Kimiti et al. Pastoralism: Research, Policy and Practice (2016) 6:24
DOI 10.1186/s13570-016-0070-0

Pastoralism: Research, Policy and Practice

RESEARCH Open Access

Community perceptions on spatio-temporal land use changes in the Amboseli ecosystem, southern Kenya

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Abstract

Resource changes observed in rangeland ecosystems have triggered a myriad of ecological, social and economic dynamics, often with adverse implications on pastoral livelihoods. This study applied an integrated approach using local knowledge and spatial technologies to assess the long-term changes in pastoral resources and their implications to pastoral livelihoods in the Amboseli ecosystem in southern Kenya. Reduction in grazing land was perceived by the community to be the main change in pastoral resources that has occurred over the 40-year period. The decline was reported to be more pronounced under sedentary (50 %) and semi-nomadic (47 %) land uses than in the nomadic pastoral land use sites (30 %). This trend was attributed to expansion of cultivation and settlements, which increased by 26 and 17 %, respectively, in sedentary and 17 and 12 %, respectively, in semi-nomadic during the period under study, due to land tenure changes. The use of participatory resource mapping provided an entry point for eliciting community perceptions of problems facing them in order to guide sustainable resource planning and action at a local level.

Keywords: Community perceptions, Land use type, Land use and land cover changes, Rangeland resource trends

Introduction

Globally, over 200 million pastoral households and over one billion livestock herds that include camels, cattle, sheep and goats are supported by the rangeland ecosystems (Alkemade et al. 2011; Dong et al. 2011; Bekele and Kabede 2014). Rangelands are often referred to as pastoral lands because pastoralism characterized by extensive livestock production is the main land use activity in these areas. They provide daily and seasonal forage, water resources and breeding grounds to large concentrations of terrestrial wild animals and livestock (Curtin and Western 2008; Western et al. 2009a, 2009b; Niamir-Fuller et al. 2012; Mbau 2013).

Rangeland ecosystems consist of various resources with many ecological, social and economic values (Little and Mcpeak 2014). The key resource areas as described by Worden et al. (2003) and Ngugi and Conant (2008) form the fundamental components that influence ecological patterns and processes in the rangeland ecosystems. The key resource patches include dry and wet season grazing areas (hereafter referred to as grazing areas), variety of habitats, salt licks, watering points and migratory corridors, which link seasonal grazing areas with settlements and markets (Behnke and Freudenberger 2013).

Rangelands are undergoing land use and land cover changes, mostly through conversion to croplands and human settlements (Tsegaye et al. 2010). Worldwide, an estimated 4.7 million km^2 of grassland and 6 million km^2 of woodland have been converted to croplands since 1950 (Tsegaye et al. 2010). In Kenya, land use changes in rangelands have been mostly attributed to permanent settlement by pastoral communities as a result of population growth and partly to the establishment of protected areas in Kenya since the 1940s (Kioko and Okello 2010; Morara et al. 2014). The result is curtailed mobility of pastoral herds which undermines extensive livestock production in the rangelands.

In Kajiado County, wildlife dispersal areas have been converted to settlements, leading to increases in croplands, fragmented habitats and reduction in riverine vegetation

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(Campbell et al. 2005; Morara et al. 2014). The Amboseli ecosystem in Kajiado County exemplifies the changes observed in most Kenya's rangeland ecosystems. Some of the resource changes reported in Amboseli include declining habitat diversity, loss of woodlands and decline in range productivity (Western and Van Praet 1973; Western 2006; Western and Maitumo 2004; Western et al. 2015a, 2015b; Kioko and Okello 2010). The changes are affecting the provision of ecosystem services such as forage production and supply of raw materials, impacting negatively the pastoral livelihoods (Caldas et al. 2015). The long-term resource changes have resulted in a number of challenges, including restricted livestock mobility, decline in grazing areas and increased conflicts over natural resources (Egeru et al. 2014). Restricted mobility is known to lead to increased grazing pressure that predisposes soil to erosion and lowers rangeland productivity and livestock production (Msoffe et al. 2011).

Traditional institutions which regulated rangeland resource use for centuries are increasingly becoming ineffective due to their lack of recognition and support, leading to deterioration of range ecosystem services. Traditionally, resource monitoring and assessment by the local communities enabled good judgment on sustainable utilization (Ghorbani et al. 2013). Although rangeland monitoring and assessment by local communities has been shown to be effective in tracking resource dynamics, combining local knowledge and practices with conventional approaches gives a better understanding of rangeland ecosystems (Msoffe et al. 2011; Dabasso et al. 2012; Suleiman and Ahmed 2013; Belay et al. 2014). As indicated by Angassa et al. (2012), involvement of local communities in assessing their opinions on changes in land use and land cover (LULC) and pastoral resources over time is crucial in devising proper management systems for sustainable use of arid and semi-arid landscapes.

This study was therefore conducted to understand community perceptions on spatio-temporal dynamics of pastoral resources in the Amboseli ecosystem. The participatory approach was considered an entry point for local involvement in perceiving their problems and designing sustainable land use and natural resource practices.

Study area

The study was conducted in the Amboseli ecosystem located in Kajiado County of Kenya. The ecosystem comprises Amboseli National Park and surrounding group ranches, which cover nearly 8,500 km^2 (Western and Behrensmeyer 2009). Figure 1 shows the study area map.

