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RESEARCH BRIEF

PROJECTED CLIMATE CHANGE AND ITS POTENTIAL IMPACT ON CATTLE IN KAJIADO COUNTY

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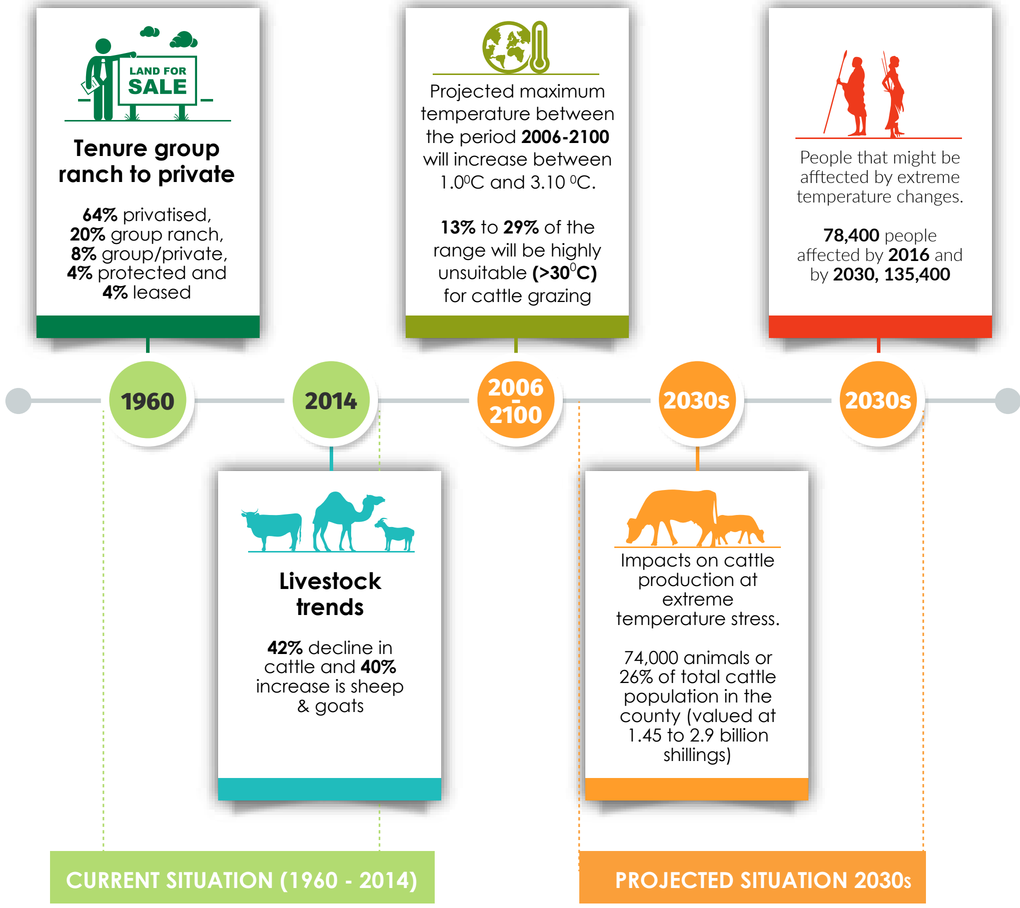
Key Findings



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Background

Livestock and climate trends

Globally, pastoralist and agro-pastoralist communities are amongst the most vulnerable to the impacts of climate change (Thornton et al., 2009). Increasing climate variability and extreme events will affect livestock production and productivity, incomes and food security. Pastoralists and agro-pastoralists already face a number of challenges, and climate change can be seen as just one of the many important drivers affecting their livelihoods. Other drivers include changes in land tenure and land use, population growth, sedentarisation, rapid urbanisation, globalisation, conflict, intensification and institutional changes (Behnke, 2008; Galvin, 2009).

Recent studies in Kenya report massive declines of wildlife and an increase in total livestock numbers in the arid and semi-arid lands (ASALs) (Ogutu et al., 2016). Specifically, the increases are on sheep, goats and camels, with large declines reported in cattle between the periods 1977 to 2016 (Ogutu et al., 2016). The declines in cattle occurred in 15 out of the 21 counties[1], with Turkana, Machakos, Garissa, Kitui and Kajiado being most affected (Figure 1a). By contrast, cattle numbers increased in only 6 counties: Lamu, Taita Taveta, Elgeyo Marakwet, Baringo, Laikipia and Kilifi. On the other hand, there were significant increases in the number of sheep and goats (Figure 1b). The numbers increased significantly in Lamu, Laikipia, Mandera, Samburu, Wajir, Marsabit, Garissa, Narok and Taita Taveta with moderate increases in Baringo, Tana River, Turkana, Kajiado, Isiolo, Machakos and Kitui and significant decreases in Kwale and Elgeyo Marakwet.

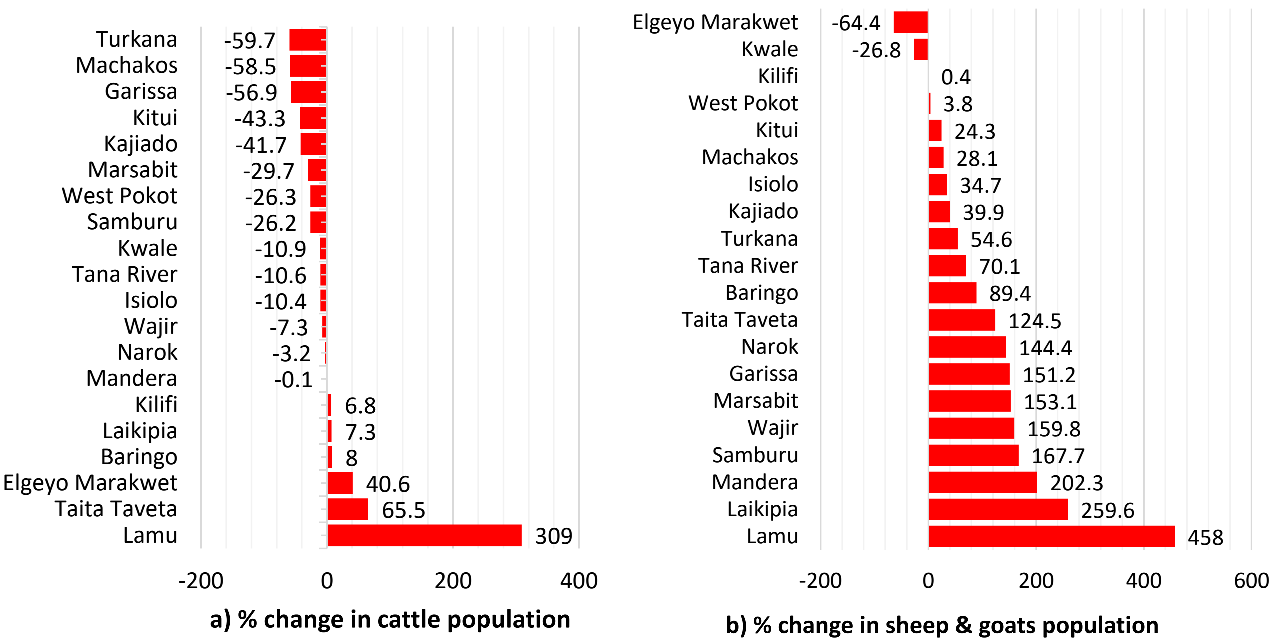


Figure 1: *Livestock population changes in the ASALs in Kenya between 1977 and 2016 (Source: Ogutu et al., 2016).*

[1]Baringo, Elgeyo Marakwet, Garissa, Isiolo, Kajiado, Kilifi, Kitui (combined Kitui and Makueni), Kwale, Laikipia, Lamu, Machakos, Mandera, Marsabit, Narok, Samburu, Tana River, Taita Taveta, Turkana, Wajir, and West Pokot

These livestock population changes have been accompanied by a reduction in rainfall and an increase in temperature between 1960 and 2014 (Ogutu et al., 2016). Fifteen (15) out of the 21 ASAL counties reported declines in rainfall during this period. Average annual maximum temperatures increased between 0.7°C and 1.9°C and average annual minimum temperatures increased between 0.6°C and 1.7 °C. These changes in temperature reflect a more general regional warming of the ASALs (Ogutu et al., 2016).

