The impact of climate change on the incidence of cattle diseases in a pastoral area of Kenya

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Abstract

Participatory epidemiological methods were used to establish local perceptions and livestock owner's knowledge, attitudes and practices (KAPs) of risk factors of climate variability, the seasonal variations in incidences of livestock diseases, disease vectors, intermediate hosts and rainfall that affect incidences of cattle diseases in pastoral Rift valley of Kenya. Factors influenced by climate change and that could affect livestock diseases include the molecular biology of the pathogen itself; vectors (if any); farming practice and land use; zoological and environmental factors; and the establishment of new microenvironments and microclimates.

East coast fever had the highest (68%) morbidity rate of all the five diseases and appeared to affect the adults - (26%) than the weaners - (21%) and calves - (21%) classes respectively. However, mortality was slightly more in the younger age classes. Foot and mouth disease had the second highest reported morbidity at 52% and affected slightly more of the weaners' and adults (20%) than it did the calves (15%). The interaction of these factors were an important consideration in forecasting how livestock diseases particularly ECF and FMD occur. The findings conclude that the future for traditional pastoralists is dismal because they continue to depend on an environment that may no longer support them. Risk assessments focus on looking for combinations of factors that may be directly affected by climate change or that may be indirectly affected through changes in human activity, such as land use (e.g. deforestation), transport and movement of animals, intensity of livestock farming and habitat change is proposed. These may be used to screen for the emergence of unexpected disease events, recommend disease management practices and policy measures to mitigate the impact of climate variability on the spread of livestock diseases.

Key words: adaption, participatory epidemiological methods, pastoralists

Introduction

According to IPCC (2007) climate change, can be defined as a variation in climate over time, whether in average weather or extreme events. In Africa's pastoral lands, climate variability has manifested through increased temperatures, decreasing rainfall reliability, and increased frequency and severity of extreme climate events. Climate change, affects the molecular biology of the pathogen itself; vectors (if any); farming practice and land use; zoological and environmental factors; and the establishment of new microenvironments and microclimates thus influences the occurrence, distribution and prevalence of livestock diseases under the changing ecological conditions. The implication is that warming means more than the annual mean of global warming, with drier subtropical regions warming more than the moister tropics (Alcamo et al 2007, Speranzaa 2010). Indeed climate variability by effecting the environmental conditions has the consequence of impacting pasture growth and quality, availability of water resources and the thus the distribution of livestock diseases (Gale et al 2008) and pastoral livelihoods (Ogunsipe and Ayoola 2012). Socio-economic factors/practices such as land use, charcoal burning, deforestation, water shed management practices could lead to desertification (Arnella et al 2004).

Participatory appraisal (PA) methods including interviews, ranking and scoring methods, and visualization methods have been used to analyse the seasonal incidences of diseases of cattle, disease vectors and rainfall. They can effectively describe important functional relationships and properties of ecological systems by referring to time, space and resource flow patterns. In addition, they demonstrate visually through the use of decision trees and Venn diagrams, the decision-making processes and power relationships between different stakeholders (Conway 1985, Conway 1991,). Amongst pastoral communities, it has been applied to establish the seasonal variations in the incidence of livestock disease (Catley et al 2002, Vallat 2008, Bett et al 2009), disease vectors (Catley and Aden 1996), livestock movements and animal management practices (Elos et al 1995).

This paper describes the use of participatory epidemiological methods to establish local perceptions of the effect of climate variability on the seasonal variations in incidences of livestock diseases, disease vectors, intermediate hosts and rainfall in pastoral Kajiado district in Rift valley of Kenya. The recommended disease management practices and policy measures to mitigate the impact of climate variability on the spread of livestock diseases are discussed

Materials and methods

Location

Kajiado Central District lies between latitude$1^0$50´ 24"South of the Equator and longitude 36^0 47´23" East. Most of the land lies within the lower midland 6 (LM6) agro-ecological zone (AEZ) with bimodal rainfall, which is too little to support rain-fed agriculture. Semi-nomadic pastoralism represents the main spectrum of production systems found in the division classified as a semi arid land (ASAL, zones V and VI) with erratic but bimodal rainfall pattern (average of 300mm). The long rains fall between March and May while the short rains fall between October and December. Temperatures range between 10^oC and 34^oC increasing East to West. The coolest period is between July and August while the hottest months are from November to April (GoK 2002). The livestock population in Central Division is estimated at 69,456 cattle, 88859 goats, 83,628 sheep, 7,891 donkeys, 852 camels, 16 pigs and 10,826 poultry (GoK 2008). Enkaroni Location covers an area of 153.9$km.^2$ it's characteristics include a population density of 22.7 persons per km2, average household size of 4.2 persons.

