

Challenges of assessing the sustainability of (agro)-pastoral systems [☆]

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ABSTRACT

Pastoralism is not only a livestock-based livelihood strategy but also a way of life with socio-cultural norms and values, and indigenous knowledge revolving around livestock. Pastoral systems in Africa are facing demographic, economic, socio-political and climatic pressures which are driving many pastoralists into non-livestock based livelihood strategies. The changing contexts in which pastoralists operate raise the issue of the sustainability of pastoral systems in dryland Africa. The specific objectives of this paper are: (i) to identify the challenges of assessing the sustainability of pastoral systems with focus on East and West Africa; (ii) to propose criteria and indicators for sustainability assessment of pastoral systems; and (iii) to demonstrate the diversity of pastoral systems by elaborating on features in East and West Africa with case studies from pastoral communities in both regions, namely Samburu in Kenya and Fakara in Niger. All these objectives are to contribute to the debates on the sustainability of pastoralism. Assessing sustainability of pastoral systems is challenging and complex in view of different aspects that should be addressed over time and at different scales. The main challenges addressed in this paper include purpose and interpretation of sustainability, time dimension and scale, diversity of pastoral systems, inter-relatedness of assessment criteria, comprehensiveness and measurability of indicators. To illustrate the challenges, we proposed a number of criteria based on key systems' components of production, stability, efficiency and resilience. For each criterion, a number of indicators were proposed. The criteria we suggested are inter-related and should not be considered in isolation bearing in mind that sustainability is a composite attribute that integrates several variables. In terms of sustainability of pastoral systems in East and West Africa, the key issues are mobility, livestock diversity, livelihood diversification options, and preservation of pastoral tradition and indigenous knowledge. The degree with which these issues are constraining pastoral production and economy will largely shape the trajectory of sustainability of different pastoral systems in both regions.

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1. Introduction

There are multiple concerns regarding sustainability of pastoral systems in Africa (Blench, 2001; FAO, 2001). Firstly,

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there is concern over the ability of pastoral systems to accommodate growing human populations within the constraints of the resources available in dryland agro-ecosystems (Fratkin and Mearns, 2003; McCabe et al., 2010; Thebaud and Batterbury, 2001). Secondly, there is the anxiety that pastoral production systems may not be sustainable because of the possible negative interactions between livestock, and the land and water resources on which they depend (Behnke, 1994). Thirdly, there is apprehension over the appropriateness of policy responses to enable utilization of dryland resources for livestock production (FAO, 2001; McCabe, 1990;

Pedersen and Benjaminsen, 2008) in view of the widespread negative perception of pastoralism by decision-makers in Africa. An assessment of sustainability of pastoral systems thus requires considering the hierarchy of environmental, socio-economic and policy dimensions.

Pastoralism has been defined as an agricultural production system characterized by mobility of animals, with more than 50% of household gross revenue (i.e. the total value of marketed production plus the estimated value of subsistence production) from livestock or livestock-related activities (FAO, 2001; Niamir-Fuller, 1999). Davies et al. (2010) defined pastoralism as extensive production of herbivorous livestock using pasture (or browse). However, pastoralism is more than a production system; it is also a livestock-based livelihood strategy and a way of life with socio-cultural norms and values, and indigenous knowledge revolving around livestock (Davies et al., 2010; FAO, 2001; McCabe, 1990; Niamir-Fuller, 1999; Straight, 1997). In this paper, we consider these various dimensions of pastoralism: an agricultural production system, a livestock-based livelihood strategy and a way of life.

Pastoralism is highly diverse, differentiated by degree of livestock mobility, gender, ethnicity and wealth (de Leeuw and Wilson, 1987; Fratkin and Mearns, 2003; Moritz et al., 2009). Nomadic pastoralism is characterized by constant movement of the herds whereas transhumance pastoralism involves seasonal (regular or irregular) movement of the herds between well-defined territories. Pastoral systems are separated from agro-pastoral systems, by the degree of household revenue coming from crop cultivation (FAO, 2001). The complex social, cultural and productive features of pastoral systems in adaptation to risky arid and semi-arid environments are well documented (Fratkin and Mearns, 2003; Hiernaux, 1993; Moritz et al., 2009; Niamir-Fuller, 1999; Western and Finch, 1986).

Pastoralism is considered (Behnke, 1994; Mace, 1991) the most appropriate production system in drylands, because moving the herds opportunistically is the best way to exploit the highly variable availability, in space and time, of pasture and water resources. Thebaud and Batterbury (2001) considered pastoral systems as the most efficient way “to take profit in common” from scattered and highly variable resources (pasture and water).

Livestock mobility is critical to pastoral systems. It promotes optimal utilization of spatially heterogeneous availability of forage and water resources. Mobility also avoids degradation as it allows herdsmen to move their animals around and thus balance the stocking rate with the availability of rangeland resources. For example, the Fulani pastoralists in West Africa take advantage of seasonal differentiation in rangeland condition, through long-distance grazing movements along a north–south axis (Bassett and Turner, 2007).

Besides, the pastoralists are widely acknowledged for their rich skills and knowledge in animal husbandry and breeding (Blench, 1999; Köhler-Rollefson, 1997). For example, many pastoralists keep detailed mental records of their animals' ancestry, even up to seven generations (Köhler-Rollefson, 1997).

Livestock are the main asset of the pastoralists (FAO, 2001). An advantage of livestock over other wealth stores is

that it has a liquidity that can be mobilized to meet short term family needs (liquidity reducing from small to large ruminants), which is not prone to dissipation due to demands from within and outside of the household (Turner, 2000). As such, livestock is a wealth store for rural households moving in and out of the cash economy as market conditions fluctuate. Moreover, livestock products are important sources of protein in urban and rural diets with demand for milk and meat increasing dramatically as household income rises above the subsistence level. Livestock manure and traction are also seen as key parts of processes of agricultural intensification in agro-pastoral systems. In these ways, livestock have and will continue to play important socio economic roles in rural development.

The ability of this livestock asset base to support pastoral livelihoods is eroding in many pastoral systems. With population growth in pastoral societies as in other rural societies in Africa, there has been decline in terms of per capita livestock holdings in many pastoral communities which below certain threshold is both economically and socially unsustainable (Fratkin and Mearns, 2003; ILRI, 2009; Little et al., 1999; McCabe et al., 2010; McPeak, 2005). As a consequence of declining per capita livestock holdings, the number of impoverished pastoralists has increased. They have thus been forced to move out and seek other forms of livelihood, such as farming, wage employment and welfare-dependency (relying on relief food, particularly in East Africa).

Apart from a livestock-based livelihood system, pastoralism is a way of life with socio-cultural norms and values, and indigenous knowledge revolving around livestock (Hesse and MacGregor, 2006; Straight, 1997). Livestock represent the means through which the continuity of pastoral institutions, traditions and cultural ties are assured and are the currency for building relationships (or social capital) between families, groups and communities. However, pastoral systems in Africa are facing demographic, economic, socio-political and climatic pressures which are driving many pastoralists into non-livestock based livelihood strategies. Besides, the changing contexts in which pastoralists operate are affecting not only the productive capacity of pastoral systems but also pastoralists' ways of life (Fratkin and Mearns, 2003). Pastoral systems are also under threat from the widespread negative perception by the decision-makers in many African countries with substantial pastoralist population (Fratkin and Mearns, 2003).

