep gorges in the area are a result of naturally occurring erosion and not of recent human impact.

The suitability of the land for crops and grazing is influenced by, among other factors, climate, and the agropastoral communities appreciate that this contributes to the potential of the land. This makes it necessary to understand the ecological and sociological factors that enable these agropastoralists to successfully exploit the rangelands.

Water is probably the most crucial resource in the rangelands. Both communities single out this commodity as being crucial for the survival of livestock and humans. Although these are common observations, the people closely assess the available water resources and monitor the spatial and temporal distribution of the resource. This to a large extent determines the pattern of utilizing the other resources especially pasture. The quality of surface water in the two study communities is ranked as poor. The communities base their assessment of water quality on colour, odour and taste. The quality is also associated with the effects the water has on consumers, like in the case of liver fluke infestation identified by the Bahima. The knowledge used to assess the quality of resources is therefore robust and the decision-making process is flexible. The agropastoral communities know that they cannot get a range in perfect condition and therefore use the available resources with contingency measures in place. Local herbal anthelmintic drugs are used when the water is suspected to be or is contaminated. Proper understanding of indigenous range management practices can be achieved if their ecological basis can be incorporated into research themes and the sociological approaches used to understand the role of range administration.

The communities cherish livestock keeping and therefore, among other parameters, appreciate livestock performance. The other factors within the production system such as availability of water and pasture remain important only when translated into good animal production. The Bahima regard milk production as the most critical indicator of range condition probably because milk was once their staple food. High milk production indicates that livestock (mainly cattle) have had enough feed and water and are in good health. Mating frequency is regarded as an important indicator because a suitable range is believed to increase libido among bulls. The difference in ranking animal performance between the Bahima and the Ateso can be attributed to what is considered the main product in the production system. With the Ateso, meat production is of higher importance and crop production is more traditional in Ateso than in the Bahima community.

Contrary to the views held by conventional science, the pastoral communities in these areas are able to closely assess and monitor resource trends. The agropastoralists in Katakwi, for instance, realize that cattle raiding by the Karamojong has led to under-utilization of the range by livestock and generally agree that other than the area around the settlement camps, the amount of pasture on the range has increased. The Bahima are aware of and appreciate overgrazing. They are also aware of the reasons why it occurs. Shrinkage of the rangeland, curtailed mobility, and large herds are considered some of the reasons for overgrazing. The introduction of perennial crops, especially banana plantations, in the agropastoral areas of Nyabushozi is partly a result of the realization that animal manure improves the performance of crops. The pastoral communities recognize livestock/environment interactions, and decisions are taken after careful ecological and socio-economic considerations.

The indigenous institutions have probably been the most dynamic in responding to changing situations. These institutions previously acted to ensure the sustainable use of pasture. They defined the rights over tracts of land, formulated rules and regulations for their management, and imposed sanctions on defaulters. In both communities, the indigenous institutions have been rendered ineffective. Sedenterization of the formerly nomadic Bahima has shifted the decision-making machinery to individual households. The household head makes most of the decisions related to the use of resources on the land. Among the agropastoral Ateso, the indigenous institutions have been weakened by cattle raiders, making insecurity an important factor in range resource use.

9. Conclusions

The findings of the studies in the three East African studies indicated that pastoralists and/or agropastoralists have a sound knowledge and understanding of their environment. The findings also showed that pastoralists have appropriate managerial skills and adaptive strategies in animal husbandry and natural resource management. Furthermore, the traditional systems recognize and use several kinds of range improvement tools and techniques: fire to regenerate growth, reduce parasite infestation and kill undesirable plant species; mixed-species herds to make optimal use of all ecological niches; and mobility to disperse grazing pressure. Through these indigenous techniques and knowledge, the pastoralists have been able to survive in their unpredictable environments, where conceptualization of ecological processes takes different forms and dimensions ranging from observable attributes to superstitious beliefs. The knowledge and techniques are passed from one generation to the other through social gatherings such as *kirurot* in the case of the Pokot or *asat lengam* in the case of the Il Chamus. Intergeneration transfer is also achieved through hands-on experience, demonstration, observation and story telling at home.

Pastoral communities have a well-developed and effective indigenous range assessment and monitoring system according to the existing conditions and management problems of the local rangelands. These techniques are based on easily observable parameters that have evolved as warning mechanisms to minimize the risks and maximize the benefits of livestock production and local resource management.

