Environmental Research Journal 5 (1): 11-17, 2011
ISSN: 1994-5396

Assessing Socio-Ecological Change Dynamics Using Local Knowledge in the Semi-Arid Lowlands of Baringo District, Kenya

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Abstract: A clear understanding of the social and ecological change dynamics in pastoral ecosystems is imperative for formulation of appropriate policies that ensure sustainable resource use and livelihood security of pastoral households. Spatial and temporal ecological knowledge expressed by those with long familiarity with the ecology has been shown to be more superior in quality and resolution than those gathered remotely and modelled digitally. This study adopted a local-perceptions approach in assessing the social and ecological change dynamics in the Njemps Flats of Baringo district over a period of four decades. The results reveal a changing vegetation structure, declining diversity and increasing soil erosion that are attributed to the rise in both human and livestock populations. The results also show a rising trend in diversification of asset portfolios in response to impoverishment as a result of the declining pasture and livestock productivity. These findings suggest that pastoralism in Baringo is a system in transition, attempting to maintain itself while at the same time trying to adapt progressively to a continuously shrinking resource base.

Key words: Socio-ecological trends, local knowledge, semi-arid lowlands, Baringo district, quality, resolution

INTRODUCTION

Technical advances in the recent past have unequivocally shown that the entire world is undergoing rapid ecological changes at local, regional and global scales (UNEP, 2008) and that the most obvious and pronounced change is caused by human land-use. Most affected are the arid and semi-arid ecosystems owing to their inherent climatic variability that render them more susceptible to land-use pressure than other ecosystems. In Kenya, just like elsewhere in Africa, all factors that undermine pastoralism are believed to be responsible for the man-induced process of range degradation. The degradation of pastoral areas has led to the erosion of the economic livelihood of pastoralists which is reflected in increased destitution among pastoral households.

Maitima *et al.* (2009) points out that the expansion of urban centres from 7% in 1960 to 30% in 2001 is partly responsible for land-use change and range degradation in Kenya. In a study conducted in the semi-arid rangelands of southeast Kajiado District, Kenya, Campbell (2003) reported the expansion of agriculture into critical grazing areas as a result of increase in human population. Kristjanson *et al.* (2002) while working in Kitengela in Kajiado District of Kenya found that considerable social and ecological changes have occurred in the area over the last 40 years. They reported increase in privatisation of land, crop cultivation and livelihood diversification. These social and ecological dynamics bear similarities across rangelands of Eastern Africa and are a cause of concern for the integrity of pastoral ecosystems and livelihoods. This calls for a clear understanding of the dynamics with the aim of formulating appropriate policies to ensure livelihood security and improved well-being of pastoral households. The spatial and temporal ecological understanding expressed by those with long familiarity with the ecology have been shown to be superior in quality and resolution to those gathered remotely and modelled digitally. Turner and Hiernaux (2002), for example have demonstrated that maps of livestock activity based on local herder knowledge prove more effective and accurate for management than those rigorously developed through spatial modelling. Similarly, Njoka *et al.* (2004) underscored the importance of investigating change from the people most affected by the change and who have experienced it over the years. It therefore implies that by incorporating and evaluating such knowledge, researchers come closer to an accurate picture of the overall system and therefore likely to bridge the gap between the rural populace and experts which is viewed largely as one of communication (Al-Kodmany, 2001). This study adopted local knowledge analysis to explore

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the longitudinal relationship between land cover, land-use, rainfall variability, human and livestock populations. The hypotheses of this study were that the social and ecological change dynamics in the Njemps Flats are interlinked and that local knowledge and perceptions on the socio-ecological trends corroborate the conventionally generated information.

MATERIALS AND METHODS

Study area: This study was conducted in the Njemps Flats of Baringo District, Kenya. The study area is a semi-arid rangeland located between latitude 00°30'N and longitude 36°00'E that falls within agro-climatic zone IV and V, receiving an average rainfall of 500 mm per annum. The average altitude of in the Njemps Flats is 900 m above sea level. The main vegetation classes include Acacia woodland (80%), permanent swamp and seasonally flooded grassland (15%) and shrub grassland (5%) (Wasonga, 2009). The soils in the Njemps Flats are generally shallow silt loam to clay loam, with low organic matter. The main land-use practice in the study area is livestock production.