Narrowing down on Kajiado County, these research findings reveal large declines in cattle and a moderate increase in sheep and goats. In 2016, Kajiado County had the second largest population of cattle (286,191) and fifth largest population of sheep and goats (963,585) amongst the 21 ASAL counties (Ogutu et al., 2016). However, analysis of projected climate change indicates that increases in temperature might negatively impact the growth of the cattle population in many ASAL counties including Kajiado (Said et al., in review).

This brief presents the projected changes in rainfall and temperature in Kajiado County and their potential impacts on cattle and the livelihoods of the pastoral community in the county. It highlights the current status of land tenure in the county and analyzes the implications of changes in land tenure on livestock movement and distribution. Based on these findings, it outlines recommended policy and program actions for the County Government of Kajiado to undertake in order to mitigate and adapt to the effects of the projected changes in climate and land tenure.

Method

Description of Kajiado County – Biophysical and land tenure

Kajiado is primarily an arid and semi-arid county located in the southern tip of the former Rift Valley Province between longitudes 36°5' and 37°55' East and 1°10' and 3°10' south. It bounds Tanzania to the south, Taita Taveta County to the west, Machakos and Makueni counties to the north west, Narok County to the east and Nairobi County to the north. It covers an area of 21,745 km^2.

Kajiado County can be divided into four ecozones. Ecozones are major habitat types, which are based on life form, or the adaptation of plants and animals to climatic, soil and other conditions (Republic of Kenya, 1982). The four major ecozones are the Athi Kaputiei Plains, the Amboseli Plains, the Central Hills and the Rift Valley ecosystem (Figure 2).

“This brief presents the projected changes in rainfall and temperature in Kajiado County

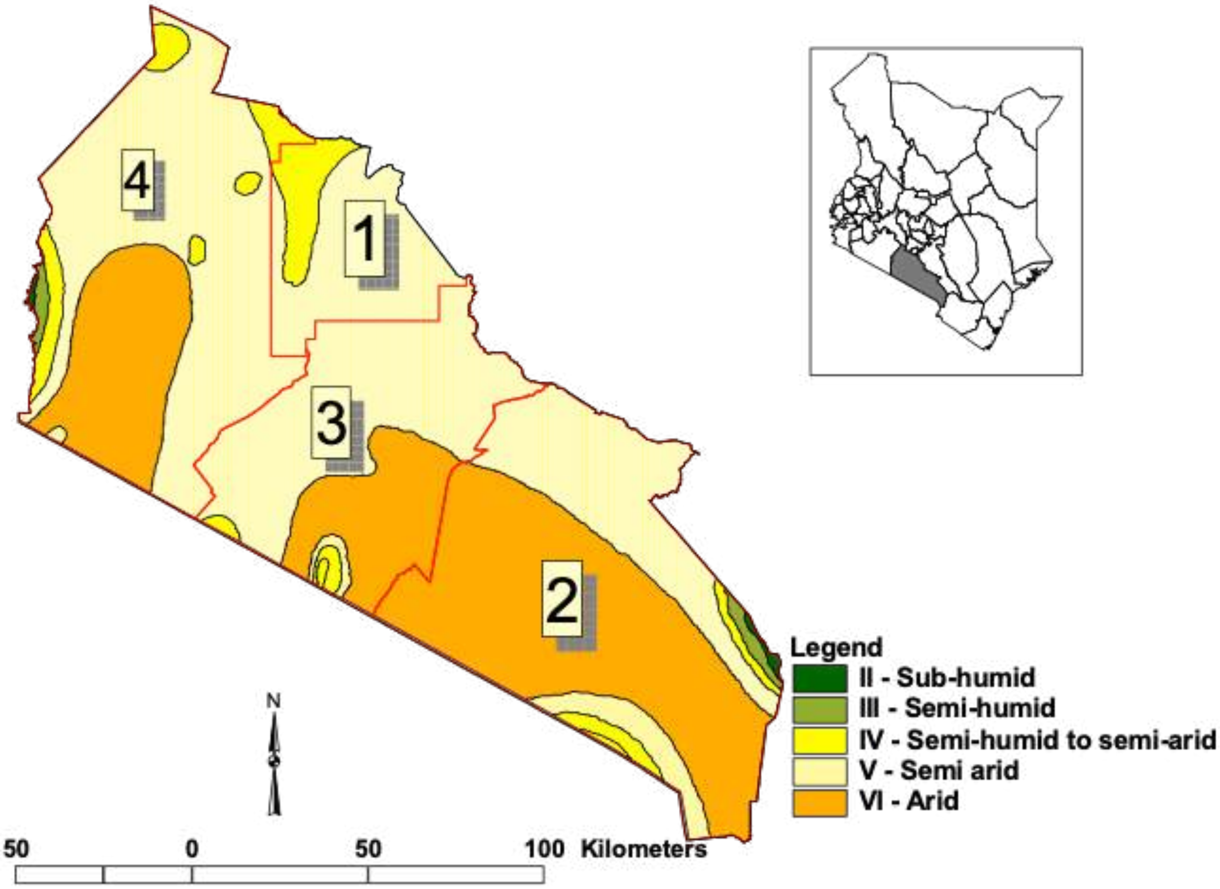


Figure 2: *Location and characteristic of the study sites: (1) Athi Kaputiei (2) Amboseli Plains (3) Central hills, and (4) Rift Valley*

Mean annual rainfall ranges from 300 mm to 800 mm. Rainfall is bimodal, with the short rains from October to December and long rains from March to May. The distribution of rainfall between the two seasons changes gradually from east to west across Kajiado County. In eastern Kajiado, more rain falls during the short rains than during the long rains. In western Kajiado, the more rain falls during the long rains (Bekure et al., 1991). The county average maximum temperature is 26°C and average minimum temperature is 15°C. Table 1 summarises the agroclimatic zones for the 4 ecozones.

Table 1. *Summary of agroclimatic zones in the four ecozones of Kajiado County*

			Area			
Ecozone	**II (Sub-humid)**	**III (Semi-humid)**	**IV (Semi-humid to Semi-arid)**	**V (Semi-arid)**	**VI (Arid)**	**Total area (km²)**
Amboseli plains	32 (0.4%)	89 (1.2%)	241 (3.2%)	2554 (33.4%)	4725 (61.8%)	7641
Central Hills		120 (2.5%)	3198 (67.5%)	1417 (29.9%)		4735
Rift Valley	15 (0.2%)	77 (1.1%)	525 (7.3%)	4662 (65.0%)	1892 (26.4%)	7171
Athi Kaputiei			457 (20.8)	1741 (79.2)		2198
Kajiado County	47 (0.2%)	286 (1.3%)	4421 (20.3%)	10374 (47.7%)	6617 (30.4%)	21745

Note: The brackets denotes calculation of area in %.

Land tenure changes and space for livestock

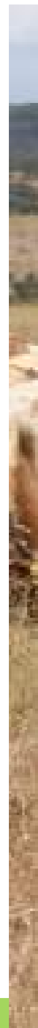
The traditional land tenure in Maasailand in 1800s and early 1900s was communal.

Land tenure data was gathered from various archived material, historical and publications. The tenure data includes the historical allocation of Maasailand in Kenya and Tanzania (Homewood et al., 2009; Rutten 1992), group ranch subdivision (Rutten, 1992; Kimani and Pickard, 1998; Mwangi, 2005) and cadaster maps showing sub-division and the privatisation of land (Said et al., 2016). The map that was used to assess the tenure changes was digitised from Rutten (1992) and updated from other sources (BurnSilver and Mwangi, 2007; Said et al., 2016; Kimani and Pickard, 1998).

The traditional land tenure in Maasailand in 1800s and early 1900s was communal. The enactment of the Group Representatives Act in 1968 and its application in establishing the group ranches land tenure system marked the beginning of tenure reforms in Kajiado, and other counties, leading to the fragmentation of many pastoral rangelands (Moiko et al., 2019). The process of land individuation in Kajiado accelerated in subsequent years following the disintegration of group ranches. In most parts of Kajiado, land tenure has changed from communal to group ranch to private land ownership (Figure 3a). In Kajiado County, 64% of land is now privatised, with the Athi Kaputiei and Central Hills almost fully privatised. Only the Rift Valley ecozone still has large tracks of land under communal tenure, with 36% under communal group ranch tenure, 51% privatised and 13% under land leased to the Magadi Soda Company.

Amboseli Plains is another ecozone with multiple land tenure arrangements with 27% under communal group ranch tenure, 41% privatised, 11% under protected areas, and 21% undergoing transition from group ranch to private ownership (Figure 3b).