Pastoral development policies of most African governments have been based on Garret Hardin's thesis of “Tragedy of the commons” (Hardin, 1948). Essentially, these policies considered pastoralism as a land use mismanaging the rangeland resources, responsible for rangeland degradation through overstocking and the associated over-grazing of the communal rangelands (Burke, 2001; Fratkin and Mearns, 2003; McCabe, 1990). To address this problem, some governments with support from international donors initiated private tenure systems for communal rangelands for example group ranch scheme in Kenya (Kimani and Pickard, 1998), commercial ranches or grazing reserves. Other governments initiated policies to sedentarize pastoralists and reduce their herd size and constrain their mobility as their pastoral way of life was perceived as backward and a

major obstacle to development. These government interventions have often had negative and sometimes disastrous effects on pastoral systems (Fratkin and Mearns, 2003; McCabe, 1990).

Above we mentioned the multiple concerns regarding sustainability of pastoral systems in Africa, the benefits of pastoralism and challenges being faced. These challenges raised the question of sustainability of pastoralism. There have been many attempts addressing sustainability in pastoral systems from a single perspective, for example rangeland management which addresses the sustainability of utilization of the land resource base (Behnke, 1994). However, sustainable development in agriculture in general and in pastoral systems in particular should aim at multiple goals such as conserving land, water, plant and animal genetic resources, in environmentally non-degrading, technically appropriate, economically viable and socially acceptable manner (de Wit et al., 1995; FAO, 1992). This implies that a multi-sectoral perspective or holistic approach is needed to address sustainability of pastoral systems (Hansen, 1996; Reardon, 1995). Thus, sustainable development in pastoral systems has to address ecological, economic, social and cultural dimensions.

The specific objectives of this paper are: (i) to identify the challenges of assessing the sustainability of pastoral systems with focus on East and West Africa; (ii) to propose criteria and indicators for sustainability assessment of pastoral systems; and (iii) to demonstrate the diversity of pastoral systems by elaborating on features in East and West Africa with case studies from pastoral communities in both regions, namely Samburu in Kenya and Fakara in Niger. All these objectives are to contribute to the debates on the sustainability of pastoralism.

2. Challenges of assessing sustainability of pastoral systems

Assessing sustainability of pastoral systems is challenging and complex (de Wit et al., 1995; Hansen, 1996) in view of different aspects (ecological, productivity, socio-economic, and institutional) that should be addressed over time and at different scales (Fratkin and Mearns, 2003), and the data requirements for such a comprehensive analysis. This complexity might be the reason for the absence of empirical data-based assessments of sustainability of pastoralism, and this might have accounted for divergent views on the future of pastoralism by different experts (ecologists, anthropologists, geographers, economists, environmentalists, animal scientists, and system analysts). The few attempts that have been made focused on single criterion such as rangeland productivity, livestock productivity, household food consumption and revenue from livestock products (Behnke, 1994; Coppock, 1994; Fratkin and Mearns, 2003; Zaal, 1998). Coppock (1994) suggested per capita production of milk and per capita accumulation of male cattle as assets for the assessment of sustainability of pastoral systems in the Borana Plateaus of Southern Ethiopia. In his assessment for the pastoral communities in Kajiado district of Kenya and for Fulani pastoralists in Oudalan and Seno provinces of Burkina Faso, Zaal (1998) focused on household revenue from sale of livestock and livestock products.

The main challenges of assessing sustainability of pastoral systems that will be addressed in this paper include purpose and interpretation of sustainability, time dimension and scale, diversity of pastoral systems, inter-relatedness of assessment criteria, comprehensiveness and measurability of indicators. These challenges are by no means exhaustive but we have focused on key ones regarding pastoral systems in East and West Africa.

2.1. Purpose and interpretation of sustainability

Sustainability is a multi-dimensional concept with diverse underlying motivations (de Wit et al., 1995; Fresco and Kroonenberg, 1992; Hansen, 1996). In his review of the concept of agricultural sustainability, Hansen (1996) provided two broad interpretations namely sustainability as an approach to agriculture developed in response to concerns about impacts of agriculture (that is, unsustainability) and sustainability as a system property. Fresco and Kroonenberg (1992) interpreted sustainable agriculture as the use of agricultural land in such a way to ensure that over time no net quantitative or qualitative loss of natural resources occurs. In elaborating on this interpretation, the above authors identified four conceptual components of sustainability namely; production (output from the system over time), efficiency (ratios of conversion of inputs into outputs), stability (degree of fluctuation around output trend) and resilience (speed of restoration of output trend after major disturbance). Essentially, Fresco and Kroonenberg (1992) interpreted sustainability as a system property.

In this paper, we also interpret sustainability as a system property as this interpretation is logically more consistent, conceptual, practical and easier to characterize than interpreting sustainability as an approach (Hansen, 1996). The motivations behind sustainability assessment are twofold: to evaluate existing systems and to design interventions as to avoid unsustainable practices (Hansen, 1996). In interpreting sustainability, we consider it as a relative value, that is, a system is sustainable up to a certain degree over a certain period and not an absolute value (that is, a systems is either sustainable or not). In addition, we consider sustainability as a composite attribute that integrates several variables (criteria). Hence, no system can be considered unsustainable based on a single criterion. A practical example is that a pastoral system cannot be considered unsustainable based on rangeland carrying capacity alone as often done (Coppock, 1994; McCabe, 1990).

2.2. Time dimension and scale

The main challenge here is what time period should be used to assess sustainability of agricultural systems. In principle, sustainability implies “long-term” viability and stability of the systems (de Wit et al., 1995). The Brundtland Commission report (United Nations, 1987) suggested a time period of 40 years (grandchildren era) to assess sustainability of a system. Thus, a variation in productivity of livestock and vegetation over short periods would not be suitable to assess sustainability as these might reflect climate driven short term variation rather than long term trends. In addressing the challenge of time dimension, de Wit et al. (1995) suggested that the acceptable time should be based on the probability of

substitution of a specific resource with long time frames in case of irreversible consequences (like extinction of species), and shorter ones for resources with higher probabilities of substitution (e.g. soil nitrogen). Whatever time frame may be used, our emphasis here is that the focus of sustainability assessment of pastoral systems should be on long term trends while filtering out short term seasonal and year to year variation. This raises the problem of lack of reliable long term data on diverse variables of the pastoral systems in Africa.

The issue of scale is very important in sustainability. The main question is at what level do we assess sustainability of pastoral systems – household, community, district, region, country, etc.? The answer to this question will depend on the purpose of sustainability assessment. The mobility of livestock and pastoral households also adds to the problem of scale. For example, grazing by livestock within a community territory may lead to natural resource degradation but if the livestock have access to pastures outside the territory in the district, there may not be degradation. In this case, we can assess the sustainability of the system at both the community level and district.

2.3. Diversity of pastoral systems

As explained in the introductory section, pastoral systems in East and West Africa are diverse depending on degree of mobility, gender, ethnic group, wealth and engagement in non-livestock based activities. There is diversity across and within pastoral systems (Moritz et al., 2009). Associated with this diversity is the challenge of identifying appropriate criteria for sustainability for different pastoral systems. For example, assessing sustainability of nomadic pastoralism is fraught with most difficulties because of the high and frequent mobility of both livestock and households, and the system's boundaries are not easy to define. Similar problem associated with mobility, though less pronounced, may be encountered with transhumance pastoralism. For pastoralists who cultivate crops and or engage in other non-livestock based livelihood activities, the criteria for sustainability has to address these in addition to livestock-based activities.