The ecosystem is characterized by a warm dry climate with temperatures ranging between 14 °C and 30 °C and two rainy seasons averaging 250 to 300 mm per annum (Kioko et al. 2012). Age and nutrient status of soils varies with geology, terrain and altitude (Western and Maitumo 2004; Kioko et al. 2012). A series of permanent swamps are fed by underground aquifers from Mt. Kilimanjaro and local run-off during rainy seasons (Okello and Kioko 2011; Mose et al. 2013).

Acacia xanthophloea, *A. tortilis*, *A. mellifera* and *Commiphora* species are the main tree species in the study area. The area has experienced reduction in woodlands due to human encroachment, agricultural expansion and destruction by elephants (Western and Maitumo 2004; Kioko and Okello 2010; Okello et al. 2011). The ecosystem has a large population of elephants (*Loxodonta africana*), zebras (*Equus burchelli*) and wildebeest (*Connochaetes taurinus*), with a rich carnivore population of lions (*Panthera leo*), hyenas (*Crocuta crocuta*), cheetahs (*Acinonyx jubatus*), leopards (*Panthera pardus*) and jackals (*Canis aureus*) (Okello and Kioko 2011).

The human population is historically low and sparsely distributed but has been growing rapidly in recent decades, mostly on the lower slopes of Kilimanjaro, around permanent swamps and rivers and on main roads. The predominant land use in the area is extensive livestock production and wildlife conservation (Kioko and Okello 2010; Kioko et al. 2012). The local inhabitants are mainly Maasai who are transitioning from nomadic to sedentary and agropastoral livelihood systems. Immigrant populations from other parts of Kenya and neighbouring Tanzania practise irrigated farming within the wetlands (Campbell et al. 2005; Kioko and Okello 2010).

Methods

Study design

The study area was stratified into nomadic, semi-nomadic and sedentary land use sites, based on the dominant land uses pre-determined by Campbell et al. (2003). These land use types also represent different land tenure transformations, with the nomadic site being predominantly undivided and the semi-nomadic and sedentary sites partially and exclusively subdivided into private parcels of land. The Eselenkei, Olgulului and Kimana group ranches were purposively selected to represent the nomadic, semi-nomadic and sedentary land use types, respectively.

Three focus group discussions (FGDs) were conducted, one in each site, aimed at soliciting community perceptions on the extent of resource change over time. The participants who included youths, elderly men and women practising varied economic activities were identified with the support of village elders, based on their knowledge on environmental changes and familiarity with the landscape. Each FGD was composed of 10 participants comprising three older men (above 70 years), two younger men (18 to 60 years), two older women (above 70 years) and three younger women (18 to 60 years), from across the three land use types. The young men and women were useful in sketching the resource mental maps, in addition to