With more than 64% of the county now privatised, shared and reciprocal grazing is difficult. Traditional movements of livestock between cool and warm regions, within Kajiado, have become challenging because of land fragmentation and enclosure (Moiko et al., 2019). Movement to counties outside of Kajiado and into Tanzania has also become difficult due to land tenure changes; new transport infrastructures (highways and railways), which block migration corridors; and county and government restrictions[2]. The remaining communal group ranches in Kajiado are under pressure to privatise, putting more weight on the already limited open spaces (Moiko et al., 2019). Increasing land fragmentation has hindered the movements of livestock and reduced the available grazing areas significantly (Said et al., 2016; Ogutu et al., 2014). Land fragmentation and restrictions on livestock movement are likely to be amplified by the projected changes in climate. When pastoralist can no longer move to cooler wet areas (such as Athi Kaputiei and Central Hills) to seek refuge during periods of stress because land has been privatised, livestock losses will be experienced leading to reduced animal numbers in the county.



[2]In October 2017, 1,300 Kenyan cows were auctioned by Tanzanian authorities for crossing into Tanzania. http://www.theeastafrican.co.ke/news/Magufuli-Kenya-cattle-diplomacy/2558-4177942-fkjac7z/index.html

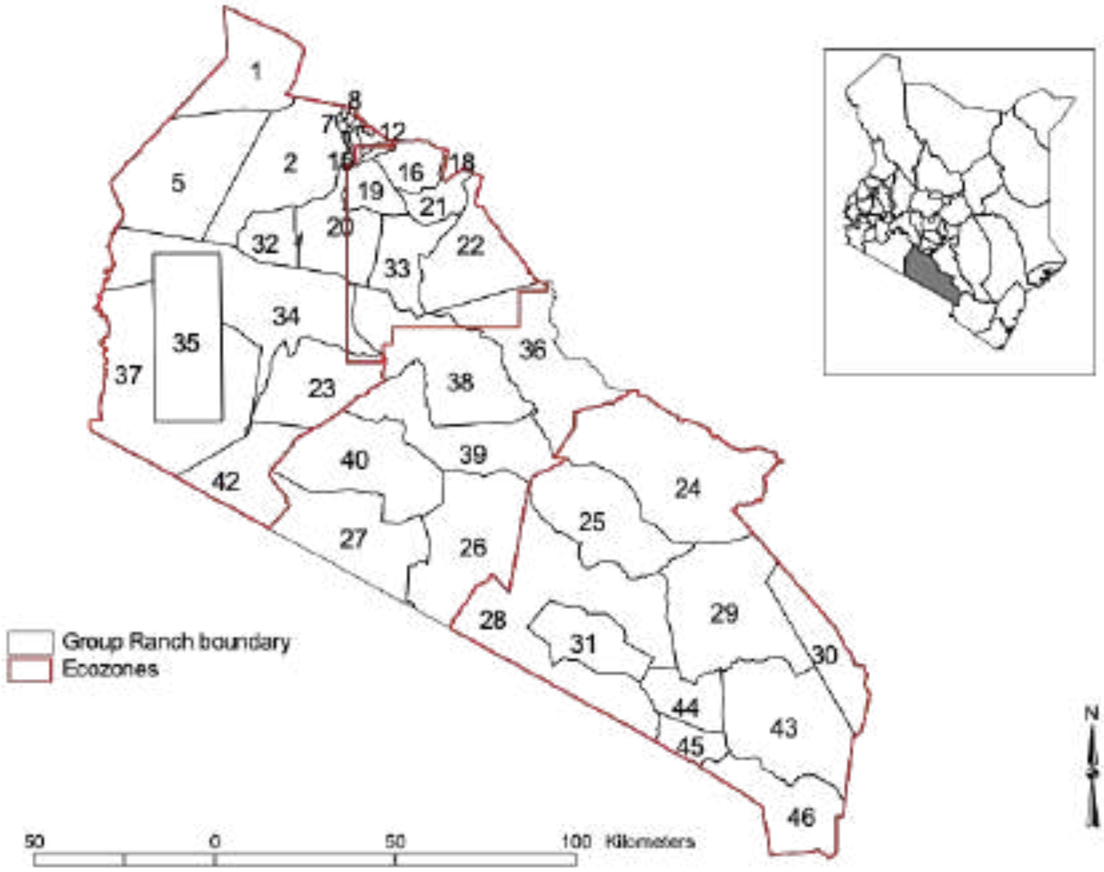


Figure 3a: *Land tenure status in Kajiado County: Protected areas include Amboseli National Park (31) and Chyulu Hills (30); group ranches not subdivided (34 and 37); group ranches semi-privatised (28, 29 & 43); land under lease (35); public forest (9 & 15); the rest of the group ranches are privatised.*

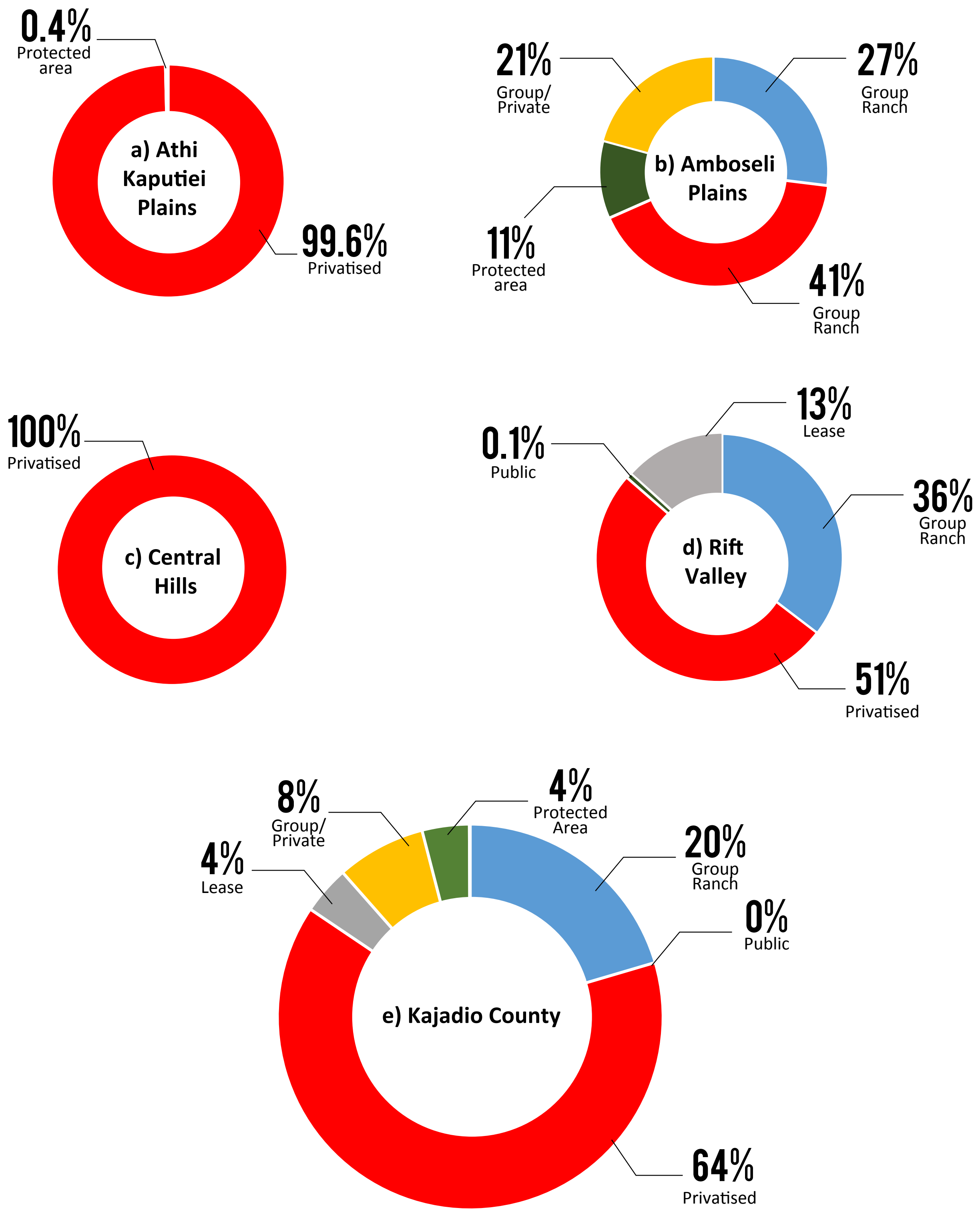


Figure 3b: *Summary of statistics of land tenure status in the four ecozones and overall in Kajiado County*