2.4. Inter-relatedness of criteria for sustainability assessment

Given that assessment of sustainability of pastoral systems is system-oriented, there is the challenge of inter-relatedness of criteria for assessment and the weight to attach to different criteria to arrive at a comprehensive and objective evaluation. For example in the proposed criteria in Table 1, pasture productivity is related to climate change and variability while livestock productivity depends on pasture productivity, livestock mobility and livelihood diversification options. The implication of inter-relatedness of the criteria is that they cannot be examined in isolation (Hansen, 1996). This also implies that it will be misleading to interpret sustainability of pastoral systems based on isolated criteria. Therefore, the observation by Sandford (2006) that if per capita livestock holdings is below certain minimum (about 5–6 cattle for “pure” pastoralists and half this minimum herd-size for “agro-pastoralists”) is questionable in terms of assessing sustainability of pastoral systems. The challenge of including many criteria in assessing sustainability of pastoral systems is

the weight to attach to these criteria. Should household food security be given higher weight than pastoral tradition (Table 1)? Again, the purpose of sustainability assessment will largely influence which criteria to include and what weight to attach to each criterion.

2.5. Comprehensiveness and measurability of indicators

Measurability of indicators for some criteria proposed in assessing sustainability of pastoral systems (Table 1) are difficult in view of the spatio-temporal heterogeneity of most production processes in the pastoral systems. This is even more challenging for indicators relating to socio-cultural aspect. For instance, which indicators can be used to capture pastoral tradition? The indicators we proposed for pastoral tradition (Table 1) such as emigration rate to urban areas, proportion of the community with higher education and proportion of the community growing crop are proxy, indirect, and are quite debatable. The temptation may be to restrict the indicators to parameters that can be quantified but the danger is leaving out important qualitative criteria. The other challenge is restricting the indicators to few manageable parameters but this can attract the criticism of not being comprehensive. The indicators we proposed in Table 1 for assessing sustainability of pastoral systems are by no means exhaustive but are to illustrate the challenges and complexity of a comprehensive assessment.

3. Study locations

For this review on sustainability of pastoral systems in East and West Africa, we used baseline data from two (agro)-pastoral communities, namely the Samburu in Kenya and the Fakara in Niger. Baseline information on the two sites is presented in Table 2. In addition to baseline information on the two study locations, we used relevant published information to illustrate the challenges of assessing sustainability of pastoral systems.

3.1. Pastoral community in Samburu

The baseline information from Samburu came from the surveys conducted by ILRI (2008) in Suguta Marmar, Ngari, Sere Olipi and Archers Post sites (ILRI, 2008). In Suguta Marmar and Ngari, some households were growing crops but Sere Olipi and Archers Post were pastoral areas with no cropping. The pastoralists in these sites are all Samburu. Samburu pastoral community is located in Samburu District which is just north of the equator in the Rift Valley province of Northern Kenya (Holtzman, 1996; Nanyingi et al., 2008). The district is bordered by five other Districts; Turkana (Northwest), Baringo (Southwest), Marsabit (Northeast), Isiolo (East) and Laikipia (South), respectively (Konaka, 1997; Straight, 1997). Samburu district lies between Latitudes 0°40" north and 2°50" north of the equator and Longitudes 36°20" east and 38°10" east of the Prime Meridian. The Samburu (people) are closely related to the Maasai of East Africa. They speak a similar language, derived from Maa, which is called Samburu and their dialect is mutually intelligible with that of the closely related Maasai (Straight, 1997). Traditionally, the Samburu are semi-nomadic pastoralists. Cattle, as well as sheep, goats and camels, are of utmost

Table 1
Criteria and indicators for assessing sustainability of pastoral systems in East and West Africa at household and community level.

Criterion	Sustainability component ^a	Mediating factor	Indicator
Provision of food for the household (food security)	Resilience	<ul style="list-style-type: none"> –Household size –Household labour –Herd size and productivity –Crop cultivation –Household assets 	<ul style="list-style-type: none"> –Energy (calorie) intake –% children under 5 years malnourished (infant mortality) –Household dependency ratio –Household income
Pasture productivity	Production, efficiency, stability, resilience	<ul style="list-style-type: none"> –Annual precipitation and rainfall patterns –Soil fertility –Floristic composition 	<ul style="list-style-type: none"> –Carrying capacity –Biomass –Pasture quality –Species richness and diversity –Soil nutrients (organic matter, nitrogen, phosphorus)
Livestock productivity	Production, efficiency, stability, resilience	<ul style="list-style-type: none"> –Feed resources –Grazing management –Herd management –Livestock species and breed 	<ul style="list-style-type: none"> –Herd size –Species composition –Milk offtake –Mortality rate –Reproductive performance
Livestock mobility	Production, resilience	<ul style="list-style-type: none"> –Land use pattern –Policy to protect livestock corridor –Information on pasture and water at destination points –Pastoral social networks –Security –Herd size –Availability of herding labour 	<ul style="list-style-type: none"> –Distance livestock can move freely to access pasture and water –Animal performance and productivity
Livelihood diversification options	Production, stability, resilience	<ul style="list-style-type: none"> –Agro-ecological zone –Household and community resource endowments –Access to credit –Market access –External shocks –Social networks/pastoral organizations –Government policy 	<ul style="list-style-type: none"> –Revenue from non-livestock based livelihood (e.g. commerce, remittances from migration) –Number of rural credit institutions
Household economy and community development	Production, resilience	<ul style="list-style-type: none"> –Livelihood strategies –Social networks –Community based development initiatives –Government investment in rural development 	<ul style="list-style-type: none"> –Household income –Remittances from migrants –Community infrastructures (e.g. school, primary health centre)
Pastoral tradition and indigenous knowledge	Production, resilience	<ul style="list-style-type: none"> –Pastoral institutions and organizations –Means of transmission of local knowledge –Livelihood strategies –Formal education –Production objective –Access to new technology 	<ul style="list-style-type: none"> –Employment rate in the community –Emigration rate to urban areas –Proportion of the community with higher education –Proportion of the community growing crop

^a These refer to conceptual components of sustainability suggested by Fresco and Kroonenberg (1992) namely; production (output from the system over time), efficiency (ratios of conversion of inputs into outputs), stability (degree of fluctuation around output trend) and resilience (speed of restoration of output trend after major disturbance).

Table 2Baseline information on biophysical and socio-economic profiles of pastoral communities in East (Samburu, Kenya) and West Africa (Fakara, Niger)^a.

Variable	Site	
	Samburu	Fakara
Agro-ecological zone	Semi-arid	Semi-arid, Sahel
Pastoral ethnic group	Samburu	Fulani
Dominant pastoral systems	Transhumance pastoralism with some households growing crop	Agropastoralism
Crop cultivation (% of households in the community)	36%	90%
Major crops	Maize	Millet, cowpea
Rainfall pattern	Bimodal; Long rain: April–June Short rain: October–December	Monomodal: June/July–Sept
Annual precipitation	300–600 mm	400–600 mm
Average household size (adult equivalent)	3.8	6.48
Annual population growth rate	2.9	3.2
Education level		
Illiterate	60%	66%
Primary school	34%	6%
Secondary	6%	0%
Koranic education	0%	28%
Average herd/flock size per household (TLU) ^b		
Cattle	3.5	7.0
Sheep	2.4	0.9
Goat	1.8	1.4
Milk offtake (l/day)	1.9	1.1
Rangeland management	Open communal rangeland	Open communal rangeland
Livestock mobility	Short distance transhumance (<50 km from homestead)	Both short and long distance transhumance

^a Data sources – For Samburu, Kenya: ILRI, 2008; for Fakara, Niger: Hiernaux and Ayantunde, 2004; Ayantunde et al., 2008.