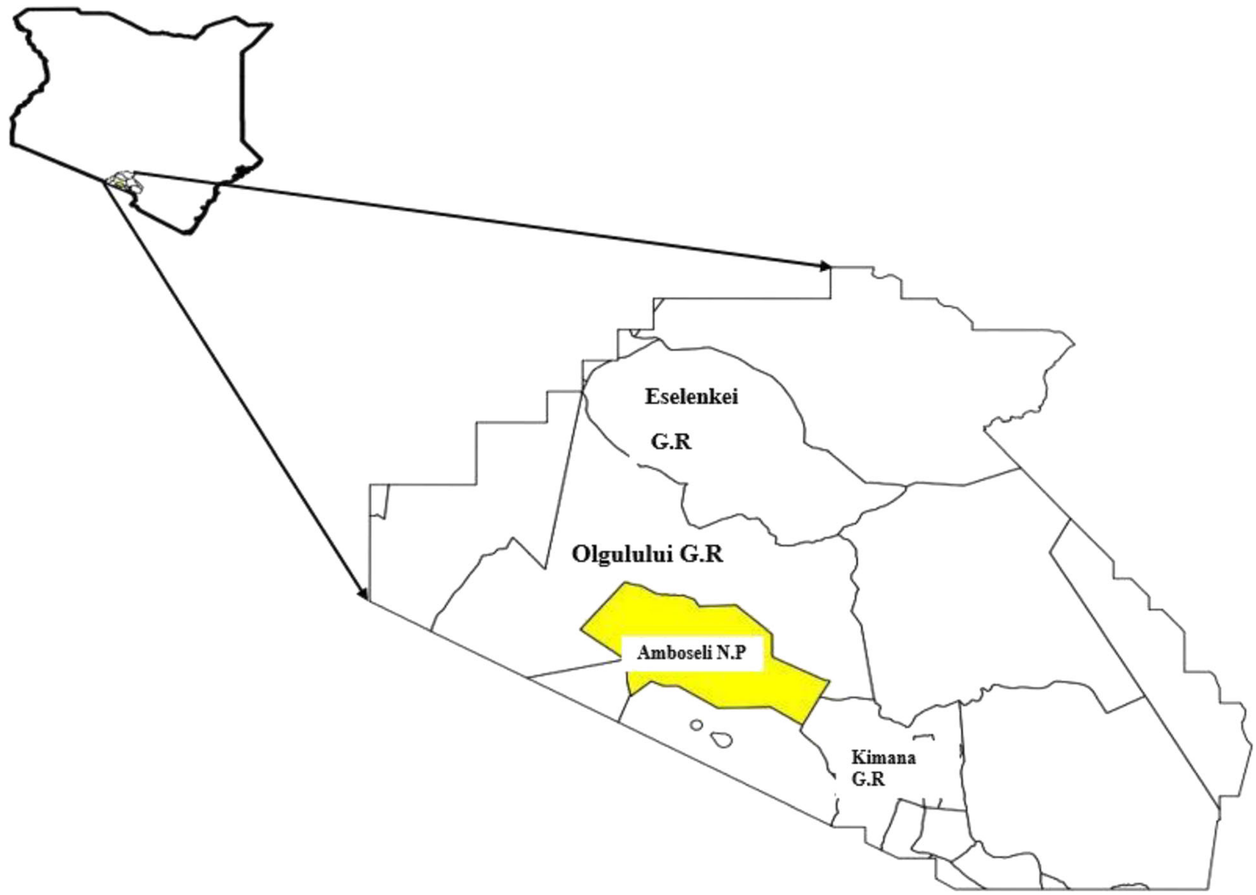

Figure 1 The study area (Amboseli ecosystem) showing the Amboseli National park and the three sampling sites

contributing information about resource changes for the past 20 years. The older men and women gave information on the status of resources for the past 30 to 50 years.

The study period was categorized into four historic periods which included pre-park (1967 to 1976), pre-settlement (1977 to 1986), post-settlement (1987 to 2006) and post-2009 drought (2009 to 2015). The four historic periods were chosen to match the main changes in land cover and land uses partly contributed by changing land tenure and pastoral practices documented by the Amboseli Conservation Program (ACP), a non-governmental organization that has been conducting ecological monitoring in the Amboseli ecosystem since 1967 (Western 2006; Western and Maitumo 2004; Western and Nightingale 2003).

Data collection and analysis

Participatory mapping of resource changes over the past 40 years was done with the community to provide the current outline of the locations and boundaries of various resources in the different land use sites during the period under study. The community identified grazing areas, settlements, cultivated, bare ground and trading centres for each entire land use type. The participants of the community resource mapping exercise were asked to sketch the changes across the areas they used within the Amboseli ecosystem for the period between pre-park and post-2009 drought. The mapping process began with the most recent, the post-2009 drought period, followed by the post-settlement, pre-settlement and pre-park periods in that order. Physical features like roads, schools, springs and boreholes acted as reference points to identify the extent of the various land use and land cover types during the periods under study. After resource mapping, field observations guided by key informants selected during the exercise were conducted to identify the mentioned resources and physical features in each site.

The community-drawn resource maps were scanned and geo-referenced using Quantum Geographical Information System (QGIS) software version 1.8.0. Five coordinates collected in the specific study sites during field observations were used as control points to guide the geo-referencing exercise. The key features and locations on the geo-referenced images were retraced onto overlaid shapefiles as polygons, lines and points representing the four study periods for the three sites. The extents of the perceived resource changes over the study periods were determined from the maps using QGIS. The data was then transferred to Excel to generate the graphs and tables showing the extent of resource changes. A chi-square goodness of fit test was used to determine whether the extent of the resource changes over time differed significantly over the study periods (Kioko and Okello 2010).

Results

Resource changes in the nomadic land use site

The community-drawn resource maps for the nomadic land use site for the pre-park, pre-settlement, post-settlement and post-2009 drought periods are shown in Figure 2. The community sketch maps show extents of areas of grazing, settlements, cultivation and bare ground, as well as roads and livestock routes in addition to other infrastructure such as schools, hospital and watering points in the various study periods. The resource trends in the nomadic land use sites during the pre-park to post-2009 drought periods are presented in Figure 3. Grazing areas ($\chi^2 = 55.50$, df = 3, $p < 0.001$) and livestock routes ($\chi^2 = 35.85$, df = 3, $p < 0.001$) were reported to have changed significantly over the last four decades. The maps show that settlements increased from 98.7 km^2 during the pre-park period to 279.3 km^2 in the post-2009 drought period.