Methods: A combination of methods was used to collect data in this study. Based on the land-use system, the study area was divided into two strata namely, sedentary agro-pastoral and semi-nomadic land-use system. A stratified random sampling procedure as described by Nyariki was used in data collection. A structured questionnaire was used to obtain specific information on socio-ecological perceptions of the local communities. A total of 110 persons were interviewed, 55 in each of the two strata. Focus Group Discussions (FGDs) were used to clarify responses that appeared unclear and assess if there was a consensus on general social and ecological trends as perceived by the individual respondents. Informal discussions involving key informants with considerable knowledge about issues under investigation were further used to verify the gathered information. This study targeted elderly persons over 60 years of age. Data collected was analyzed using Statistical Package for Social Sciences (SPSS).

RESULTS AND DISCUSSION

Vegetation and soil change dynamics: The perceptions of the respondents on the changes in vegetation characteristics and the reasons behind the trends are shown in Fig. 1 and Table 1, respectively. The results indicate that plant diversity and cover generally declined in the study area during the period under study. The

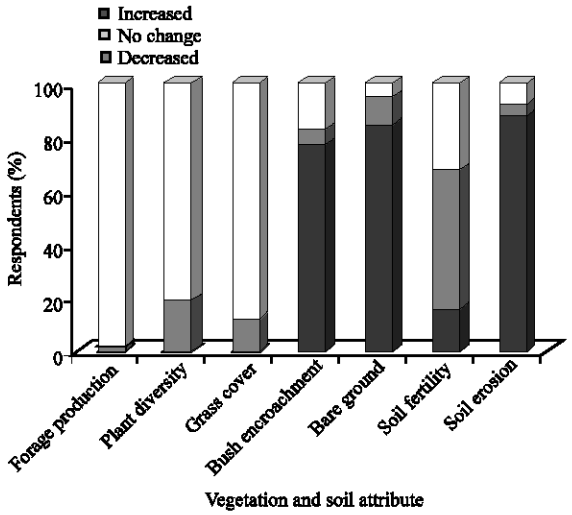

Fig. 1: Vegetation and soil change trends in the past 40 years as perceived by local communities

Table 1: Reasons for the observed trends in vegetation and soil characteristics

Attribute	Reason for the observed trend	Frequency (N = 105)	Percentage of respondents
Forage production, plant diversity and vegetation cover	Land clearing for settlement and cultivation	49	46.7
	Overgrazing	27	25.7
	Decline in rain-days and frequent droughts	21	20.0
	Cutting of trees for building and fencing	8	7.6
Soil erosion	Overgrazing	55	52.4
	Land clearing for settlement and cultivation	43	40.9
	Cutting of trees for building and fencing	7	6.7

decrease in rain-days, overgrazing and tree felling for building and fencing in that order were mentioned as the main causes of the decline in plant species diversity. The general decrease in vegetation cover was however, attributed to land clearing for settlement and cultivation, decline in rain-days and frequent droughts, overgrazing and cutting of trees for building and fencing, in that order. While grass cover has declined in the area during the past four decades, bush encroachment was reported to have increased, the latter trend being attributed to invasion by *Prosopis juliflora* which is an exotic species introduced in the area in the 1980s.