^b TLU: Tropical Livestock Unit represents 250 kg live weight; equivalent of 1 camel, 1.43 cattle, 10 sheep/goats.

importance to the Samburu culture and way of life. For the Samburu, livestock are more than a form of wealth and a source of subsistence. Livestock constitute the cement of social relations, and a focal point of ritual acts and meanings (Holtzman, 1996; Perlov, 1987; Straight, 1997). Though Samburu regard themselves as cattle herders, there has been an increase in the significance of small stock in both highland and lowland areas (Perlov, 1987).

The Samburu lands are mostly quite dry, but with considerable variation due primarily to altitude (Straight, 1997). The lowlands are predominantly semi-desert and *Acacia* scrub, while the highland areas of the Leroghi Plateau are open grasslands, going into forest at the highest elevations (Straight, 1997). Cropping by Samburu pastoralists is common in the highlands but absent from the lowlands due to low and erratic rainfall and low soil fertility. Their huts, so called *manyattas*, are built from mud, hide and grass mats strung over poles. A thorny fence is built around the huts to protect livestock from wild animals (Nanyingi et al., 2008). The huts are constructed so they are easily dismantled and portable when they move to a new location. The Samburu usually live in groups of five to ten families. Traditionally men look after the cattle and they are also responsible for the safety of the tribe. As warriors they defend the tribe from attack by both man and animals. They also go on raiding parties to try and take cattle from rival Samburu clans. Samburu boys learn to tend cattle from a young age and are also taught to hunt. Samburu women are in charge of gathering roots and vegetables, tending to children and collecting water. They are also in charge of maintaining their homes. Samburu girls generally help their mothers with their domestic chores. Samburu society is fundamentally based on their age-set system (gerontocracy;

Konaka, 1997). Young men are initiated around the age of 15–18, and stay unmarried bachelor warriors (*Imurram*) for approximately 14 years (Straight, 1997).

In recent decades a variety of factors have greatly reduced the vitality of the livestock economy, forcing most Samburu to supplement their subsistence with wage labour, commercial livestock trading (though irregular), brewing, and in higher rainfall areas, farming (Straight, 1997). As with many traditional tribes in Africa, the Samburu are also under pressure from the government to settle into permanent villages (Nanyingi et al., 2008) but this has been met by extreme reluctance by the Samburu as it would disrupt their entire way of life. Besides, the status and wealth in Samburu culture is synonymous with the amount of cattle one owns. Hence, a sedentary agricultural lifestyle is not attractive (Nanyingi et al., 2008). From the household surveys conducted in Samburu in 2008 (ILRI, 2008), average household size was 3.8 adult equivalent and the herd and flock size per household were 3.5, 2.4 and 1.8 TLU for cattle, sheep and goat, respectively (Table 2). In addition, 36% of about 300 households interviewed were growing crops, especially maize. The study area has a bimodal rainfall distribution from April to June (long rains) and October to December (short rains). The annual rainfall ranges from 300 to 600 mm (Table 2). There is a livestock market in Suguta Marmar, one of our four study sites in Samburu. In a study on Samburu livestock market in Suguta Marmar by Konaka (1997), he observed that though the Samburu take advantage of the livestock market, their aim is not maximization of cash but maximization of their livestock. Hence, they seem to utilize the livestock market for a system of conversion based on two-way flow of circulation between livestock and cash.

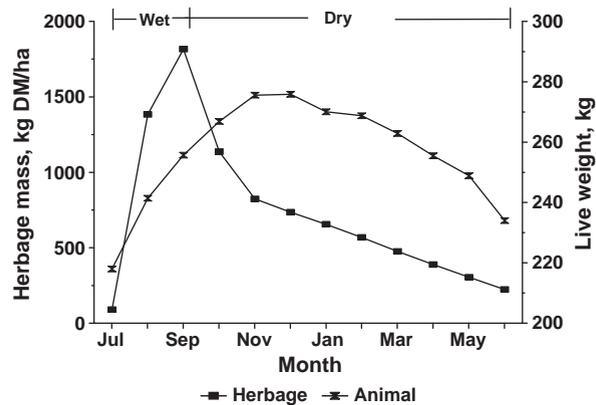


Fig. 1. Standing herbage mass (kg dry matter/ha) of rangeland and body weight development of grazing steers in agro-pastoral system in South western Niger. Source: Ayantunde (1998).

3.2. Pastoral community in Fakara

Fakara region is situated in southwestern Niger (Kollo administrative district) and it lies between the confluent valleys of the Niger River to the west and the fossil valley of the Dallol Bosso to the east. The study site has been described in detail by Turner and Hiernaux (2002). The climate of Fakara is typical upland semi-arid tropical climate with annual rainfall ranging from 400 to 600 mm (Turner and Hiernaux, 2002). The study site is populated mainly by the Djermas ethnic group, who are historically land cultivators. Fakara also harbours significant numbers of Fulani (about 20% of the population of the study site) who are pastoralists by tradition but are increasingly engaged in farming. According to the survey conducted in 2004 (Ayantunde et al., 2007), about 90% of the Fulani households in Fakara grew crops in addition to livestock husbandry (Table 2). Since the droughts of the 1970s, pastoralists with insufficient livestock are increasingly farming on land that is usually leased to them by farmers holding usufruct. There are many poor Fulani in Niger who have abandoned pastoralism to take up farming (Moritz et al., 2009).

Nevertheless, for the Fulani most prestige is derived from keeping cattle. The Fulani pastoralists are found in the arid and semi-arid zones of many countries in West Africa from Senegal to Nigeria. In Fakara as in many rural communities in sub-Saharan Africa, human population is growing rapidly as shown in Fig. 2. The population of Fakara grew from 3000 to 13,300 from 1950 to 2000 (Fig. 2). Due to the demographic pressure there is increasing expansion of crop field into grazing lands and this is pushing the pastoralists to go on long distance transhumance to the sub-humid zones (Bassett and Turner, 2007).

Livestock in Fakara graze either freely or supervised by herders, the latter being the most common practice, especially for cattle. Cattle, sheep and goats are generally corralled during the night to collect manure in fields scheduled for cultivation the following cropping season (Fernández-Rivera et al., 2005). With the exception of some lactating cows kept on the homestead for the provision of milk and animals unable to walk long distances, cattle are taken on transhumance to the pastoral zone at the beginning of the rains and

returned to the cultivated zone when millet and cowpea are harvested (Fernández-Rivera et al., 2003). Once back in the cultivated zone the herds are taken to graze crop residues in millet fields in intensely cultivated areas before returning to the village lands. The vegetation in Fakara, as in other West African Sahel, is dominated by annual grasses (Hiernaux et al., 2009). Rangeland biomass in Fakara fluctuated from 700 to 1300 kg DM/ha between years in response to variability in precipitation (Hiernaux et al., 2009). The natural vegetation in Fakara and the West African Sahel as a whole remains remarkably resilient to droughts, in spite of wide amplitude of the inter-annual changes in production and species composition (Hiernaux and Ayantunde, 2004). The soils are sandy and generally of low fertility. To demonstrate rapid expansion of crop field into grazing areas, the cropped area in Fakara increased from about 9% of the territory in 1950 to about 40% in 1995 at the expense of fallow and rangelands (Hiernaux and Ayantunde, 2004), and this trend is expected to continue. However, the decline in pasture availability due to reduction in grazing areas is partly compensated for by the increase in crop residue biomass.