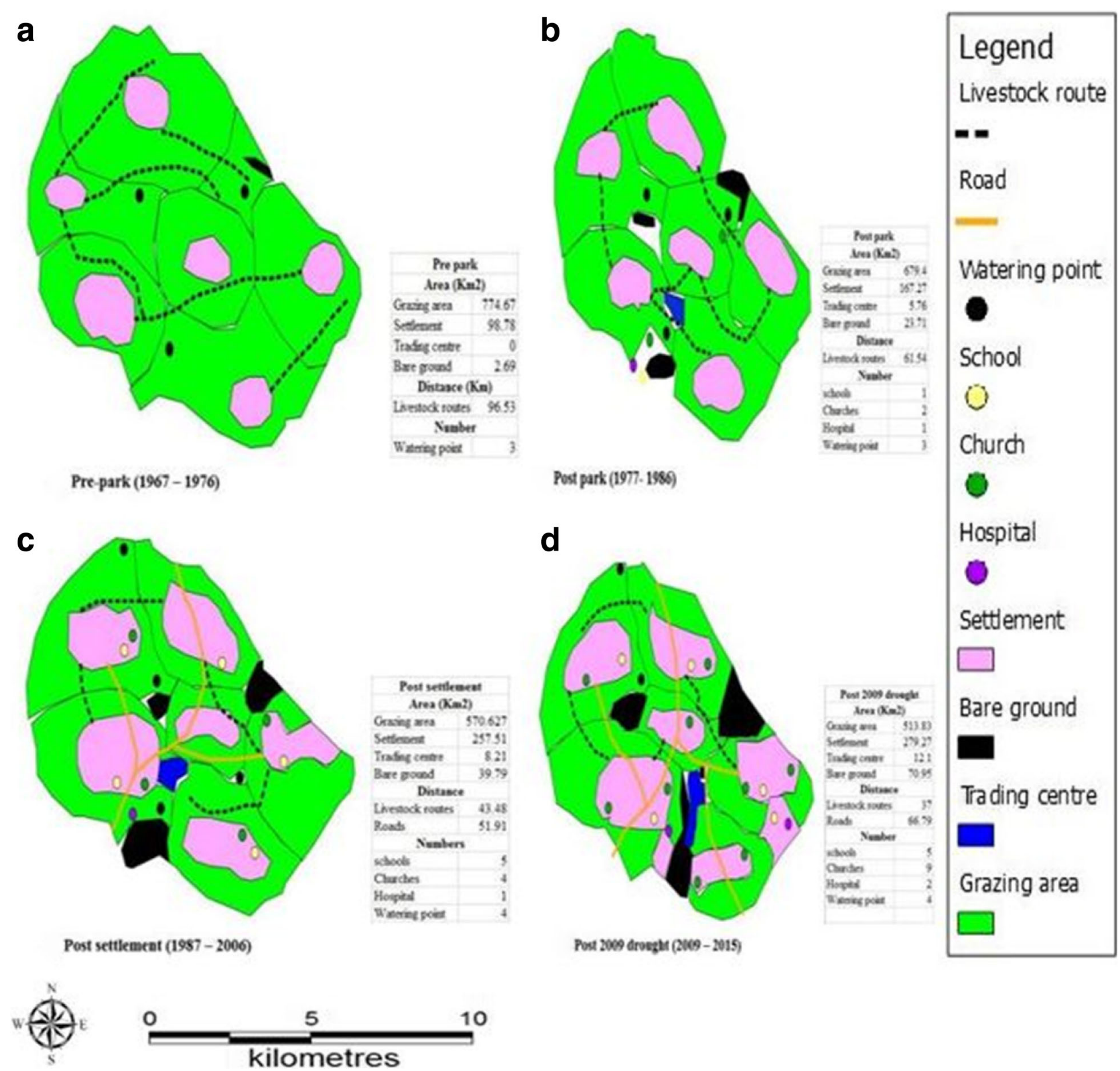

Figure 2 Pastoral resource change maps for the nomadic land use site

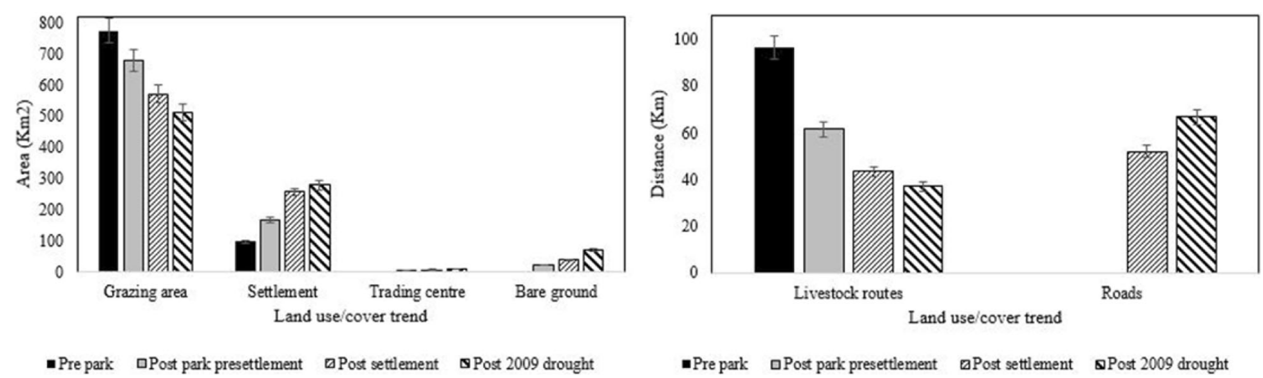

Figure 3 Land use and land cover changes in the nomadic land use site

Estimations derived from the resource maps drawn by the community showed that grazing land declined by 30 % and settlements increased by 21 % over the last four decades as illustrated in Table 1. Routes used for daily livestock grazing and migration declined by 38 % over the same period. Trading centres increased from nearly zero to 1 % of the area between the pre-park and the post-2009 drought period.