The results of this study show that certain plant species decreased while others increased in abundance in the last 40 years. Most of the species that declined in abundance were key perennial forage species such as *Cynodon dactylon*, *Eragrostis superba*, *Heteropogon contortus*, *Aristida mutabilis*, *Acacia nilotica*, *Terminalia brownii*, *Zizyphus pubescens*, *Cordia sinensis*

Table 2: Plant species that declined in abundance in the past four decades

Plant species				
Scientific name	Local name*	Growth form	Uses	Reasons for decline
Aristida adscensionis L.	Chelwoyon (T) Chelwowis (T)	Perennial grass	Source of forage and thatching material	Cutting for thatching, and decline in rainfall
Aristida mutabilis Trin. and Rupr.	Nyorikibsowe (P)	Perennial grass	Forage	Decline in rainfall
Cynodon dactylon (L.) Pers.	Longeri (N) Seretion (P)	Perennial grass	Forage	Overgrazing and decline in rainfall
Eragrostis superba Peyr.	Chaya (P)	Perennial grass	Forage; used for making beddings/ cushions and burnt to produce aromatic smoke	Overgrazing and decline in rainfall
Heteropogon contortus (L.) Beuv. ex R. and Sch.	Salwan (T)	Perennial grass	Forage	Overgrazing and decline in rainfall
Indigofera schimperi Jaub. and Spach	Longortomia (N) Barkelat (T) Mbirkwo (P)	Shrub	Forage	Overgrazing and decline in rainfall
Ficus thonningii Blume	Ilng'aboli (N) Tipoiwa (P) Boyotwa (T)	Tree	Source of logs for making bee hives	Land clearing for settlements and cultivation
Acacia drepanolobium Harms ex Sjostedt	Ngowo (T) Ayelion (P) Luai (N)	Tree	Forage	Overgrazing
Acacia nilotica (L.) Del.	Chebiwey (T) Kopkwo (P)	Tree	Source of construction posts	Cutting for building and fencing and land clearing for cultivation
Terminalia brownii Fres.	Koloswet (T) Koloswo (P)	Tree	Source of edible fruits, medicine for yellow fever, forage and timber	Cutting for building and fencing and land clearing for cultivation
Zizyphus pubescens (Oliv.)	Tangarurwet (T)	Shrub	Source of forage and edible fruits	Decline in rainfall
Acacia rubica Benth.	Ildepe (N) Pilil (P)	Tree	Forage	Decline in rainfall
Cordia sinensis (*C. gharaf*, *C. rothii*)	Salabani (N/T) Adomeon (P)	Shrub	Forage	Charcoal burning
Grewia sp. K. Schum	Ilkogomi (N) Toronwo (P/T)	Shrub	Forage	Cutting for building and fencing

*P = Pokot; T = Tugen; N = Njemps (Il Chamus)

Indigofera schimperi, *Grewia* sp. and *Acacia drepanolobium* (Table 2). The decrease in abundance of these species was generally attributed to overgrazing, harvesting for building and fencing, decline in rain-days, clearing of land for settlement and cultivation, overgrazing and charcoal burning.

On the other hand, some exotic species such as *Prosopis juliflora*, *P. chilensis*, *Opuntia ficus-indica* and *Euphorbia tirucalii* introduced in the area during the early 1980s have increased in abundance. The most widespread alien species is *P. juliflora*. According to the local communities, since its introduction, *P. juliflora* has colonized initially bare grounds and invaded critical grazing areas, thereby suppressing herbaceous vegetation.

The findings indicate that soil erosion increased while soil fertility and vegetation cover declined during the period under investigation. Loss of vegetation cover through overgrazing, land clearing for settlement and cultivation were mentioned as the main factors that predispose soil to wind and water erosion. Soil erosion was mentioned to have contributed to declining forage and crop productivity and consequent insecure and often loss of livelihoods in the study area. According to De Groot *et al.* (1992), in the 19th century, periodic burning of pastures by pastoralists suppressed thorny scrubs and most of the study area was covered by grassland. Otieno and Rowtree (1986) indicated that loss of vegetation diversity and cover in Baringo district begun during the colonial administration as a result of land reforms that restricted mobility of pastoralists and increased cultivation.