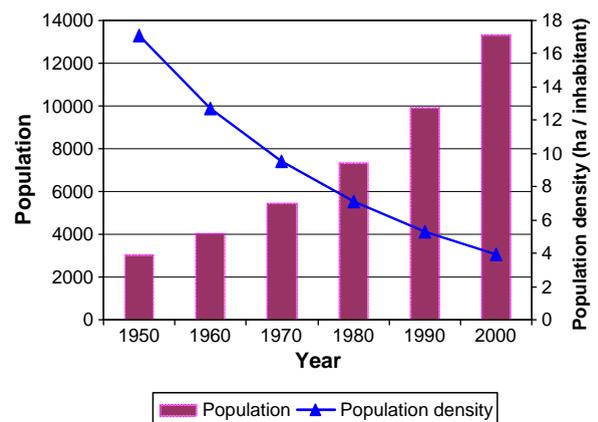


Fig. 2. Population growth of agro-pastoral community in Fakara, South-western Niger from 1950 to 2000. Source: Baoua (2003).

4. Proposal for assessing sustainability of pastoral systems in East and West Africa

To illustrate the challenges and complexity of a comprehensive assessment of sustainability of pastoral systems, we proposed a number of criteria and the indicators that could be used to measure different criteria (Table 1). These criteria were selected based on key elements of the systems namely production, stability, efficiency and resilience. However, in addition to these components suggested by Fresco and Kroonenberg (1992), we also considered socio-cultural aspect and household economic welfare in determining the criteria for sustainability assessment. The criteria we suggested are, household food security, pasture productivity, livestock productivity, livestock mobility, livestock diversification options, household economy and community development, and pastoral traditions. These criteria address ecological, socio-economic and institutional aspects of sustainability. These criteria could be used at household and community level.

4.1. Ecological sustainability of pastoral systems

The key criteria to assess the ecological sustainability of pastoral systems in East and West Africa include pasture productivity, livestock productivity and mobility (Table 1). These criteria address the production, efficiency and resilience components of sustainability. All these criteria are significantly affected by climate change and variability, which greatly influence the ecological sustainability of pastoral systems (Blench, 2001; FAO, 2001). African drylands, where pastoral systems are dominant, are characterized by climate variability especially in terms of rainfall amount and distribution (Ellis and Galvin, 1994). Associated with the climate variability are the frequent occurrences of drought in pastoral areas over the past three decades in East and West Africa. In both our study locations, Samburu and Fakara, the incidence of drought was reported to be frequent (Hiernaux and Ayantunde, 2004; Perlov, 1987; Sperling, 1989). With climate change, it has been predicted that extreme weather events such as drought and flooding will be more frequent (Thornton et al., 2009) and this will directly affect the ecological sustainability of the pastoral systems in terms of both primary and secondary productivity. In the past, one of the key coping strategies of the pastoralists in response to drought was short or long distance movement of their herds in search of pasture and water (Bassett and Turner, 2007; Straight, 1997; Turner, 2000) but livestock mobility is increasingly becoming restricted due to expansion of crop field into grazing lands especially in West Africa (Hiernaux and Ayantunde, 2004) and due to land fragmentation in East Africa (McCabe et al., 2010). Thus, protection of grazing lands from encroachment by the cultivators through relevant land use regulations and tenure systems is critical to ensuring livestock mobility. Besides, livestock mobility is necessary to avoid overstocking.

Pasture productivity mainly determines the number of animals that could be supported for different production objectives (meat, milk, traction and manure). The determinant factors for pasture productivity include annual precipitation and rainfall patterns, soil fertility and floristic

composition of the vegetation (Table 1). Useful indicators for pasture productivity include carrying capacity, biomass, pasture quality, species richness and diversity and soil nutrients (Table 1). In West African Sahel where pastoral systems dominate, pasture productivity and quality are high in the wet season but decline as the season advances (Fig. 1). Also, livestock productivity always follows the trend of pasture productivity (Fig. 1). The late dry season (March to June) is characterized by severe feed shortage and low (poor) animal performance. Surveys of pasture productivity in agro-pastoral territory of Fakara in Niger from 1994 to 2006 showed that there was 5% annual decrease in herbaceous production (Hiernaux et al., 2009) which was not explained by rainfall. The declining trend in herbaceous production could be attributed to soil fertility and land use patterns. Changes in land use, grazing pressure and soil fertility also triggered changes in species composition with a strong reduction in diversity in rangelands and fallows (Hiernaux et al., 2009). The declining trends of pasture productivity and species diversity may not be a good sign for ecological sustainability of pastoralism in Fakara region in view of increasing restriction on livestock mobility. However, for the agro-pastoralists in Fakara as in many pastoral communities in West Africa, crop residues form important feed resources in the dry season. In East Africa, forage availability is most likely to be affected negatively by land fragmentation. And in view of low integration between pastoralism and crop agriculture in the region, declining trend in pasture productivity will seriously affect livestock productivity. In lowland areas of Samburu where rainfall is low and erratic, pasture productivity is low though there is dominance of perennial plant species with bi-modal rainfall pattern (Perlov, 1987; Straight, 1997). In the highland areas of Samburu, there is one long rainy season from April to August with intermittent rain in November and rainfall is generally high (Perlov, 1987; Straight, 1997). Though pasture productivity on highlands is relatively high, there is the problem of rapid expansion of crop fields to grazing areas due to favourable soil conditions (Perlov, 1987).

Livestock productivity is another key criterion to assess the sustainability of pastoral systems (de Leeuw and Wilson, 1987). Reproductive performance, mortality especially calf mortality and herd growth are the main determinants of herd performance of pastoral systems in East and West Africa (de Leeuw and Wilson, 1987). According to these authors, calf mortality has been identified as the most important factor causing low output of pastoral systems because at the death of the calf, milk supply from its dam for human consumption ceases and the future performance and growth of the herd can be seriously affected. Besides, mortality is a critical factor in determining herd reconstitution by the pastoralists after seasonal loss due to feed scarcity and drought (McCabe, 1990). Herd size is another indicator of livestock productivity in pastoral systems as keeping large herd size is a common risk mitigation strategy by the pastoralists (McPeak, 2005). The logic behind keeping large herd size is that the more animals one has going into a crisis period, the more one can expect to have once the crisis has passed (McPeak, 2005). In Samburu, as for most pastoralists in East Africa, per capita livestock holdings have declined significantly since 1980 (Little et al., 1999). Ten to 12% of pastoral population in

Samburu district was reported to be stockless or near-stockless herders (Little et al., 1999).