Plate 1: *Growth of Kitengela into an urban town. Kitengela was an open area for grazing both wildlife and livestock. Source Google earth maps of 2001 and 2014.*

Plate 2: *Advertisement of land for sale in Kajiado County (Source: https://www.the-star.co.ke/classifieds/land-plots/land-for-sale-in-kajiado-kenya.html) - Year: 2018*

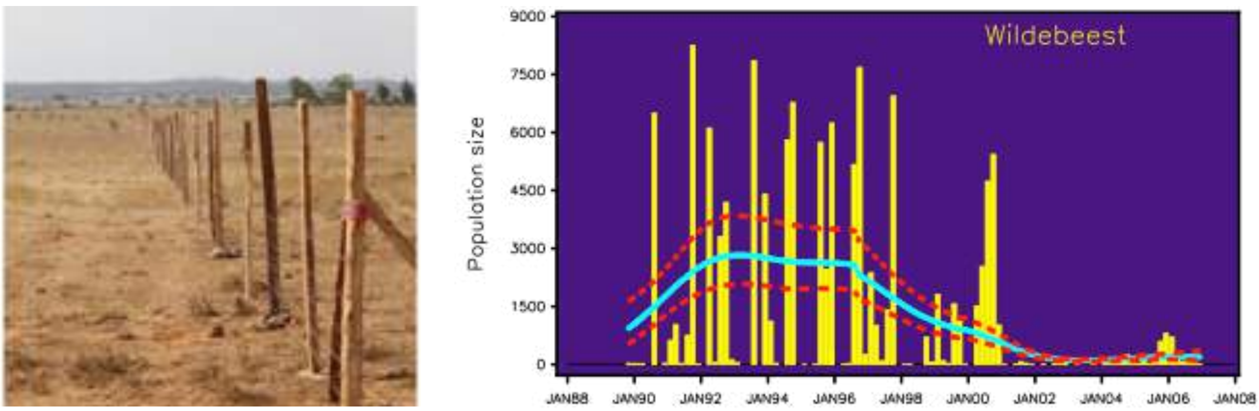


Plate 3: *Fencing of property in the rangelands – blocks both wildlife (collapse of wildebeest migration to Nairobi National Park) and livestock movements.*

Source: *Ogutu et al. (2013); Said et al. (2016)*

Data and Statistical Analysis

Historical trends of cattle, and shoats (sheep and goats) in Kajiado

In this study, 16 censuses conducted in Kajiado County from 1977 to 2014 collected by the Directorate of Resource Surveys and Remote sensing (DRSRS) were used. The data was collected by using the Systematic Reconnaissance Flight (SRF). High-winged aircraft equipped with GPS, intercom, and radar altimeters are used for aerial census. A crew of a pilot, two rear seat observers (RSO) and one front seat observer (FSO) conduct the censuses. The RSO are responsible for animal counts, while the FSO assists in navigation, crew coordination and records general environmental parameters. The ecosystem was surveyed along transects in east-west direction and spaced at 5 km intervals. Each transect was divided into equal sample sub units. During surveys a standard flying height and flying speed was maintained. During the survey all visual observations by RSO of animals within the survey strip were recorded using tape recorders. For herds greater than 10 animals, a photograph was also taken. After every survey, the tape-recorded observations were transcribed to data sheets. Photographs were processed and interpreted for animal species (Norton-Griffiths, 1978; Ogutu et al., 2016). Sheep and goats were grouped into shoats as it difficult to distinguish clearly the differences between the two in the photos.

Population estimates for each species for each of the ecozones were calculated using Jolly's Method 2 (Jolly, 1969; Norton-Griffiths, 1978; Ogutu et al., 2016). The livestock trends were analysed using linear and quadratic models. The corrected Akaike Information Criterion (AIC) was used to choose between the supporting models. The model with the least AIC was selected as the supporting model.

Climate data and projections[3]

The IPCC (2013) recommended the use of Representative Concentration Pathways (RCPs) to analyse climate change. Three Representative Concentration Pathways (RCPs) that describe possible climate futures (scenarios) were adapted in this study. The three RCPs used in this study were 2.6, 4.5 and 8.5.

RCP 2.6 represents an optimistic projection characterised by a very low concentration and emission levels of greenhouse gases. RCP 4.5 represents a moderate emission scenario where international communities are working on limiting emissions with limited implementation of climate change policies. RCP 8.5 represents a pessimistic projection with high levels of concentrations, and assumes no implementation of climate change policies.

The projected changes in temperatures for the three scenarios are based on three future time slices, 2030s (2016–2045), 2050s (2036–2065) and 2070s (2055–2085) to provide information on the expected magnitude of the climate response over each time window. The period 1971–2000 is considered as a reference for the present climate. The projected climate change signals for each time window are calculated as the difference between the future time windows (averages calculated over 30 years) and the reference period (Giorgi, 2006).

[3]This study used climate data from the Rossby Center Regional Atmospheric Model (RCA4) driven by the Earth system version of the Max Planck Institute for Meteorology (MPI-ESM-LR) coupled global climate model from the ongoing CORDEX project (Endris et al., 2013). The goal of the Regional Climate Circulation Model (RGCM) programme is to advance the predictive understanding of Earth's climate by focusing on scientific analysis of the dominant sets of governing processes that describe climate change on regional scales (see details in Endris et al., 2013).

Projected impacts on cattle based on temperature changes

The negative effects of increased temperature on feed intake, reproduction and performance across the range of livestock species are reasonably well understood (Porter et al., 2014; Thornton et al., 2015). Paula-Lopes et al. (2012) indicate that high environmental temperatures observed during the hot months of the year reduce fertility in lactating cows. The ability of the various cattle species to withstand extreme temperatures varies. Bos indicus animals (Zebu) have greater thermoregulatory ability than Bos taurus (European) (Lopes et al., 2012). The thermoregulatory efficiency of Bos indicus cattle is due to their lower internal heat production and/or higher heat dissipation to the environment. Thus, these breeds are more resistant to hyperthermia.

This study analysed the relationship between cattle and rainfall and temperature based on more than 300 censuses conducted in the Kenya rangelands between 1977 and 2016 (Ogutu et al., 2016). Cattle densities declined with increases in maximum temperature. Below 30°C, the cattle density was around 10 animals per km^2, whereas at about 34°C, cattle density reduced to approximately 1 cattle per km^2 (Figure 4a). This study therefore used 30°C as a threshold temperature above which cattle will be impacted and will have a low production (Figure 4b). Moreover, Thornton et al. (2015) indicate that above 30°C, each increase of 1°C reduces cattle feed intake by 3–5%.

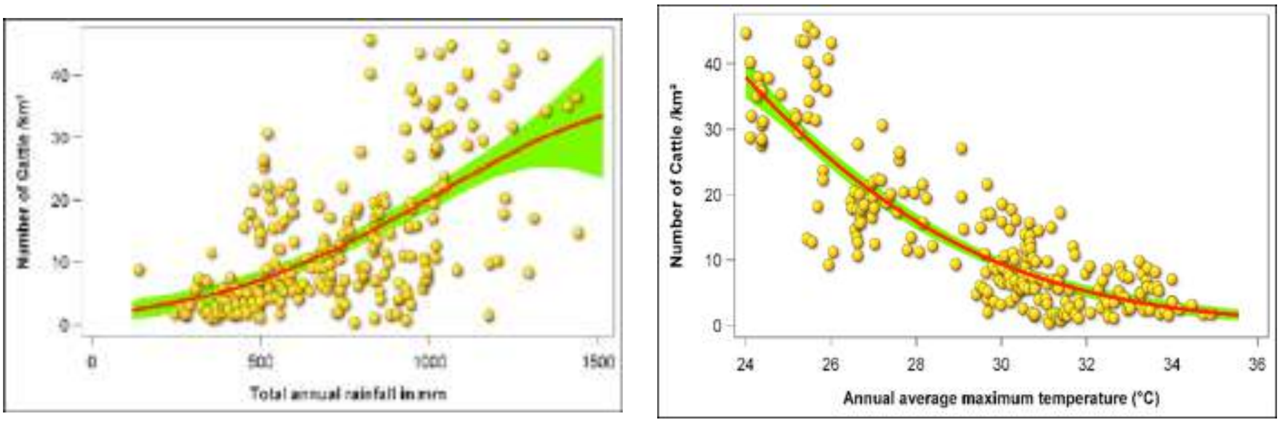


Figure 4a: *The relationship between cattle density (in km2) and a) rainfall and b) maximum temperature (°C).*