Climatic and hydrological trends: This study reveals that the study area experienced notable climatic changes in the past four decades. Figure 2 shows the climatic trends as perceived by the local communities. Despite the decrease in rain-days, heavy torrents accompanied by floods were reported to be more common currently than 40 years ago. The results show that rainfall has become increasingly unreliable over the years. While the atmospheric temperature was perceived not to have changed much in the last four decades, winds were reported to be stronger than before. This in addition to the torrential rains were

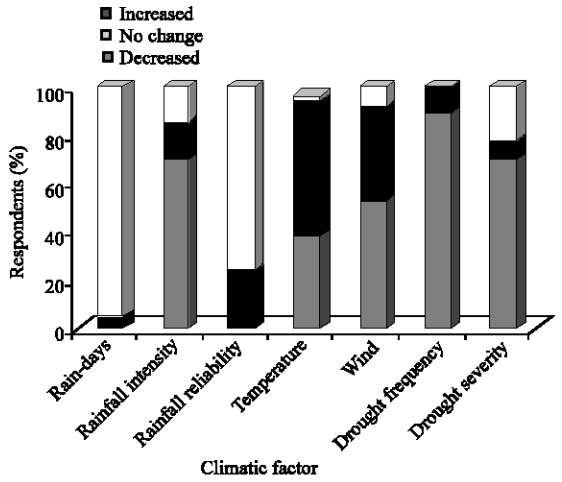

Fig. 2: Climatic trends during the last 40 years as perceived by local communities

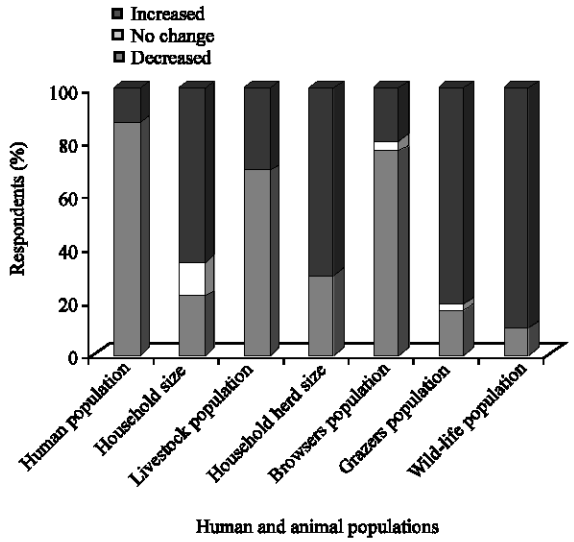

Fig. 3: Human and animal population trends in the Njemps Flats during the last 40 years as perceived by local communities

blamed for the soil erosion observed in the area. More frequent and severe droughts were perceived to be responsible for the reduced water level in Lake Baringo and intermittency of most rivers which were previously permanent. Lake Baringo was reported to have receded for approximately 2 km.

River Endao, one of the major sources of water in the area was reported to have changed its course several times in the recent past and has since become seasonal. Although, they could not give clear reasons for the changes observed in climatic factors, the local communities alluded to the destruction of the environment but could not quantify how this affected the rainfall regime. What they believed, though and stated with some degree of certainty was that climate is changing.

According to Kipkorir (2002), while the annual rain-days have been decreasing in the study area, annual and monthly rainfall has been homogeneous between 1965 and 2000, implying that the rainfall amount per rain-day is increasing in the study area. The shrinking of Lake Baringo was attributed to frequent droughts and siltation due to soil erosion in the lake basin. Onyando *et al.* (2005) reported a decrease in the depth of the lake from 8 m in 1969 to 1.7 m in early 2003.

The report also shows a decreasing trend in the surface area of the lake from 219 km^2 in 1976, 136 km^2 in 1986, 114 km^2 in 1995 and 108 km^2 in 2001. A study conducted by Johansson and Svensson (2002) found that a number of streams have dried out and become seasonal in the past few decades. The study also reported fluctuating water discharge amounts in river Molo and river Perkerra between 1963 and 1985.