Livestock mobility is another important criterion in assessing ecological sustainability of pastoral systems in East and West Africa. There is a general consensus that the sustainability of pastoral systems hinges heavily on ability to move the livestock around for pasture and water. McCabe (1990) observed that mobility and livestock diversity are the cornerstones of sustainable pastoral productivity. However, there is increasing restriction to livestock mobility in both East and West Africa due to cultivation in former grazing areas and land fragmentation, particularly in East Africa (Bassett and Turner, 2007; McCabe, 1990; McCabe et al., 2010; Pedersen and Benjaminsen, 2008). In our study location in Samburu, livestock mobility is restricted to short distance transhumance (less than 50 km from the home-stead; Table 2). In Fakara, both short and long distance transhumance are practiced. In a study on transhumance in 1998, Fernandez-Rivera et al. (2003) reported that herders from Fakara covered 350 km on long distance transhumance to the northern Sahel in the wet season. On returning to their base in Fakara after crop harvest, the herders went on short transhumance southward of about 85 km to graze crop residues. Transhumance practices by the pastoralists in Fakara demonstrate that transhumance (in this case both short and long distance) complements feed resources between cultivated and pastoral zones, and this contributes positively to sustainability of the systems.

In applying these proposed criteria for assessing ecological sustainability of pastoral systems, a number of challenges that have to be addressed include scale, time dimension, definition of system's boundaries, and inter-relatedness of assessment criteria. For example, with long-distance livestock mobility in Fakara, low pasture productivity may not be a limiting factor to livestock production if there is access to pasture in other territories and to crop residues. This confirms the observation of McCabe (1990) that sustainability of pastoral productivity rests heavily on livestock mobility. The challenge of time dimension in assessing sustainability of pastoral systems can be illustrated by pasture productivity in the Sahel, which is normally characterized by wide spatio-temporal variability (Hiernaux et al., 2009). The challenges of scale, diversity and inter-relatedness of assessment criteria have to be addressed in assessing the pastoral systems in Samburu in view of the enormous differences between lowland and highland areas in terms of bioclimatic conditions, diversification options, and food aid dependency. Sustainability assessment at district level will mask much of the variation within the district. Assessment at household level will characterize well certain sustainability criterion such as livestock productivity but criteria such as livestock mobility and pasture productivity (if rangeland is communal) may not be well captured.

4.2. Socio-economic sustainability of pastoral systems

Some essential criteria proposed for inclusion in the assessment of socio-economic sustainability of pastoral systems in East and West Africa are household food security, livelihood diversification options, household economy and community development, and pastoral tradition (Table 1). All

these criteria are pertinent to resilience of pastoral systems. Meeting household food need (calorie intake) is a key indicator of socio-economic sustainability. This implies that sustainable pastoral systems not only meet the present household food requirements but also assure satisfaction of the future household food needs. Based on this premise, the increasing dependency on external food reliefs to meet dietary needs in many pastoral communities in East Africa is not a good sign regarding the sustainability of the systems. In many pastoral communities in East Africa, food aid is a critical component of local economies, and many families depend on it on a regular basis (Little et al., 1999). In a review by Little et al. (1999) on economic diversification and risk management among East African herders, they reported that in lowland Samburu more than 45% of women were frequently receiving food aid during the late 1980s. For such food aid dependent communities, it has been suggested that many of the pastoralists should abandon pastoralism (Fratkin and Mearns, 2003). According to these authors, some Maasai pastoralists have transformed rapidly from semi-nomadic pastoralists to agro-pastoralists, ranchers and urban workers and the ability of most Maasai to achieve self-sufficiency through livestock production alone has been lost. Sustainability for many pastoral communities necessitates having access to agricultural as well as pastoral resources (Fratkin and Mearns, 2003). For Samburu pastoral communities, Sperling (1987) reported that since the droughts of 1980 and 1984, there has been increasing involvement in wage labour and settling in towns by the Samburu pastoralists. According to this author, 54% of young men of less than 40 years in Samburu district had wage labour experience. In West African pastoral communities, food aid is not common except during severe droughts (Pedersen and Benjaminsen, 2008).

Livelihood diversification strategy is another criterion proposed for assessing socio-economic sustainability of pastoral systems in East and West Africa (Table 1). Livelihood diversification options vary with different pastoral communities depending on agro-ecological zone (bioclimatic condition), household and community resource endowments, access to credit, market access, external shocks, social networks and government policy. Little et al. (1999) observed that favourable agricultural areas offer a high prospect of crop cultivation by the pastoralists. Agriculture is only viable in about 3% of the Samburu district, according to Straight (1997) which implies that the option of farming by the Samburu pastoralists is limited. In lowland areas of Samburu district, agriculture is not viable due to low and erratic rainfall and low soil fertility whereas the highlands serve as important pockets of crop production by the Samburu pastoralists (Little et al., 1999). In Fakara, there is expansion of crop field into grazing areas and nowadays most pastoralists (90%) grow crops, mainly millet and cowpea. Household wealth is another important factor in diversification options to pursue. Whereas the poor pastoralists are "pushed" or forced into diversification through poverty, the wealthy ones often choose to diversify to maximize economic returns and to manage risk. Besides, there are also gender-specific diversification strategies (Little et al., 1999). For example, young men from Samburu pastoral community often work as security guard while women are involved in petty trade such as selling milk, vegetable trading, handicrafts

and illegal brewing of beer (Holtzman, 1996; Straight, 1997). From sustainability perspective, the more diverse the livelihood options pastoral communities can pursue the better.

Preservation of traditions of pastoralists is also essential to the sustainability of pastoralism in East and West Africa. Knowledge and skills of livestock husbandry and breeding are unique to the pastoralists and the future of pastoralism will depend partly on the preservation of this social capital. Preservation of the cultural identity of pastoral communities requires that indigenous knowledge be passed from generation to generation. Migration of the young pastoralists into urban areas and formal education are seriously undermining pastoral traditions and local knowledge. Related to this is the household economy and community development as this has significant effect on the decision of the young pastoralists to leave their communities to urban areas. Poor pastoral households are surely under economic pressure to send their young people to urban areas for work in order to improve household economy. In both East and West Africa, seasonal migrations of young pastoralists to urban areas for work are quite common and some migrants even stay permanently at their destinations (Ayantunde, 1998; Hesse and MacGregor, 2006). Holtzman (1996) and Nanyingi et al. (2008) also reported that many Samburu families who have been forced to settle often send their young men to the cities to work as guards. This underlines the necessity of diverse livelihood options for the present survival and future security of many pastoral communities. Pastoral environments are changing rapidly and the pastoralists have to change by adopting non-livestock based livelihood strategies in addition

to livestock husbandry. Sustainability of pastoralism in East and West Africa will depend on opportunities for pastoral communities to participate in a diverse number of economic activities.

In applying these proposed criteria for assessing socio-economic sustainability of pastoral systems, a number of challenges that will be faced are scale, time dimension, inter-relatedness of assessment criteria and measurability of indicators for the assessment criteria. While there may not be a problem of scale as regards household food security and economy, pastoral traditions can be both at household and community level. Besides, these proposed criteria are inter-related. For example, household economy is related to food security and livelihood diversification strategy. Moreover, pastoral traditions influence livelihood diversification strategy and household economy. Measuring the indicators we proposed for pastoral traditions is particularly challenging as they are proxy and debatable compared to the indicators for criteria for assessing ecological sustainability such as biomass, pasture quality, mortality rate etc.