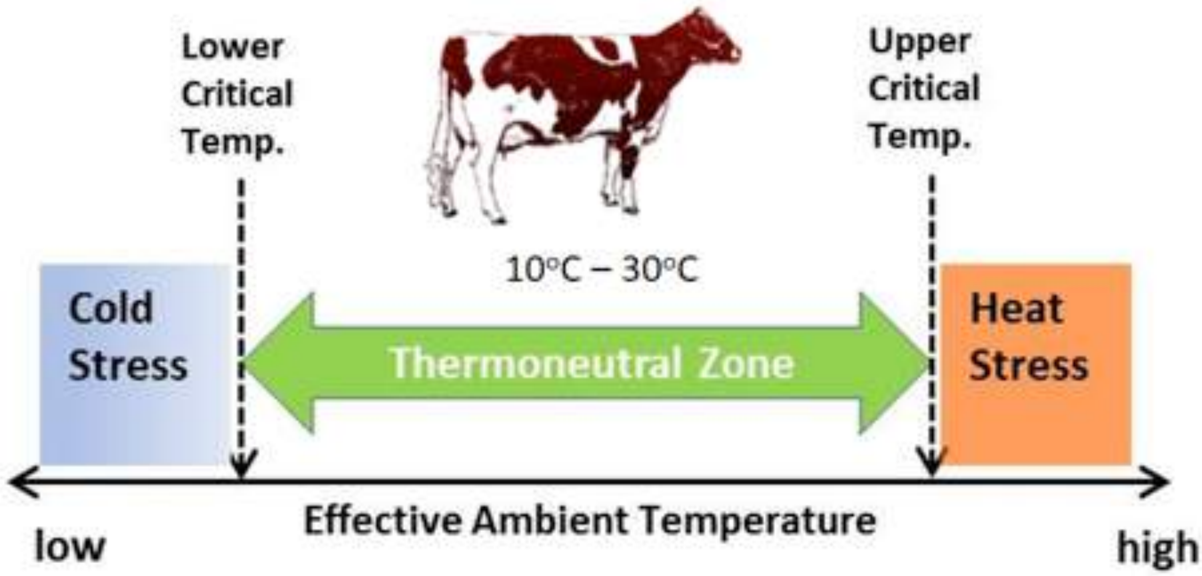


Figure 4b: *Effective ambient temperature for survival of cattle. Adapted and modified from NRC (1981).*

Spatial analysis was undertaken using ArcGIS 10 (ESRI 2010 Inc.). The cattle range maps were based on 17 censuses undertaken by the Directorate of Resource Surveys and Remote Sensing (DRSRS) and overlaid with the projected maximum temperature for the three RCPs 2.6, 4.5 and 8.5 for the time periods 2030s, 2050s and 2070s.

Results

Population and distribution trends of cattle and shoats in Kajiado's ecozones

Livestock trends for Kajiado County level show a significant decline (-42%) in cattle and an accompanying high increase (40%) in sheep and goats (shoats) between 1977 and 2014. Narrowing down to the ecozones, there is a high and significant decline in cattle in two out of the four ecozones – Amboseli (-61%) and Rift Valley (-52%) – and a high decline in Central Hills (-41%) (Table 2 and Figure 5). There was a slight decline of cattle in Athi Kaputiei (-14%) but this was not significant ($r^2 = 0.023$, $p = 0.8451$). In absolute numbers, the Amboseli Plains cattle population declined from a population of 211,470 animals in 1977 to 82,180 animals in 2014. In Rift Valley, the decline was equally high, with a reduction from 151,880 animals in 1977 to 72,930 animals in 2014. In the Central Hills, the cattle population reduced from 127,930 to 75,825 in the same period and in Athi Kaputiei the declines were minimal, although the region has the lowest cattle population of about 49,590 animals as reported in 2014 (Figure 5).

All four ecozones registered a decline in the population of sheep and goats between 1977 and 1995, but during the last 20 years there has been steep increases in shoats in all four ecozones (Figure 5). The highest increases are in Amboseli Plains (72%) followed by Rift Valley (61%) and Central Hills (57%); slight declines were observed in Athi Kaputiei (-7%).

Table 2: Cattle, and sheep and goats population trends per ecozone 1977–2014

Ecozones		Equation	R^2	F Ratio	P Value
Athi Kaputiei	Cattle	$-5.36389E+07+54042.6x-13.5970x^2$	0.023	0.170	0.8451
	Sheep & goats	$4.47852E+08-448499x+112.312x^2$	0.124	0.993	0.3950
Amboseli	Cattle	$7119980 - 3494.44x$	0.580	19.374	0.0006*
	Sheep & goats	$9.32511E+08-937574x+235.698x^2$	0.585	9.198	0.0032*
Central Hills	Cattle	$2911920-1408.19x$	0.201	3.518	0.0816
	Sheep & goats	$1.21321E+09-1218520x+305.992x^2$	0.578	8.903	0.0036*
Rift Valley	Cattle	$4370260-2133.73x$	0.411	10.505	0.0054*
	Sheep & goats	$1.49014E+09-1497460x+376.252x^2$	0.402	4.696	0.0274*

**Statistical significant at $P < 0.05$*

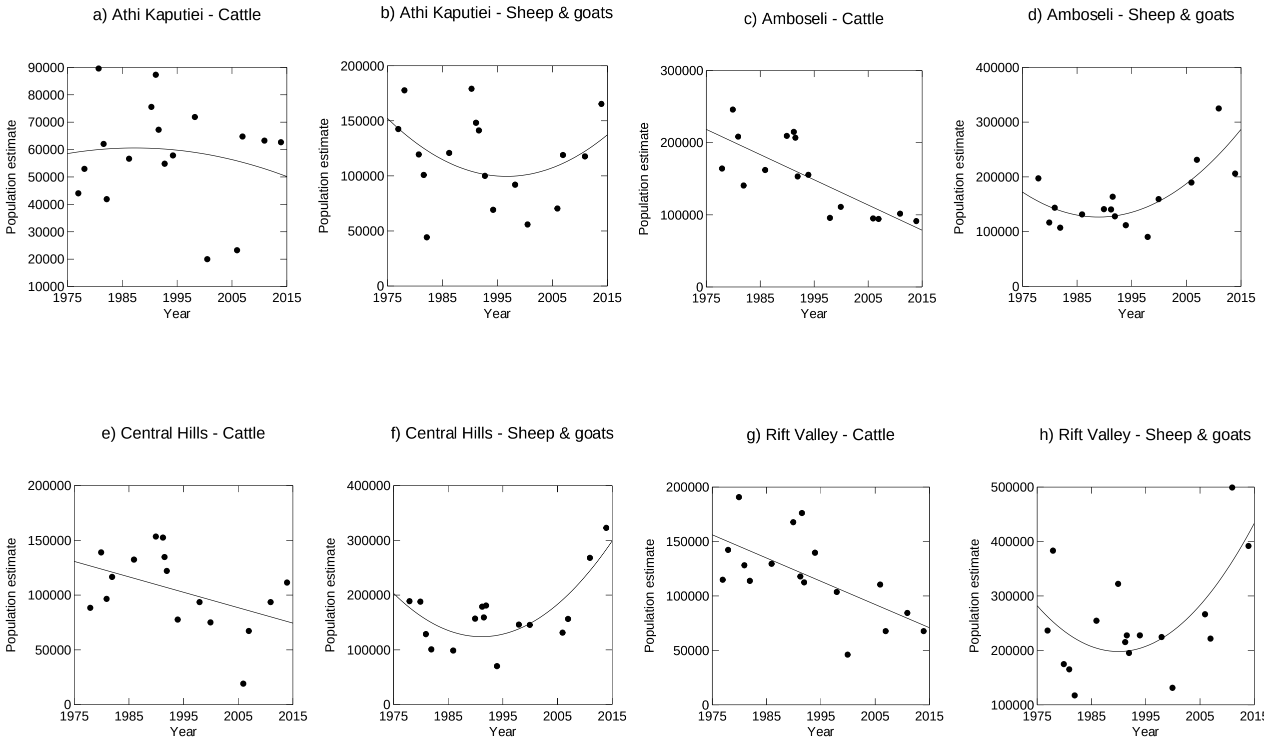


Figure 5: *Trends of cattle, and sheep and goats in Kajiado County based on the ecozones.*

Projected rainfall

The projected rainfall for 2030s for all RCPs indicate that the October–November–December (OND) short rains will increase for many counties in Kenya except for the coastal counties (Figure 6). In comparison, the March–April–May (MAM) long rains will be extremely low for RCP 2.6 for most of Kenya, whereas the RCP 4.5 and 8.5 projections indicate that most of northern Kenya will have rainfall deficits whilst southern Kenya will have a slight increase of rainfall including Kajiado. During the dry season June–July–August–September (JJAS), the rains are projected to decrease for RCP 2.6 and 8.5, whilst for RCP 4.5, western Kenya is projected to have an increase in rains.