While differing in finer details, the assessment and monitoring techniques of the different pastoralist groups have a lot in common. They are all, for instance, well grounded in the indigenous knowledge repertoire, which evolves as conditions and responses change. There is a remarkable difference in the assessment and monitoring of the range largely because of the land tenure regimes. The Ateso of Uganda, for example, generally promote relatively equitable access to the resources to all members of the community, including the poorer and socio-politically weaker ones. The use of local pasture resources is regulated by the enforcement of well defined and mutually agreed upon rights and rules, backed by various social controls and sanctions. The Bahima, have tended towards private ownership of land and have incorporated techniques that are closely related to conventional science in an attempt to address the challenges of maximizing production on restricted land area.

These studies confirm that the pastoralists/agropastoralists keenly observe the range resources, contradicting the view that is generally held that they are simple exploiters of these resources. The pastoralists are conservation oriented, concerned with maintaining the productivity of the local resource area at a sufficiently high level to meet their long-term needs, often foregoing the use of resources to allow regeneration.

Indigenous techniques are generally effective, but there are situations when they may not be optimally so. Many indigenous systems concern themselves more with the utilization of resources and less with biological management objectives as reflected in the mitigation measures undertaken by the agropastoralists of Uganda. Herd mobility and shifting cultivation are the main mitigation measures when the resources are inadequate. This is not sustainable given the increasing pressure on the resources. The indigenous techniques sometimes fail to effectively achieve agronomic or silvicultural objectives—such as increased regeneration of preferred species. There are also problems of climate, topography and soil erosion, all of which lack easy solutions.

For a number of decades, government policies on range resource management have discouraged indigenous practices. This has undermined the local people's initiative, role and responsibility for local resource management. Nevertheless, the fact that these systems have persisted in the affected communities bears witness to the adaptability and sustainability of the indigenous techniques in the understanding of the rangeland and overall environmental conditions. The relative similarity in the attributes used in assessment and monitoring of the rangelands is evidence that societies under similar environmental stress tend to share mechanisms for regulating access and for managing resources in a sustainable manner.

The local indigenous systems often face challenges brought about by external conditions that require further changes and adaptation. The sedenterization of pastoralists and agropastoralists is one such challenge that has led to the communities incorporating many ideas and information from conventional science through purely local initiatives. Destocking as a mitigation measure during water and pasture scarcity, for example, is a recent phenomenon that arose when the communities realized that the traditional movement patterns were no longer possible. Indigenous resource assessment systems are therefore generally dynamic; they respond to changing situations.

The indigenous technical knowledge identified in these studies forms the basis for local-level decision-making pertaining to food security, natural resource management, animal health, and a host of other vital activities of the rural poor. It is therefore important to *recognize, identify, validate* and *document* the indigenous pastoral techniques with a view to integrating them into mainstream range management. Recognition of the traditional techniques and practices would not only restore the confidence of pastoralists in their own traditional knowledge and skills but would also lead to the preservation of unique indigenous knowledge.

The studies have shown that, among other factors, the use of colour to classify soils, though it seems simple, is a technique that has resulted in sustainable utilization of the range resources as a whole. The technique can be used as a basis for the formulation of land capability classes. These classes if used consistently with grazing resources would result in improved utilization of vegetation, water and animal resources.

Being able to identify and classify soils and plants is vital to understanding the way these resources are used. The existence of plant associations in different ecological sites makes it possible to have a variety of niches that are invaluable to livestock in different grazing seasons. This knowledge could be used to initiate studies on soil-vegetation-water-animal relationships.

The availability of a number of sources of water for livestock and human beings is invaluable in diversifying the use of water sources within reasonable distances in the dry season. Water exploitation skills and knowledge accumulated over years can be used as a basis for a better water system in pastoral areas, particularly for the dry season. Surface runoff would be more fully exploited by constructing dams at suitable sites through cost sharing in pastoral communities.

The knowledge of pastoralists on plant identification, assessment of plant species, nutritive value, biomass cover, animal performance, water quality and quantity, animal health, and livestock productivity is an area which can be explored to broaden the scope and understanding of conventional range and animal sciences.

Interventions aimed at improving fodder quality (nutritive value) such as planting leguminous and fodder tree species would complement indigenous knowledge and are likely to be adapted easily since they enhance increased biomass, cover, nutritive value and animal performance. The knowledge of the pastoral communities on the genetic potential and herd splitting of animals enables interventions in genetic improvement through crossbreeding with heavy and quick maturing breeds. This would increase the utilization of the range resource by different classes of livestock. This technique can be assimilated into specialized production systems like cow-calf and weaners, depending on management objectives.