5. Features of pastoral systems in East and West Africa

To elaborate further on the challenges of assessing sustainability of pastoral systems with respect to diversity, we examine the features of pastoralism in East and West Africa. In spite of the high diversity of pastoralism as differentiated by ethnicity, gender and livestock assets (Fratkin and Mearns, 2003; McCabe, 1990; McPeak, 2005), pastoral systems in East and West Africa still have many features in common (Table 3). Pastoral systems in both

Table 3
Key features of pastoral systems in East and West Africa.

Feature	East Africa	West Africa
Production objective	To meet subsistence needs, sale of live animals and livestock products to meet household needs, coping strategy against shocks especially drought, socio-cultural functions	To meet subsistence needs, sale of live animals and livestock products to meet household needs, coping strategy against shocks especially drought, socio-cultural functions; some pastoralists engage in livestock trade
Drivers of change	Demographic pressure, market opportunities, climate change, government policy to sedentarize pastoralists	Demographic pressure, climate change especially drought, government policy
Land use pattern	Increasing privatization of rangeland, emergence of group ranches especially in Kenya, cultivation of crop	Communal rangeland, expansion of crop field into grazing areas
Feed resources	Mainly dependent on natural pastures	Mainly dependent on natural pastures but with increasing importance of crop residues
Vegetation	Perennial dominated species characterized by spatio-temporal variation	Annual dominated species characterized by spatio-temporal variation
Herd management strategies	Herd mobility, herd diversity (raising different species), herd dominated by female especially for cattle, herd splitting	Herd mobility, herd diversity (raising different species), herd dominated by female especially for cattle, herd splitting, giving out animals to relations to keep
Livestock mobility	Short distance movement but increasing restriction to mobility due to privatization and fragmentation of land	Short and long distance movement but increasing restriction to mobility due to expansion of crop field into grazing land. Some pastoralists go on long distance transhumance to sub-humid zones
Other livelihood options (beside livestock)	Crop cultivation though recent, remittances from migration of young people to urban areas	Most pastoralists grow crops since the droughts of 1970s and 1980s, seasonal migration to urban areas and coastal countries, small scale commerce
Conflict and security issue	Tradition of violent theft of cattle (cattle rustling) and problem of armed rebellion in the Horn of Africa	Most pastoral areas are safe except near Sahara desert where there is armed rebellion by the Tuaregs. Problem of livestock theft is very low. However, farmer–herder conflicts persist near the cropping zones.
Market access	Long distance from the urban centres	Proximity to large urban centres and developed cattle markets
Vulnerability to climate change especially drought	Increasingly vulnerable due to increased frequency of droughts and less diversified livelihood strategies, high reliance on external reliefs.	Increasingly vulnerable due to increased frequency of droughts, increasing reliance on crop, little or no reliance on external reliefs except in case of major drought

regions are facing similar drivers of change in term of demographic pressure, climate change especially drought, and government policy to settle the pastoralists. In both regions, pastoral households still depend on livestock-based livelihood and engage in similar herd management strategies of mobility, diversity (raising different species), herd splitting and giving out animals to relations to keep. Besides, there is a growing trend of crop cultivation though to a varying degree. In West Africa, more pastoralists cultivate crops than in East Africa (Moritz et al., 2009), a pattern also apparent from the surveys in Samburu, Kenya and Fakara, Niger (Table 2). Moritz et al. (2009) attributed the higher prevalence of farming among pastoralists in West Africa to bioclimatic conditions and mono-modal rainfall patterns which make it easier to grow crops. The production objectives of pastoralists in East and West Africa are similar which are first of all meeting the household subsistence needs (household food need) and meeting emergency needs (Hesse and MacGregor, 2006; Thebaud and Batterbury, 2001). In addition, livestock serve as insurance against shocks such as droughts, when pastoral households normally sell their animals to buy grains. Cattle ownership is still a source of prestige to many pastoral groups in both East and West Africa, and the culture and values of pastoralists still revolve around livestock. Regardless of the region, mobility is critical to pastoral systems though the degree of mobility differs between the East and West Africa. In Samburu, most pastoralists are increasingly engaging in short distance movement of less than 50 km whereas in Fakara, the pastoralists engage in both short and long distance movement. In the region, more pastoralists are moving their herds to even longer distance to the sub-humid zone (Bassett and Turner, 2007).

A major difference between East and West Africa is that mobility and drought response in West Africa is along a latitudinal gradient of about 1000 km, with ample space and grazing resources in areas in the south where there is agriculture. This poses the challenge of scale in assessing the sustainability of pastorals systems in both regions. Though there may be competition with increasing crop cultivation with the southerly movement of livestock in West Africa, the lands south of the Sahel are still capable of receiving pastoralists with their livestock and also offer the possibility of poor pastoralists switching to farming (FAO, 2001; Turner, 2000). In East Africa, climatic gradients are not latitudinal but topographic. Accordingly, the change in rainfall per km distance is steeper in East Africa than in West Africa, the difference being one to two orders of magnitude, depending on topographic gradient (Fig. 3a and b). Besides, in the East African highlands there are land uses which are incompatible with livestock grazing as high elevation drought refuges for the pastoralists have been converted to agriculture thereby reducing the resilience of pastoral systems in East Africa (Campbell, 1999). Consequently, livestock mobility in East Africa is restricted and largely within arid lowland areas where the possibility of finding good grazing is erratic.

Another major difference between pastoral systems in East and West Africa concerns land use. There is increasing privatization of rangeland in East Africa, especially Kenya, whereas this does not exist in West Africa as grazing lands are still communally owned. In Kenya, there is the emergence of group ranches which has been promoted by the government

(Kimani and Pickard, 1998). The group ranch scheme was launched in Kenya in the late 1960s and was perceived as an enlightened approach to modernizing the Maasai pastoralists. The thrust of this scheme was the conversion of communal land tenure, with flexible access to resources, to group tenure with fixed and legally recognized boundaries. However, from the mid 1980s, group ranches were sub-divided and group ranch members were issued title deeds to individual plots (Kimani and Pickard, 1998) and this has led to further rangeland fragmentation. In addition Maasai pastoralists sold their plots to non-Maasai with a background in cropping. These immigrants tend to fence their lands as they do not appreciate benefits of livestock mobility. Consequently, land fragmentation is now a serious constraint to livestock mobility in Kajiado district and many other pastoral areas in Kenya (Kimani and Pickard, 1998). The above example of group ranch scheme by the Kenya government illustrates the important role government policy may play in sustainability of pastoral systems. If we consider sustainability as a system property, government policy may not be an appropriate criterion for sustainability assessment but the reverse is the case if sustainability is considered as an approach to agriculture. This demonstrates the challenge of purpose and interpretation of sustainability.

In addition there is a major difference in the level of integration of livestock husbandry with agriculture (Moritz et al., 2009) between pastoralism in East and West Africa. West African pastoralists have a tradition of integrating agriculture and pastoralism, which is not common in East Africa (Ellis and Galvin, 1994). The case of the Fulani pastoralists who have a long tradition of interactions with farming groups such as Hausa and Djerma in Niger through manure contracts and exchange of milk for grains is a good illustration of this. In the case of East African pastoralists, it has to be emphasized that there is increasing integration of crop production and livestock among certain pastoral communities in the past four decades where bioclimatic conditions are favourable. For example, McCabe et al. (2010) reported that about 90% of the Maasai pastoral communities in the Ngorongoro Conservation Area in Tanzania had adopted cultivation due to decline in per capita livestock holdings. The integration of livestock husbandry with agriculture poses the challenge of scale and definition of system's boundary in assessing sustainability of pastoral systems.