Resource changes in the semi-nomadic land use site

Figure 4 shows the perceptions of the community on resource changes in the semi-nomadic land use site over the last four decades. The change dynamics for the various land use and land covers for the semi-nomadic land use area over the study periods are presented in Figure 5. Whereas the grazing land ($\chi^2 = 391.4$, df = 3, $p < 0.001$) and livestock routes ($\chi^2 = 44.73$, df = 3, $p < 0.001$) decreased, areas under cultivation ($\chi^2 = 487.71$, df = 3, $p < 0.001$), settlement ($\chi^2 = 76.15$, df = 3, $p < 0.001$), trading centres ($\chi^2 = 146.77$, df = 3, $p < 0.001$), bare ground ($\chi^2 = 38.83$, df = 3, $p < 0.001$) and road infrastructure ($\chi^2 = 104.24$, df = 3, $p < 0.001$) increased significantly over the last four decades.

Table 1 Extent of resource changes derived from the resource maps for the nomadic land use site

Resource/ cover	Percent changes in pastoral resources between 1967 and 2015			
	Pre-park-post-park	Post-park-post-settlement	Post-settlement-post-2009 drought	Pre-park-post-2009 drought
Grazing area	−10.9	−12.4	−6.5	−29.8
Livestock routes	−36.0	−55.0	−61.7	−38.3
Settlement	7.8	10.2	2.5	20.6
Trading centre	-	0.3	0.4	0.7
Roads	-	-	28.7	28.7
Bare ground	2.3	1.8	3.6	7.7

The extent of resource changes presented in Table 2 show that areas under cultivation increased by 1.4 % between the pre-park and post-park periods, 7.5 % between the post-park and post-settlement periods and 8 % between the post-settlement and post-2009 drought periods, indicating an overall change of 16.8 %.

Contrary to the increase in settlement and cultivation, grazing areas declined by 47 % and the livestock routes linking seasonal grazing resources shrank by 61 %, thereby reducing herd mobility. The road network was perceived to have increased by 110 %, with 70 % of the rise occurring between the post-park and post-settlement and 24 % between the post-settlement and post-2009 drought periods.

Spatial and temporal resource changes in the sedentary land use site

Figure 6 shows the sketch maps drawn to illustrate the trends in the perceived range resources over the various study periods. The resource maps showed significant changes ($p < 0.001$) in the range resources in the sedentary land use site. The long-term changes included a decrease in grazing land ($\chi^2 = 75.89$, df = 3, $p < 0.001$) and livestock routes ($\chi^2 = 66.77$, df = 3, $p < 0.001$) and a significant increase in areas under cultivation ($\chi^2 = 124.55$, df = 3, $p < 0.001$) and trading centres ($\chi^2 = 17.83$, df = 3, $p = 0.0005$). Livestock routes in the pre-park and post-park periods were lost in the post-settlement and post-2009 drought periods as shown in Figure 7.

Table 3 shows the extent of changes in the pastoral resources between the study periods. Over the last 40 years, the grazing land declined to a half by the post-2009 drought period in the sedentary land use site. The reduction was attributed to increase in settlements, trading centres and cultivation. Areas under cultivation increased by 26 % over the study period. The number of