The projected rainfall for Kajiado will vary across the 3 RCPs. In RCP 2.6, the annual rainfall is projected not to change much but the MAM and JJAS rainfall will be dry and there will be a slight increase in rainfall in the short rains of OND. The projected rainfall for RCP 4.5 and 8.5 are similar in that there will be a slight increases in MAM and OND rainfall and JJAS rainfall is expected to be drier especially for the RCP 8.5. This will translate into an overall slight increase in annual rainfall for the county.

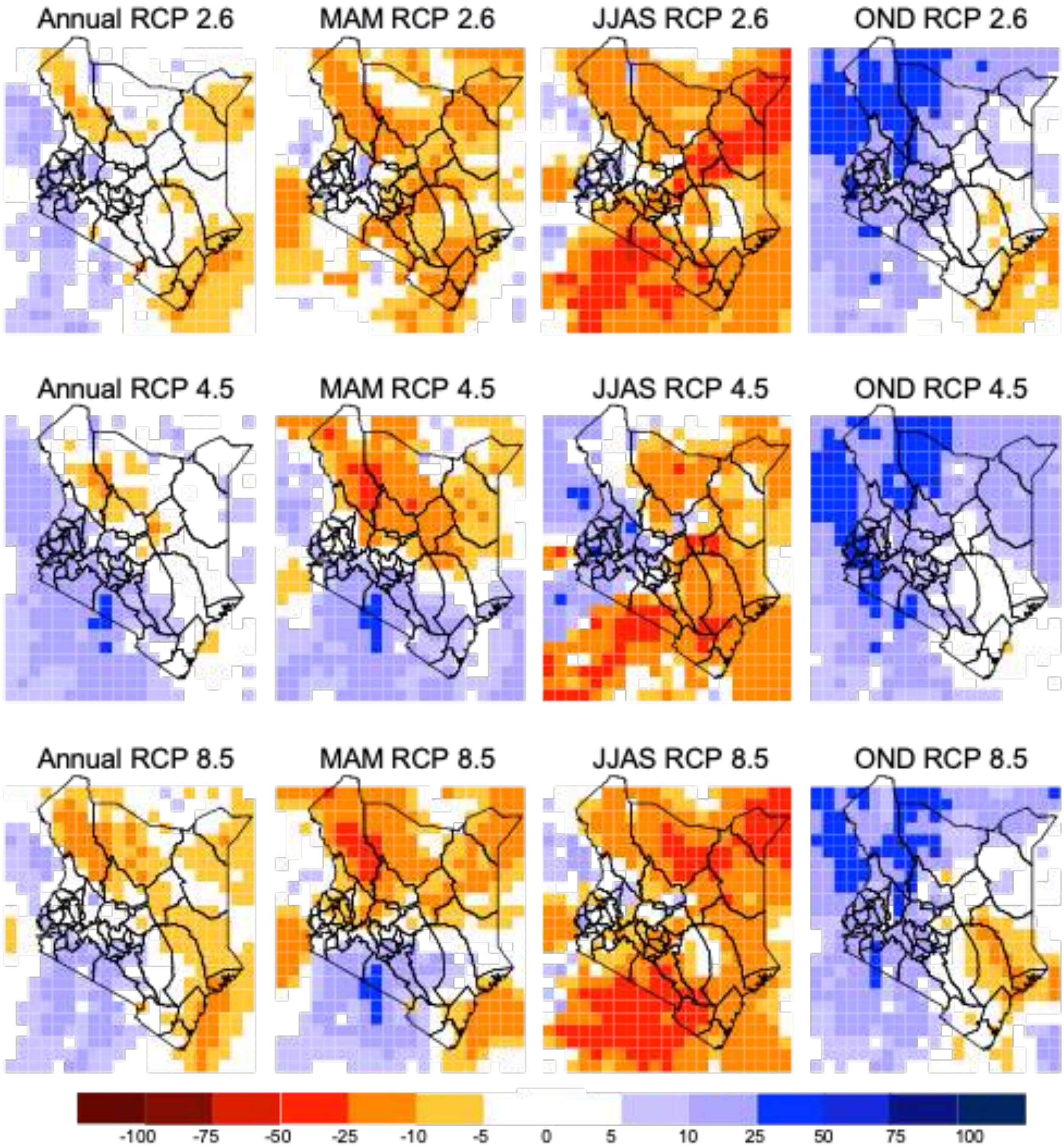


Figure 6: *Projected rainfall changes (%) in Kenya by 2030s for the four seasons – annual, MAM (March–April–May), JJAS (June–July–August–September) and OND (October–November–December).*

Projected temperatures for Kajiado County

The projected temperatures for Kajiado County show a significant change in both the minimum and maximum temperatures for all three RCPs. On average, for RCP 2.6, the maximum temperature will increase by 1.14°C in 2030s, 1.26°C in 2050s and 1.10°C in 2070s. For RCP 4.5, the maximum temperature will increase by 1.00°C in 2030s, 1.55°C in 2050s and 1.83°C in 2070s (Table 3). The highest increase in maximum temperature will be observed under the RCP 8.5 scenario, by 1.35°C in 2030s, 1.99°C in 2050s and 3.10°C in 2070s (Table 3; Figure 7). The minimum temperatures will follow similar patterns but with even higher values. By 2050s, the minimum temperatures for RCPs 4.5 and 8.5 will exceed 1.5°C.

Table 3: *Annual average maximum temperature increase (°C) for 2030s, 2050s and 2070s for Kajiado County*

	RCP 2.6			RCP 4.5			RCP 8.5		
	2030s	**2050s**	**2070s**	**2030s**	**2050s**	**2070s**	**2030s**	**2050s**	**2070s**
Maximum	1.14	1.26	1.10	1.00	1.55	1.83	1.35	1.99	3.10
Minimum	1.31	1.48	1.32	1.40	1.95	2.30	1.59	2.51	3.80

Figure 7 shows the spatial map of projected maximum temperatures for the three RCPs 2.6, 4.5 and 8.5 for the time periods 2030s, 2050s and 2070s. The maps clearly identify that the projected climate hotspots in Kajiado County will be Amboseli Plains and Rift Valley. Under all projections, Rift Valley will be the warmest. Amboseli Plains will be moderately impacted, but RCP 8.5 for 2070s shows that the area will be heavily impacted by large increases in temperatures. Athi Kaputiei and Central Hills are projected to face fewer challenges in temperature increases compared to Rift Valley and Amboseli Plains.

Overall, the analysis of rainfall for Kajiado County indicates that the rainfall for RCP 4.5 and 8.5 will increase slightly compared to RCP 2.6, such that rainfall will not be the limiting factor for cattle production (Aduma et al., 2018). However, the increase in temperature is likely to impact cattle production as some areas are projected to have temperatures above 30°C, where cattle productivity falls to less than 10 cattle per km^2 (Figure 4).