Another difference is access to market. Pastoralists in West Africa are near to large urban centres where there are historically well-developed cattle markets and therefore have better opportunities to market their livestock products (Moritz et al., 2009) compared to the pastoralists in East Africa who are often far away from the urban centres. For example, some Samburu villages in north-central Kenya are far away from major towns and it is not uncommon to find livestock travelling hundreds of kilometer (walking for about 4 days) to the nearest livestock market (Konaka, 1997). To address this problem, Kenya government established a periodic livestock market in Suguta Marmar in Samburu district in 1991 (Konaka, 1997). In West Africa, there is a well established livestock trade between the Sahelian countries (Burkina Faso, Mali and Niger) and coastal countries (Nigeria, Ghana and Cote D'Ivoire) which also provides market opportunities for the pastoralists (Williams et al., 2006).

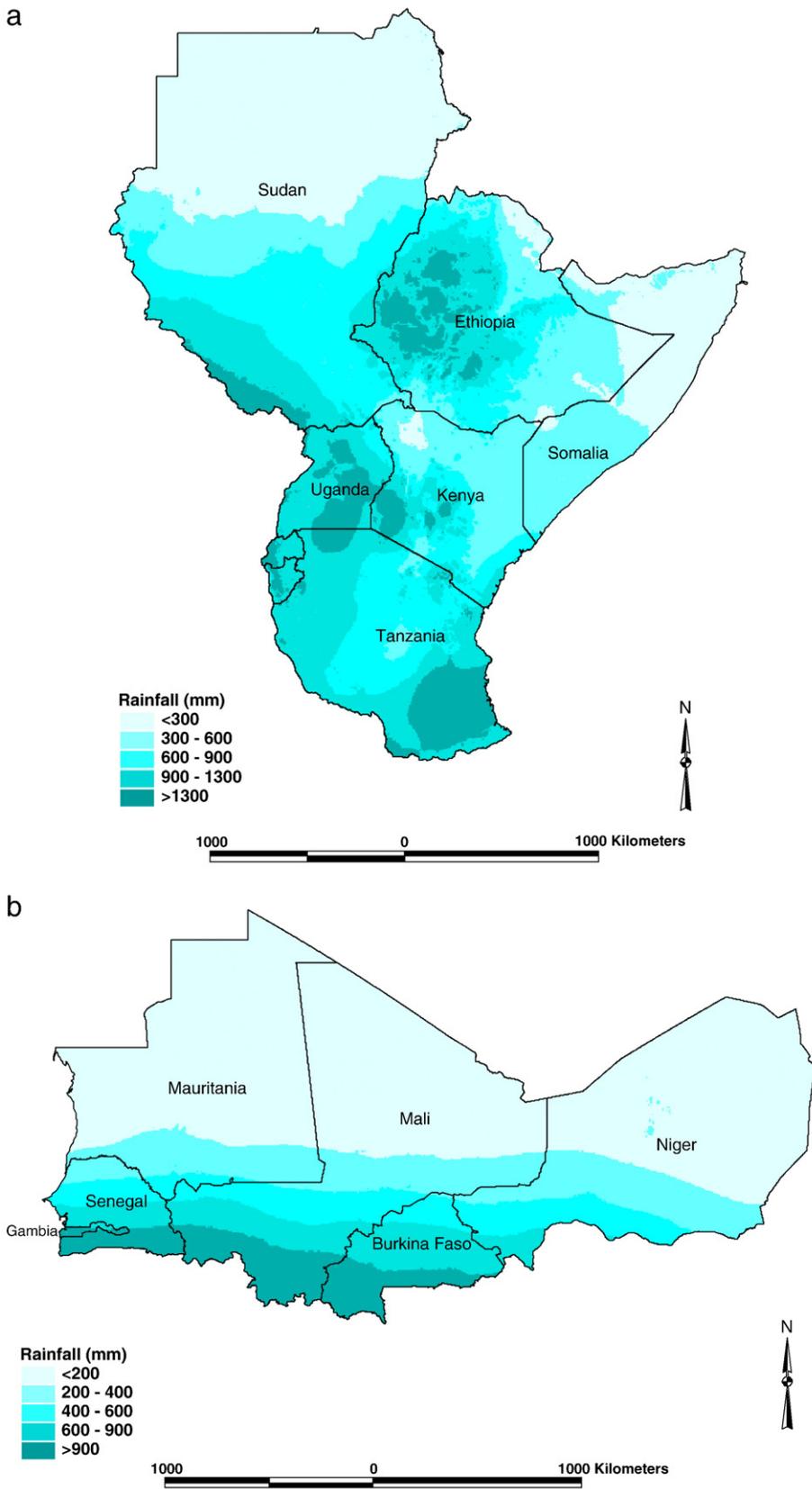


Fig. 3. a. Gradient in rainfall in East Africa. b. Gradient in rainfall in West Africa.

Though there is the potential of exporting livestock and livestock products from East Africa to the Middle East, there are sanitary and phytosanitary regulations (SPS) to meet which often serve as barrier to livestock trade.

At regional level, most features of pastoralism in East and West Africa are similar except for the major differences in terms of the level of integration of crop production with livestock and its effect on mobility, and market access. There is also the major difference of food aid dependency which is increasingly becoming a feature of pastoralism in East Africa but is not an issue among pastoral communities in West Africa. The major weakness of our comparison at regional level is that location-specific differences and variance between the different pastoral systems in both regions are not well addressed.

6. Conclusion

This paper on challenges of assessing sustainability of pastoral systems in East and West Africa has shown a number of issues to address for any comprehensive assessment, namely purpose and interpretation of sustainability, time dimension and scale, diversity of pastoral systems, inter-relatedness of assessment criteria, comprehensiveness and measurability of indicators. In terms of sustainability of pastoral systems in both regions, the key issues to address are mobility, livestock diversity, livelihood diversification options, and the preservation of pastoral tradition and indigenous knowledge. The extent to which these issues are constraining pastoral production and economy will largely shape the trajectory of sustainability of different pastoral systems in East and West Africa. Other main conclusions from this review are:

- Sustainability is a composite attribute that integrates the system as a whole and includes several criteria. It would be inappropriate to consider a pastoral system unsustainable based on a single criterion. A practical example is that a pastoral system cannot be considered unsustainable based on rangeland carrying capacity alone as often done.
- Criteria for assessing sustainability of pastoral systems are inter-related and they cannot be examined in isolation. It will therefore be misleading to interpret sustainability of pastoral systems based on isolated criteria.
- Focus on sustainability assessment of pastoral systems should be on long term trends while filtering out short term seasonal and year-to-year variation.
- Sustainability of pastoralism in East and West Africa will depend on opportunities for pastoral communities to have access to agriculture and participate in a diverse number of economic activities.
- Pastoral systems in both regions have many features in common. However, there are major differences in land use patterns, the level of integration of livestock husbandry with agriculture, access to market and degree of food aid dependency.

Conflict of interest

There is no conflict of interest in any way which influenced our views in this manuscript.

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