The vegetation types vary from deciduous bush lands to deciduous shrub land consisting mainly of the *Acacia melifera, Commiphora spp, Tarconanthus spp, Acacia tortilis, Acacia xanthopholea* interspaced with star grass and Maasai red oats. In addition, the area has other natural resources such as wildlife. Encroachment into the fragile water catchments/ conservation areas through charcoal production, quarrying and mining have had long-term effects on grazing land.

Data Collection

Initial meetings with the Provincial Administration, community based organizations, community leaders large and small scale producers were held between August 2008 and April 2009. Qualitative and semi-quantitative data were collected using Participatory Epidemiology (PE) techniques described by Mariner and Paskin (2000). Examples of applications of these methods have been described (Catley and Admassu 2003, Bedelian et al 2007). Data were collected from fourteen groups of pastoralists consisting of 5 and 8 persons per group (all were Maasai and each group comprised at least 50% women). All the scoring exercises utilized 100 beans (for 100%). Key informants (veterinary personnel, development workers, provincial administration and community opinion leaders and elders) were always interviewed independently either before or after the group sessions.

Focused groups discussions were used to come up with a daily activity calendar, seasonal cropping calendar, matrix scoring, proportional piling, and comparison of the control measures of the various livestock diseases. A resource map of the area, geophysical features, seasonal migration patterns of livestock, human-wildlife interactions, livelihood profiles and institutional analysis was also developed. Stakeholder analysis was done to establish their presence, interactions, power, influence and control over the flow and access to resources such as pastures, water, charcoal, milk, meat, livestock and firewood both within the community and at household level by different gender groups.

Trends lines were developed to elucidate the historical changes in livelihoods, population, food, water, livestock numbers, livestock diseases, rainfall/ drought, and pastures over the years. In addition, it indicated important historical events. Key-informants including community leaders, development/implementation partners (Red Cross, Neighbours Initiative Alliance (NIA) and Government officials' from Ministries of Agriculture, Water, and Social Services were asked to provide information on livestock diseases, climate (rainfall) data, food production and availability, human populations, problems addressed in the location, water sources and location, livestock disease control infrastructure and markets that was used to triangulate information from the community. Transect walks were used to elucidate the condition of pastures, vegetation, water sources and availability, climate, land tenure and market support infrastructures. Semi structured interviews (SSI) were used to establish the problem pastoralists faced and their coping mechanisms.

Disease ranking

The participants were asked to give a list of diseases acquired by cattle kept over a 1-year period preceding the time of the interview. The pastoralists often used the local disease names to identify cattle diseases. When the participants provided syndromes rather than specific names of diseases, probing using open-ended questions was done to characterize the syndrome whilst trying not to guide them. The names of the diseases and descriptions given by the pastoralists were later validated at the local veterinary office. Subsequently, the five diseases perceived to have been most prevalent in the previous year were determined through pair-wise ranking. A total of 100 beans representing the population of each species of livestock was used for scoring. The participants were asked to divide the beans into two, a pile representing the proportion of cattle that became ill during that period and the other representing the proportion that remained healthy over the same period. This gave an overall proportion of cattle that became ill over the year (from any of the diseases listed). The participants were then asked to give reasons that could explain the scores given.

The pile representing the proportion of animals that became ill was further sub-divided with three age-categories of cattle i.e. calves up to about 1 year of age (*ilasho*); calves between1-2 years old (*olarum*); and adults more than 2 years old (*ngishu*). The five most-important cattle diseases thus identified by the proportional pile were in a matrix with specific symptoms, season of occurrence and the cost effectiveness, ease of application for the treatment method. The final step in this exercise involved sub-dividing the piles representing individual diseases into the proportion of cattle that recovered and those that died from each disease to determine case fatality rates. The group of ‘‘other diseases’’ was not included in the estimation of case fatality rates.

A seasonal calendar was used to generate associations between the ethological factors and the incidence of disease by mapping the occurrence of rainfall, pastures, cattle diseases, pests, access to markets and food availability. Additionally their daily activity log was also drawn showing the daily activities relating to their livelihood.

A five-part analysis process is described including preparation of the data, grouping and coding, consolidation, making sense of the data, and producing a report. The semi-quantitative data generated from the study were entered into MS Excel database and exported to SPSS programme for analysis. Descriptive statistics like means, frequencies, percentages, bar-charts, pie charts and graphs were used to present the results. Inferential statistics such as ANOVA, and t-tests were used in testing the study hypotheses. The significance differences were tested at 5% level of significance.