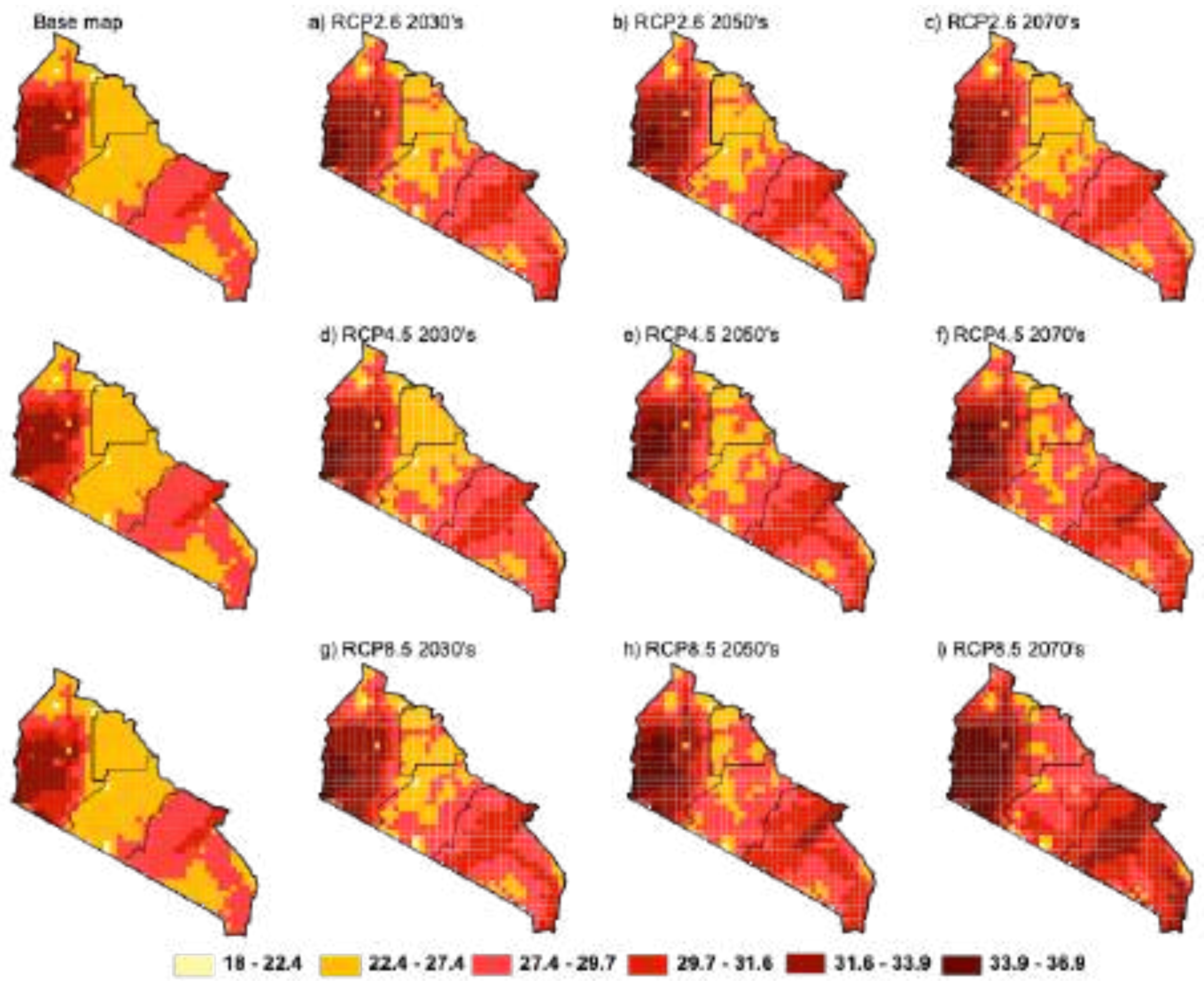


Figure 7: *Spatial projections of maximum temperature (°C) in Kajiado County and ecozones (black continuous line) based on RCPs 2.6, 4.5 and 8.5 for the period 2030s, 2050s and 2070s.*

Projected impacts of temperature changes on cattle

Analysis at the landscape level indicates that the Rift Valley and Amboseli Plains will be impacted heavily by further increases in temperature. In the Rift Valley for RCP 2.6, about 62% of the area will be above 30°C and thus highly unproductive for cattle production. The second scenario RCP 4.5, shows a slight variation between 2030s and 2070s from 61% to 66.7% of the area affected. For RCP 8.5, there is a large variation between 2030s and 2070s, with a projected increase by 2070s to 78.3%. In the Amboseli Plains, the highest increment in areas that will be less productive for cattle is projected to occur in RCP 4.5 and RCP 8.5. In 2070s for RCP 4.5, the projected area that might not be productive for cattle is around 47.4% and for RCP 8.5 this is almost doubled to 83.7% (Figure 8).

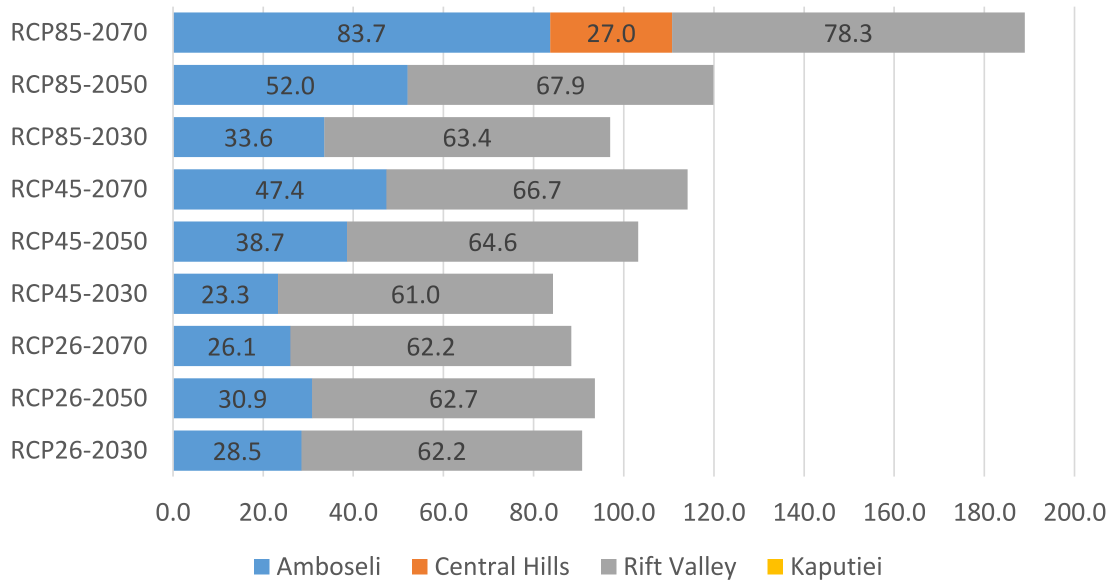


Figure 8: *Potential impacts of temperature changes on cattle range for RCP 2.6, 4.5 and 8.5*

Potential social economic impacts

It is projected that by 2030, 135,400 livestock keepers in Kajiado County might be affected critically by temperature changes in landscapes where the projected temperatures will be above 30°C. The current number of people in projected areas above 30°C is 78,400 people. This will be about 11.5% of the total county projected population. In terms of livestock, about 74,000 animals or 26% of the total current cattle population might be affected and lose of these animals will cost between Ksh 1.45 and 2.9 billion (USD 14.8–29.6 million). Kajiado County has an annual budget of around Ksh 5.4 billion (2015–2016 budget estimates), illustrating that a Ksh 2.9 billion loss in projected cattle production represents more than 50% of Kajiado County's budget.

Land tenure and climate change and their potential impact on livestock

The analyses of livestock trends show that Kajiado County has experienced a large decline (42%) in cattle and accompanying high increase (40%) in sheep and goats between 1977 and 2014. This mirrors the wider trend reported for the Kenya ASALs, where the cattle population have decreased by 25% and the sheep and goats population increased by 76% over the same time period (Ogutu et al., 2016). This switch from cattle to small stock may be explained by the changing land tenure and increasing intensification of land use and sedentarisation of pastoralists. Sheep and goats have smaller home ranges and require less forage, and are a common strategy where mobility is curtailed (Dahl and Hjort, 1976). This trend in switching from cattle to sheep and goats is already evident on the ground by local livestock keepers (http://news.trust.org/item/20180503003026-81xxa/) and has also been found in other increasingly fragmented rangelands (Bedelian and Ogutu, 2017). The other factor influencing the shift from cattle to sheep and goats is attributed to the better adaptability of sheep and goats to harsh environmental conditions. Switching livestock herd composition from cattle to small stock is a common pastoralist livestock management/climate change adaptation strategy to reduce the impact of drought. Sheep and goats are able to reproduce more quickly than cattle, have lower feed requirements and (have traditionally) played an important role in rebuilding herds following drought (McPeak and Little, 2005; Homewood and Rodger, 2004).