Demographic trends: The findings of this study show that the overall human and livestock populations increased during the last 40 years (Fig. 3). The household size was however, perceived to have declined during the same period. A report by Tokida (2001) indicated that the historical immigration and the natural population growth led to a tenfold increase in the human population in the Njemps Flats between 1948 and 1999 and that the population density increased from 4.4-44 persons km^{-2} in the same period. The 1999 human population census shows that the population of Baringo district was growing at 2.65% and was expected to rise from 265,241 in 1999 to 336,346 in 2008 (ROK, 2001). A similar trend was reported in the rangelands of Kajiado district. The human population of Kajiado district increased from 4,799 in 1927 to 258,659 in 1989 (ROK, 2001), to 406,054 in 1999 and was projected to reach 464,883 in 2002 and 609,349 at the end of 2008 (ROK, 2001).

The human population increase in Kajiado was attributed to encroachment into high potential ranges of the district by farming communities. The reasons given by the local communities for the observed population trends are shown in Table 3.

The increase in human population was attributed to immigration of non-pastoral communities, growth of urban centres and improved health care. The rise in livestock population was however ascribed to both increase in human population and improved veterinary services. The decrease in household size was associated with the tendency towards monogamy and increase in formal education. While goat and camel populations have

Table 3: Reasons for the observed trends in human and animal populations as perceived by local communities

Attributes	Reason for observed trend	Frequency (N = 105)	Percentage of respondents
Increasing human population	Improved health care	35	33.3
	Immigration of non-pastoral communities and growth of urban centres	70	66.7
Decreasing household size	Formal education	74	70.5
	Decline in polygamy	31	29.5
Increasing livestock population	Rising human population	67	63.8
	Improved veterinary services	38	36.2
Decreasing household herd size	Diminishing grazing land	53	50.5
	Poverty	26	24.7
	Tribal conflicts	8	7.6
	Sale of livestock to pay school fees	11	10.5
	Lack of herding labour	7	6.7
Decreasing grazers population	Tribal conflicts	10	9.5
	Lack of herding labour	18	17.2
	Bush encroachment	77	73.3
Increasing browsers population	Lack of herding labour	39	37.1
	Bush encroachment	66	62.9
Decreasing wildlife population	Destruction of habitat	100	100.0

increased in the area, the population of cattle and sheep has declined, a trend linked to bush encroachment implying that the environment has become more suitable for browsers than grazers. Household herd size was reported to have decreased mainly due to diminishing grazing land, increased poverty and tribal conflicts in that order. Sale of livestock to pay school fees and lack of herding labour were other reasons for the dwindling household stocks.

Herding labour was mentioned as a serious problem as most of the children attend school therefore making them unavailable for herding. This is made worse when the livestock have to be sold to pay their school fees. The destruction of habitat as pastoralists continue to settle and cultivate was given as the major reason for decline in wildlife numbers. It emerged in this study that donkey population is rising in the Njemps Flats and that the reason is the frequent droughts that necessitate the need for the beast in fetching water. The fact that donkeys do not require herding has further contributed to their growing population.

Livelihood trends: The main sources of livelihood in the study area were found to be livestock and crop production, in order of importance. Important alternative livelihood options included small business enterprises (petty trade), honey production, formal employment, fishing and charcoal production, in that order. Livestock and crop production were reported to have shown declining trends in the past 40 years while with exception of fishing, all the alternative livelihoods were perceived to be increasing (Fig. 4). The declining trend in livestock production was linked to the diminishing grazing land, followed by frequent droughts and lack of herding labour (Table 4). The latter was attributed to school attendance by children who traditionally provide herding labour. The