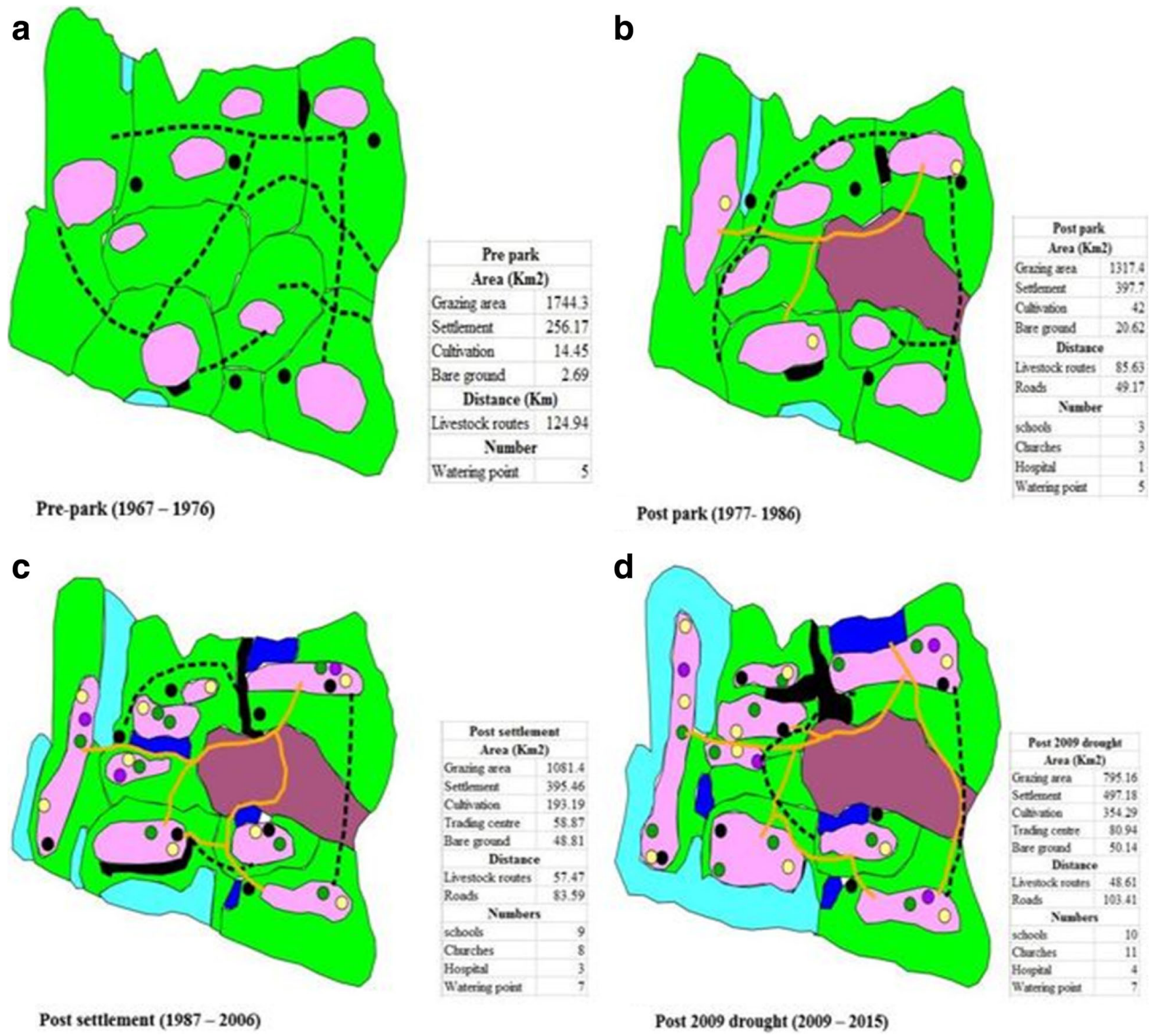

Figure 4 Pastoral resource change maps for the semi-nomadic land use site

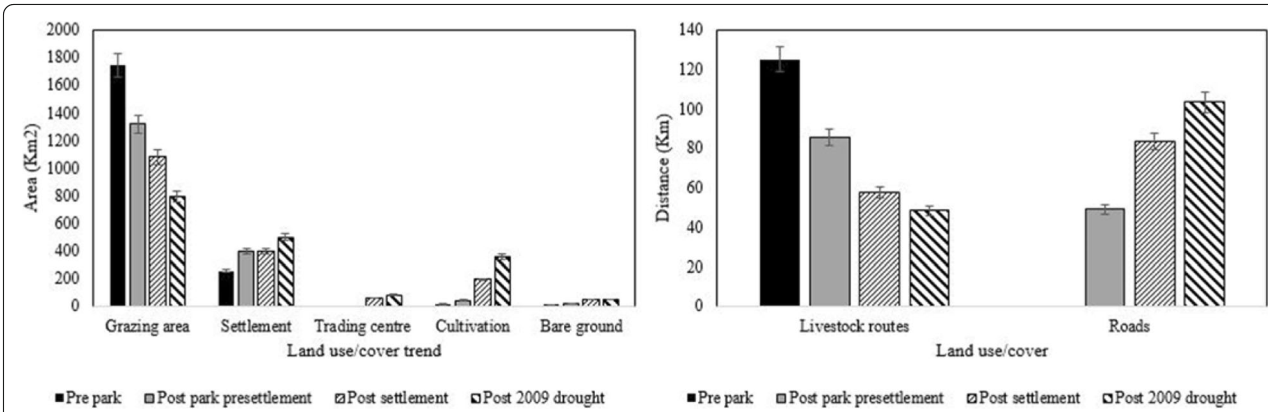

Figure 5 Land use and land cover changes in the semi-nomadic land use site

Table 2 Extent of changes in resources derived from the semi-nomadic land use resource maps

Resource/cover	Percent changes in pastoral resources between 1967 and 2015			
	Pre-park-post-park	Post-park-post-settlement	Post-settlement-post-2009 drought	Pre-park-post-2009 drought
Grazing area	−21.1	−11.7	−14.1	−46.9
Cultivation	1.4	7.5	8.0	16.8
Livestock routes	−31.5	−32.9	−15.4	−61.1
Settlement	7.0	−0.1	5.0	11.9
Trading centre	0.0	2.9	1.1	4.0
Roads	-	70.0	23.7	110.3
Bare ground	1.0	1.4	0.1	2.0