When narrowing down on the different ecozones, the highest declines in cattle are found in the Amboseli Plains (-61%) and the Rift Valley (-52%), accompanied by the highest increases in sheep and goats at 72% in the Amboseli Plains and 61% in the Rift Valley. These are the ecozones that also contain the remaining communal land, at 27% and 36% in the Amboseli Plains and the Rift Valley, respectively. Thus, according to the above explanations, the stronger factor influencing the shift to sheep and goats maybe more related to climate than the increasing privatisation of land. The Amboseli Plains and the Rift Valley are Kajiado's more arid ecozones (Table 1), as well as the climate hotspots where projections indicate the highest maximum temperatures will be experienced. Athi Kaputiei and Central Hills are expected to experience lower temperature increases. Thus, the environmental aspects of these areas may supersede land tenure aspects in terms of explaining these dynamics, where sheep and goats offer a more commonly applied strategy to adapt to the predicted high temperatures, and hence their large increases in number are already evident.

The increases in maximum temperatures have significant implications for pastoralist drought coping strategies, especially if the remaining communal land in the Rift Valley and Amboseli Plains is threatened with further land privatisation. As land is privatised, landowners introduce fences to protect forage for their livestock to use. Fences and other obstructions, cut off migration routes and constrain the mobility of livestock, as well as wildlife. Land fragmentation and fencing reduces the ability of livestock to access dry season grazing reserves, water resources and salt licks. With Athi Kaputiei and Central Hills now fully privatised, the ability to move to these cooler areas is already limited. Any further constraints on mobility are likely to further accentuate these impacts.

Additionally, Amboseli Plains and Rift Valley are also the more remote areas of Kajiado County, further away from Nairobi and other major towns[4]. They commonly have less livestock infrastructure such as livestock dips, water points and livestock marketing infrastructure, and also experience lower

[4] Major towns include Kitengela, Kiserian, Kajiado, Namanga, Isinya and Ilbissil

access to veterinary services. During times of drought, these areas have more constrained access to hay and other feeds due to their greater distance and ability to purchase feeds from major towns and Nairobi. Combined with their harsher climatic conditions, these factors may contribute to explain the higher increases in sheep and goats and reductions in cattle evident in these ecozones. This points to improvements that can be made in these areas to help increase the resilience of livestock to the projected climate changes.

The significant number of livestock and livestock keepers likely to be affected, as well as the loss to the county economy, suggest that urgent action needs to be taken to reduce the impacts of these temperature changes. This should occur through climate change adaptation and investment options, including enhanced infrastructure to support livestock production, and through better land use planning and greater support to mobility.

Key Findings

1. Land tenure

Land tenure changes in Kajiado County indicate that 64% of the county has been subdivided and privatised, 20% of land is still under group ranch, 4% under protected areas, 4% under lease to Magadi Soda Company, and 8% is under transition from group ranch to private land.

2. Livestock trends

Kajiado County has the second largest population of cattle (286,191) and fifth largest population of sheep and goats (963,585) amongst the 21 ASAL counties. However, it registered a 41.7% decline in cattle and 39.9% increase in sheep and goats population. At a landscape level, Amboseli Plains (-61%) and Rift Valley (-52%) registered the highest declines in cattle population and Central Hills (-41%) registered a moderate decline and Athi Kaputiei (-14%) the least decline. The trends in sheep and goats showed that the highest increase was registered in Amboseli Plains (72%) followed by Rift Valley (61%) then Central Hills (57%). A slight decline was observed in Athi Kaputiei (-7%).

3. Projected climate trends

On average for RCP 2.6, the maximum temperature will increase by 1.14°C in 2030s, 1.26°C in 2050s and 1.10°C in 2070s. RCP 4.5 maximum temperature will increase by 1.00°C in 2030s, 1.55°C in 2050s and 1.83°C in 2070s. RCP 8.5 maximum temperature will increase by 1.35°C in 2030s, 1.99°C in 2050s and 3.10°C in 2070s. Projected climate hotspots in Kajiado County are Amboseli Plains and Rift Valley. Under all projections Rift Valley will be the warmest.

4. Potential impacts of climate on cattle population, people and the economy

The analysis indicates that the temperature in Kajiado County will increase by between 1.00°C to 3.10°C depending on the climate scenario and time period. For the 2030s, it is projected that about 74,000 cattle might be affected by extreme temperatures in the county. The number of people relying on cattle will also be affected and by 2030s, it is projected that a population of about 135,400 people will be affected based on a population growth rate of 3.5%[5]. In terms of cost, the loss of these cattle from production is estimated to be between Ksh 1.45 and Ksh 2.9 billion based on current cattle prices[6]. This represents a huge loss to the pastoral community in Kajiado, and argues the need for steps to cushion them from climate change for their economic and social well-being.

What Next?
Key Recommendations

1. The projected increases in temperature and subsequent impacts on the cattle production in Kajiado have serious implications for livelihoods, and the economy of Kajiado. Kajiado County needs to fully assess the potential impacts of projected climate change on its livestock (including sheep, goats and camels), wildlife, agriculture (suitable areas and productivity), and genetic preferences (for animals, crops and fodder). An assessment of impacts should also include studies on the economic cost of not taking action or not having appropriate adaptation and mitigation plans.
2. The projections indicate that urgent action will need to be taken to build resilience of communities and adapt to the changes in temperature, particularly as noted in the Rift Valley and Amboseli Plains. The county government, supported by their development partners should establish a County Climate Change Fund (CCCF) in Kajiado to help provide local communities with access to climate finance from county funds and national and international sources. The purpose of setting up the CCCF will be for local communities to have funds they can use to prioritise the type of public investments they need to build their resilience to climate change.
3. These investments could, for example, be used to acquire more climate resilient breeds, commercialise fodder production, enhance water conservation and management, establish livestock marketing infrastructure, livelihood diversification or other interventions communities deem necessary. The enactment of a law and a policy for setting up the CCCF at the county level will allow local communities to directly access climate finance from both domestic and international sources.
4. The private sector should also support these investments in the livestock value chain that help to build resilience to drought, for example in establishing new markets for livestock, supporting the

[5]The current population of people in the affected areas is 78,400 people.

[6]It is estimated that on average, the price of cattle in the ASALs ranges between Ksh 20,000 (US$ 100) and Ksh 40,000 (US$ 400) (see 2016, 2017 and 2018 NDMA reports for Narok, Laikipia, Nyeri, Wajir and Garissa).

development of infrastructure, water, alternative feeds and pasture.

5. Kajiado County lacks a comprehensive and enforceable land use and land zonation strategy and plan. This has allowed the haphazard growth and spread of settlements, industries and urban townships in a manner that has made sustainable land management a mounting challenge. This calls for Kajiado County to revisit their land use plans and strategies and to take into considerations climate scenarios since its major resources are livestock and wildlife. The potential impacts of projected climate change might be devastating to both resources and the largely pastoral population. In these plans, vulnerability assessments should be conducted so as to inform the county the possible outcome of each chosen path.

6. The Ministry of Lands, Urban Planning and Housing in Kajiado County needs to develop and/or fully enforce legislation for monitoring and preventing land fragmentation and enclosure in the county, especially in the livestock and wildlife rich Amboseli Plains and Rift Valley ecozones. This should include developing mechanisms for protecting existing communal lands and protected areas, such as forests, conservation areas and livestock holding grounds, which are important for conservation, but also double up as places of refuge for pastoralists during times of climatic stress. The ministry should also provide mechanisms for consolidating fragmented parcels into larger land holdings that have better economic and utilisation potential as conservancies or pastoral grazing areas. Large open landscapes are climate change resilient and more conducive for animal production than small enclosed parcels.

7. To facilitate mobility as an adaptation measure used by pastoralists and conservationists in response to increasing climatic stress, the ministries related to livestock, land planning and wildlife conservation at the county, national and regional levels, should put in place mechanisms and legislations to facilitate movements of wildlife and livestock across community, county and national boundaries. There is need to eliminate physical and socio-political boundaries to animal movement. These would include establishing legal animal migration corridors, crossing points and underpasses in roads and railway lines, and entrenching reciprocal systems for sharing of resources across community, county and national boundaries.

8. There is an urgent need to develop both short-term and long-term intervention plans for livestock. This includes mainstreaming climate change within the County Integrated Development Plans (CIDPs) and the County Spatial Plan. CIDPs provide a legislative roadmap for the integration of climate change mitigation and adaptation in policy, planning, budgeting and implementation at the county level.

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