Pastoralists agree that not all indigenous techniques are beneficial to the sustainable development of local communities and not all traditional practices provide the right solution for a given problem. However, it is evident from the results of these studies that most of the indigenous techniques and practices are acceptable and are similar in approach to modern techniques. Therefore, the most logical decision is to seek the integration of the indigenous techniques with conventional range resource management. This should be done as a way of increasing the effectiveness, acceptability and success of development interventions that are aimed at improving food security and livelihoods not only of the pastoralists but also of all rural communities. However, while emphasizing the integration of indigenous knowledge with scientific range management techniques, several factors need to be considered:

- There is need to develop and present the current early warning system signals in familiar ecological and biological indicators that can be easily interpreted by the pastoralists. This would facilitate their transfer into meaningful and timely management decisions that ensure not only survival during but also quick recovery after the disaster and sustainability afterwards. An example is a recent innovation in LEWS where NIRS faecal profiling is used to scan faecal samples to predict the diet of free-ranging livestock. This tool provides an objective and reliable indicator with an early warning capability when interfaced with a geographic information system. NIRS faecal profiling has the potential for compatibility with pastoral communities since the indicator (livestock faeces) is one for which indigenous knowledge is already in existence; in this study, animal faeces/dung is used as an indicator of forage quality.
- The conventional indicators used in monitoring range condition trend should also be developed and transformed to be closely related to the environmental changes that are near in space, time and relationship to the pastoralists to promote the understanding and interpretation of the signals.
- The modern techniques of assessing and monitoring environmental changes should be used to strengthen the existing traditional techniques and practices to improve their effectiveness and promote their adoption without inducing social imbalances.
- It is necessary to have an effective intergeneration transfer of indigenous knowledge by developing it in the local context and incorporating it into school curricula and research; strengthening the traditional information channels; and utilizing civil and religious institutions to promote ITK.

- All the stakeholders (farmers, policy makers, researchers and extension staff) should be involved in problem solving strategies that touch on the indigenous knowledge.
- Networking is necessary to share experiences with other communities considering that indigenous knowledge can be developed out of culture diffusion and is not static.
- A participatory approach is essential to address community-based cultural and socio-economic needs, for example, involving the community in identifying sites for drilling boreholes.
- A well-defined resource tenure system should be put in place to give the pastoralists security of tenure and the right to own land. This would make the herders willing to conserve soil and practice sound range resource management which is imperative given the amount of pressure on natural resources.
- There is need to encourage the pastoralists to diversify their economy and ease reliance on subsistence livestock production so as to escape certain risks which are associated with pure pastoralism.
- It is also necessary to strengthen research on ethnoveterinary medicine and practice and to utilize the knowledge on both traditional and modern medicines to develop more effective remedies for livestock diseases.

Bearing in mind the proposals listed above, there are generally no comprehensive studies that have documented indigenous knowledge in rangeland management in East Africa. The few studies that have been carried out mainly present work that has been done in the rangelands in terms of range productivity in respect of animal productivity. This study has attempted to document the indigenous range resource assessment and monitoring techniques in six selected pastoral and agropastoral communities. However, a further in-depth examination of indigenous range management practices, alongside an analysis of the problems the herders are facing and the solutions they have worked out, would enhance our understanding of the various processes regarding range management. Specifically, there is need for case studies on the various policies that affect the economies and environments of the pastoral and agropastoral communities.

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Appendix 1.

List of plant species with medicinal value mentioned by the Pokot and the Il Chamus