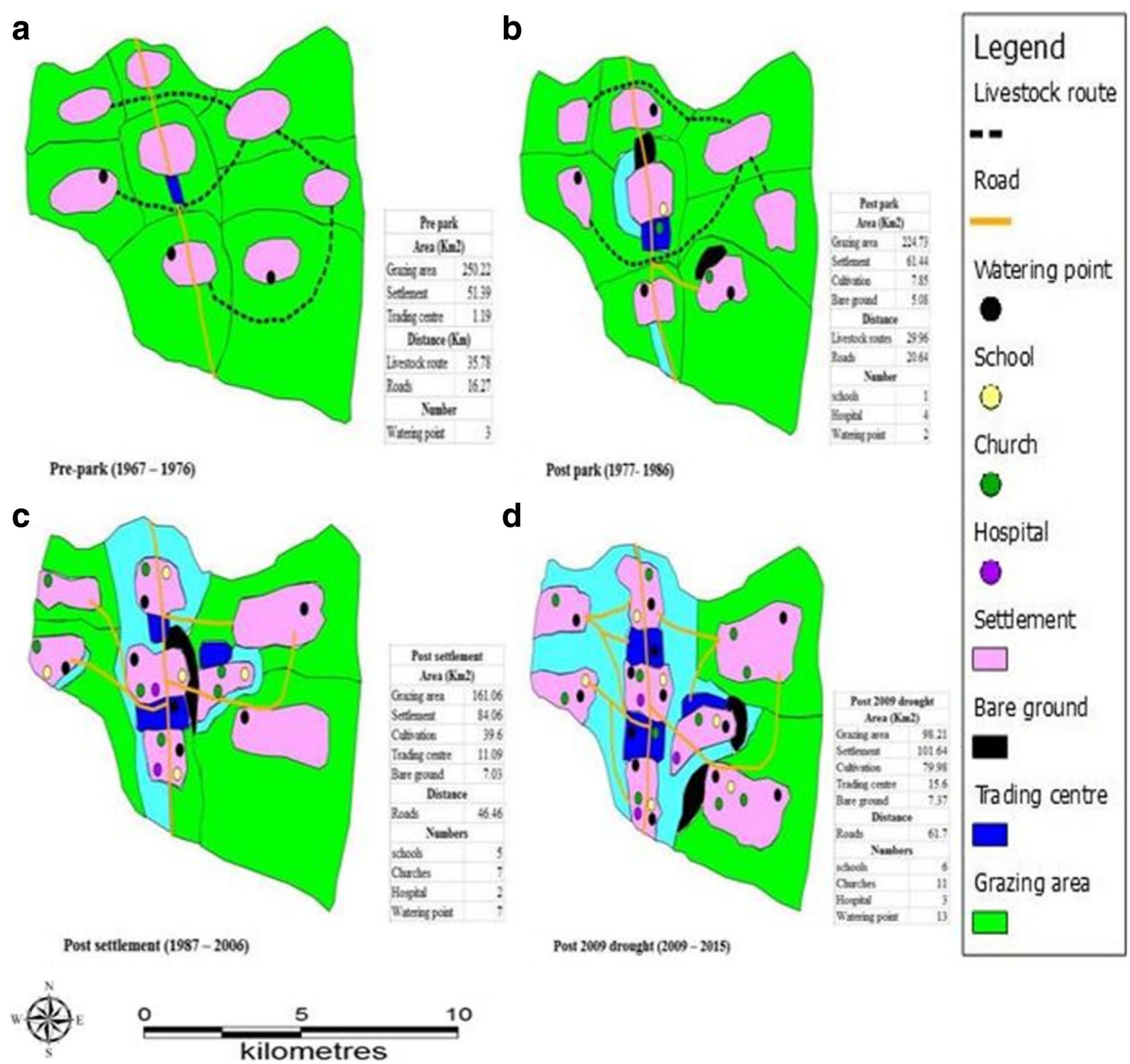

Figure 6 Pastoral resource change maps for the sedentary land use site

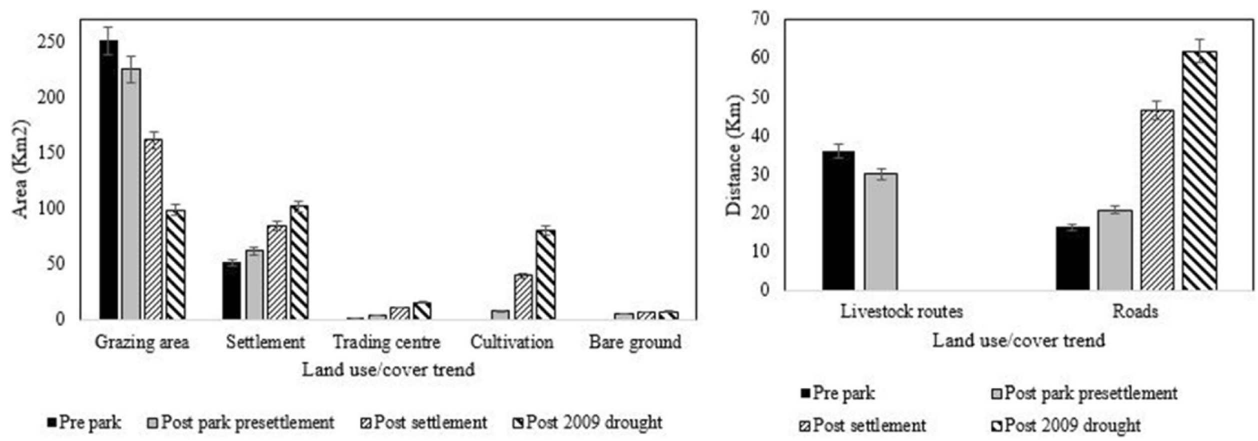

Figure 7 Land use and land cover changes in the sedentary land use site

watering points in the area increased from three in the pre-park to 13 during the post-2009 drought period.

Discussion

Pastoral resources were reported to have generally changed across the three land use types in the Amboseli ecosystem. The most notable changes were the reduction in the grazing areas in all sites and increase in cultivation activities. Greater reduction was reported in the semi-nomadic and sedentary than in the nomadic land use sites. The variety of pastures, diversity of habitats and tree cover were mentioned to have declined significantly over the period under study. This was attributed to the rising grazing pressure due to restricted herd movements. Differential disappearance of preferred forage species and habitats reported by respondents indicate that the pasture quality as grazing area has deteriorated over time.