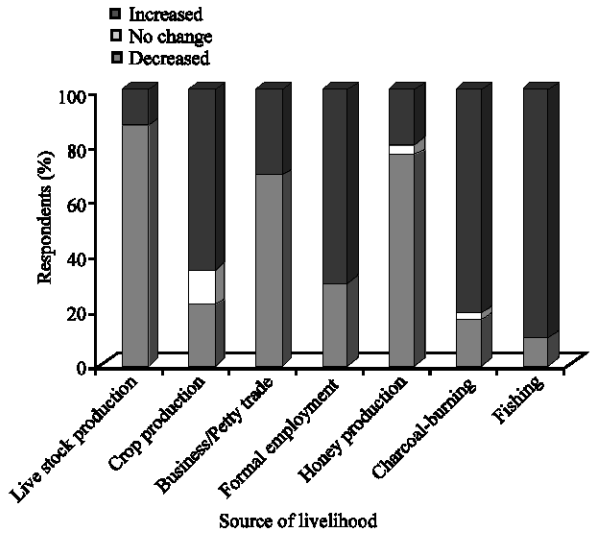

Fig. 4: Livelihood trends as perceived by local communities

Table 4: Reasons for the observed trends in livelihood activities

Livelihood activity	Reason for the observed trend	Frequency (N = 105)	Percentage of respondents
Livestock production	Diminishing grazing land	53	50.5
	Droughts	35	33.3
	School attendance by children	17	16.2
Crop production	Droughts	63	60.0
	Soil degradation	42	40.0
Petty trade	Diminishing grazing land	81	77.1
	Declining livestock production	13	12.4
	Droughts	11	10.5
Honey production	Declining livestock production	56	53.3
	Diminishing grazing land	38	36.2
	Poverty	11	10.5
Charcoal production	Poverty	55	52.4
	Declining livestock production	30	28.6
	Diminishing grazing land	20	19.0
Fishing	Droughts	69	65.7
	Siltation of Lake Baringo	36	34.3
Formal employment	Declining livestock production	46	43.8
	Diminishing grazing land	59	56.2

perceived major reason for declining crop production was frequent and severe droughts and soil degradation. The increasing poverty, decline in livestock production and shrinking grazing land were blamed for the rising charcoal burning by the pastoral households. The increasing involvement of pastoral households in petty trade as an alternative livelihood activity was attributed to diminishing grazing land, declining livestock production and frequent droughts (Table 4). These perceptions corroborate the findings of Kristjanson *et al*. (2002) who reported declining productivity in both livestock and crops accompanied by an increase in diversification of livelihoods in the pastoral areas of Kitengela and Magadi divisions in Kajiado district of Kenya. They linked the trends to land sub-division, sedentarization and population increase, especially due to immigration of cultivators into high potential grazing areas of the district.

CONCLUSION

The results of this study reveal a changing vegetation structure, declining plant diversity and herbaceous cover and increasing soil erosion in the study area during the past four decades. These trends are attributed to the land-use pressure associated with rise in both human and livestock populations, in addition to rainfall anomalies. As perceived by the local communities, despite the decline in rain-days, torrential rains have become common and are responsible for the soil erosion in the study area. The increasing alternative sources of livelihood among the pastoral households are responses to deprivation due to declining range productivity and recurrent droughts. These findings indicate that pastoralism in Baringo is a system in transition, attempting to maintain itself while at the same time trying to adapt progressively to continuously changing socio-ecological environments. It is crucial to encourage the pastoralists to venture into viable alternative activities, as adaptation to the inevitable changes, than try to improve their productivity under the traditional production systems. Livelihood diversification should, however, not undermine the pastoral system of production but modify it to conform to the current socio-ecological conditions to ensure its sustainability as the key livelihood activity.

The results demonstrate that pastoralists have a good understanding of their environments and that their knowledge and perceptions provide a rich source of historical information. The general concurrence of these results with those that are conventionally generated indicates the potential of local knowledge as a complimentary source of information. This, therefore, calls for more investigation, documentation and dissemination of local knowledge as away of bridging the gaps in historical data.

ACKNOWLEDGEMENTS

This research was made possible by funding from the Swedish International Development Co-operation Agency (Sida) through the Pastoral Information Network Programme (PINEP), University of Nairobi. We are grateful to Mr. Philemon Kemei, Laban Labat, Maina Kemei and pastoral communities in the Njemps Flats for their support during this study.

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