Species	*Disease*	*Form of application*
Salvadora persica	Diarrhoea	Extract of boiled roots administered orally
Salvadora persica	Retained placenta	Extract of boiled roots administered orally
Grewia bicolor	Retained placenta	Extract of boiled roots administered orally
Zanthoxylum chalybeum	Retained placenta	Extract of leaves and bark soaked in water is administered orally
Acacia tortilis	Diarrhoea	Extract of boiled bark administered orally
Cordia sinensis	Diarrhoea	Extract of boiled bark administered orally
Zanthoxylum chalybeum	Cough	Extract of boiled bark administered orally
Zanthoxylum chalybeum	Black quarter	Extract of leaves and bark soaked in water is administered orally
Boscia Salicifolia	Black quarter	Extract of leaves and bark soaked in water is administered orally
Boscia Salicifolia	Cough	Extract of boiled bark and leaves administered orally
Albizia anthelmintica	Worms	Concoction from boiled bark and roots administered orally as a dewormer
Terminalia brownii	Anaplasmosis	Extract of boiled bark administered orally
**Lauruaki*	Trypanosomiasis	Extract of boiled roots administered orally
**Leminyi*	Trypanosomiasis	Extract of boiled roots administered orally
Boscia coriacea	Eye disease	Powder from roasted and crushed seeds and leaves are applied to the affected eye
**Sikirai*	Eye disease	Powder from roasted and crushed seeds and leaves is applied to the affected eye
Acacia nilotica	Eye disease	Raw fruits and pods are squeezed into affected eye
Maerua decumbens	Abscess	Smashed leaves is applied to the affected area, which is later pierced to drain pus
Teclea nobilis	Cough	Concoction of boiled of roots and honey administered orally
Cordia sinensis	Eye disease	Extract from crushed leaves soaked in water overnight is applied to the affected eye
Acacia nilotica	Wounds	Concoction of boiled pods and bark soaked overnight is applied to the affected area
Acacia species	Fracture	An arm's length of bark from Acacia tree trunk is tied on either side of the fractured limb to straighten it
Croton dicigamus	Fertility disorders	Extract from the boiled roots given orally
Maerua subcordata	Fleas	Extract from leaves soaked in water overnight is used to wash the kids and lambs
**Sukuroi*	CCPP	Concoction of extract from crushed leaves soaked in water and mixed with magadi soda is given orally

*Species not identified by their botanical names

Appendix 2.

List of some plant species mentioned by the pastoralists and their uses

Scientific name	*Pokot*	*Il Chamus*	*Use*
Cynodon plectostachyus (G)	*Seretion*	*Longeri*	Forage
Maerua subcordta (S)	*Chepliswo*	*Lamayoki*	Water purifier
Zanthoxyylum chalybeum (T)	*Songowow*	-	Medicinal
Echinochloa haploclada (G)	*Amaranyon*	-	Forage
Boscia coriacea (T)	*Sorichon*	*Sericho*	Medicinal
Acacia mellifera (T)	*Talamong*	-	Forage
Grewia bicolor (S)	*Sitet*	-	Medicinal
Salvadora persica (T)	*Ashokonyon*	-	Medicinal
Cleome gynandra (H)	*Suriyo*	-	Traditional vegetable
Zizyphus mauritianal (T)	*Tilomwo*	-	Forage
Setaria verticellata (G)	*Amerkwia*	-	Forage
Terminalia spinosa (T)	*Tikiti*	-	Forage
Balanites aegyptiaca (T)	*Tuyunwo*	*Lowei*	Medicinal
Teclea nobilis (T)	-	*Llgalai*	Forage
Eragrostis superba (G)	*Chaya*	-	Forage and medicinal
Acacia tortilis (T)	*Ses*	*Lltepesi*	Forage and medicinal
Boscia Salicifolia (T)	*Likwon*	-	Forage
Albizia anthelmintica (T)	*Mukutan*	*Mukutani*	Medicinal
Terminalia brownii (T)	*Koloswa*	*Lbukoi*	Medicinal
Aristida adscensionis (G)	*Chelwowis*	-	Forage
-	-	**Lauruaki (S)*	Medicinal
-	-	**Leminyi (S)*	Medicinal
-	-	**Sikirai (S)*	Medicinal
Acacia nilotica (T)	*Kopkwo*	-	Forage and medicinal
Maerua decumbens (S)	-	*Lamakwenyi*	Forage
Cordia sinensis (T)	-	*Salabani*	Medicinal
Eragrostis cilianensis (G)	*Punyun*	-	Forage
Croton dicogamus (T)	*Kerelwa*	-	Medicinal
Themeda triandra (G)	*Ngiriamatin*	-	Forage
Hyparrenia rufa (G)	*Presongoloion*	-	Forage
Cenchrus ciliaris (G)	-	*Lokorengok*	Forage
Amaranthus spp.(H)	*Kaptanya*	*Llkamasi*	Traditional vegetable
Indigofera spinosa (S)	*Amekunyan*	*Atula*	Forage
Chloris roxburghiana (G)	*Amerkuayon*	-	Forage

Shrub growth form (S); tree (T); grass (G); other herbaceous species (H)
*Species not identified by their botanical names

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