It seems likely that reduction of grazing area and degradation in pasture resources does reflect the expansion of cultivation and increased grazing pressure, as suggested by the respondents. Kioko et al. (2012) reported similar observations in the Amboseli ecosystem. In their study, respondents reported the disappearance in certain grass species over the last few decades, which they attributed to grazing pressure and deforestation. These perceptions are in line with the findings of different authors (Western and Nightingale 2003; Western and Maitumo 2004; Western 2006; Kioko and Okello 2010; Msoffe et al. 2011; Morara et al. 2014), who indicated declining trends in habitat diversity, woodlands, grass quantity; conversion of large tracts of land into settlements, croplands and trading centres; and a reduction in both dry and wet season grazing areas. The loss of habitat diversity (Western 2006) and grassland productivity (Western et al. 2015a, 2015b) has been reported in the study area. These authors attributed the changes to increased human activities. Similar results attributing the decline in grazing areas and conditions to the expansion of crop cultivation have been reported in the semi-arid areas of Karamoja in Uganda (Egeru et al. 2014).

Table 3 Extent of changes in resources derived from the sedentary land use resource maps

Resource/ cover	Percent changes in pastoral resources between 1967 and 2015			
	Pre-park-post-park	Post-park-post-settlement	Post-settlement-post-2009 drought	Pre-park-post-2009 drought
Grazing area	−8.4	−21	−20.8	−50.0
Cultivation	2.6	10.4	13.3	26.4
Livestock routes	−16.3	-	-	-
Settlement	3.3	7.5	5.8	16.6
Trading centre	0.8	2.4	1.5	4.8
Roads	26.9	25.1	32.8	179.2
Bare ground	1.7	0.6	0.1	2.4

Extensive traditional livestock production associated with herd mobility is still prominent in the nomadic land use site where land has not been sub-divided. In this site, herd mobility was reported as an important strategy that allows pastoral households to exploit heterogeneous environments and cope with droughts and disease outbreaks. According to the World Initiative for Sustainable Pastoralism (2008), well-governed mobile pastoralism is conducive to biodiversity conservation and sustainable land management. Settlements in the nomadic land use site are mostly temporary, intended to support mobile livestock production and exploit varying pasture conditions between locations and in response to seasonal fluctuations. Settlement location and turnover reflects social and physical factors which favour extensive traditional livestock production systems (Western et al. 2009a, 2009b, Nkedianye et al. 2011).

Land subdivision in the semi-nomadic and sedentary land sites has reportedly reduced grazing areas and herd mobility, both of which undermine the effectiveness of mobile pastoral systems (Western et al. 2009a, 2009b; Groom and Western 2013). Curtin and Western (2008) and Kioko and Okello (2010) reported that restricted mobility has led to loss of biodiversity, consequently impacting negatively on rangeland health and the resilience of grasslands and pastoral livelihoods to droughts.

As reported by Okello and Kioko (2011), the rise of crop cultivation in the Amboseli ecosystem has led to loss of grazing land and livestock herds (Western and Nightingale 2003), forcing households to switch to alternative livelihoods. The expanding road network in the Amboseli area, especially the recent construction of the Emali-Loitokitok tarmac road, has greatly improved access to markets for farm produce, further stimulating adoption of cultivation by pastoralists due to better returns from crop farming than livestock production in the area (Okello and Kioko 2011; Kioko et al. 2012). Mbau (2013) in a study of land use changes in Taita-Taveta and Maitima et al. (2009) in their study of the linkages between land use, land degradation and biodiversity loss in East Africa showed that increase in crop cultivation reduces grazing area. They observed that such trends were triggered by road developments and greater returns from cultivation than pastoral livestock production.

Conclusions

The most significant changes perceived by communities in the Amboseli region are reduction in grazing land as a result of encroachment of other land uses in the area. The changes are more pronounced in the semi-nomadic and sedentary than in the nomadic land use sites. Sedentary and semi-nomadic land use sites reflected greater transformations in land tenure from group to individual ownership, an expansion of crop production and a reduction in grazing land. The decline in grazing land has partly been attributed to sedentarization, rangeland fragmentation and degradation due to land tenure shift from group ranches to private ownership. However, in the nomadic land use site, extensive traditional livestock production is still possible due to little farming activities.

The study shows that participatory resource mapping is a useful tool for engaging local communities in mapping the status of their resources, a prerequisite for sustainable community-based resource use planning and management.

Abbreviations

ACP: Amboseli Conservation Program; FGD: Focus group discussion; LULC: Land use and land cover; QGIS: Quantum Geographical Information System; WISP: World Initiative for Sustainable Pastoralism

Acknowledgements

The first author would like to thank the Amboseli Conservation Program for funding this study and facilitating the field process. Thanks to the Amboseli resource assessors George Sunte, Paul Kasaine, Samuel Lekanaya and David Maitumo for their assistance in conducting the field work. Special thanks go to all the community members from the Olgulului, Eselenkei and Kimana areas who participated in the focus group discussions and key informant interviews.

Authors' contributions

KSK developed the concept, collected and analysed the data and drafted the manuscript. OVW, DW and JSM helped in the conception of the research idea and design and made comments on the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Received: 17 August 2016 Accepted: 25 October 2016
Published online: 29 November 2016

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