Results

Impact of climate variability on the occurrence of livestock diseases

Historical profile/trends of the location revealed an increase in the incidence drought, a corresponding decrease rainfall that became increasingly unpredictable. The areas experienced devastating droughts accompanied by massive livestock morbidity and mortality in the years 1974, 1981, 1990, 2000, 2004, and most recently in 2008. The droughts cycles appear to be occurring more frequently (Table 1).

Table 1: Trends and changes of events between 1970 and 2007

Events	1970-1980	1981-1990	1991-2000	2001-2007
Livestock numbers	+ + + + + + + + + + + + +	+ + + + + + + +	+ + + + + + +	+ + +
Livestock diseases	+	+ + +	+ + + + +	+ + + + + + + + + + +
Annual rainfall received	+ + + + + + + + +	+ + + + + + + +	+ + + +	+ +
Drought occurrences	+ +	+ + + +	+ + + + +	+ + + + + + + + + + +
Pastures	+ + + + + + + + + +	+ + + + + + +	+ + + +	+ +

Key: + *Represents magnitude or abundance*

Major livestock disease epidemics occurred during this period including foot and mouth disease (1970-80), East coast fever (1984) and blue tongue in sheep and goats in the year 2000 (Table 2).

Table 2: Historical events related by pastoralists

Year	Events
– 1970-1980	– 1st FMD vaccination
	– Severe Drought, 1974
	– High livestock deaths
	– Graduation of *Iseuri* age group
	– *Esilanke* dam constructed
	– 1977-1978 very good weather, ample pastures
– 1981-1990	– Enkaroni Dam constructed
	– Severe drought 1984
	– Pastoralist migrated to Tanzania
	– Death of livestock
	– Graduation of *Ilkitoip* age group
	– Severe ECF problems
	– *Enkaroni* group ranch started
– 1991-2000	– Severe drought 2000
	– Migration to Tanzania
	– Migration to Nairobi
	– *Endoingo* pre-school started
	– *Ilparua* Pre-school started
	– Title deeds 1992
	– Outbreak of sheep and goats blue tongue disease
– 2001-2008	– Severe drought 2004
	– Severe drought 2005/06
	– Floods, Outbreak of bird flu in world
	– T.D. Jakes drilled a borehole
	– *Ol tepesi* bore hole drilled
	– Shallow well at *Noolera*
	– *Oloosiyiamalil* community borehole drilled
	– Electricity line to *Enkaroni*
	– 2008/09 drought

Economic impact of cattle disease

The five cattle diseases in decreasing order of importance were East Coast Fever (ECF), Foot and Mouth disease (FMD), Lumpy Skin Disease (LSD), Blackquarter (BQ) and Anthrax (Table 3).

Table 3: Pair-wise ranking of diseases of cattle 2008

Disease	**ECF**	**FMD**	**BQ**	**ANT**	**LSD**	**MCF**	**TRYP**	**ANA**	**CBPP**	**RIND**	**HEL**	**Score**	**Rank**
ECF		ECF	ECF	ECF	ECF	ECF	ECF	ECF	ECF	ECF	ECF	10	1
FMD			FMD	FMD	FMD	FMD	FMD	FMD	FMD	FMD	FMD	9	2
BQ				BQ	LSD	BQ	BQ	BQ	BQ	BQ	BQ	7	4
ANT					LSD	ANT	ANT	ANT	ANT	ANT	ANT	6	5
LSD						LSD	LSD	LSD	LSD	LSD	LSD	8	3
MCF							MCF	ANA	MCF	MCF	MCF	4	7
TRYP								ANA	CBPP	TRYP	HEL	2	9
ANA									ANA	ANA	HEL	5	6
CBPP										CBPP	HEL	3	8
RIND											HEL	1	10

KEY: *ECF-East Coast fever; FMD-Foot and Mouth disease; LSD-Lumpy Skin Diseases; BQ-Black Quarter; ANT-Anthrax; CBPP – Contagious Bovine Pleura Pneumonia; MCF- Malignant Catarrhal Fever; TRYP-Trypanosomoses; ANA- Anaplasmosis; RIND- Rinderpest; HEL Helminthosis*

Matrix scoring of the severity of diseasesymptoms/risk factors or indicators

The pastoralists ranked the important cattle diseases against the severity of their symptoms using beans for scoring (Table 4). Each bean represented increasing severity of the symptom or association as a causative factor. Foot and mouth diseases was reportedly associated with lameness, a reduction in milk yield and salivation. ECF was associated with high mortality, enlarged lymph nodes, diarrhoea, coughing and occurrence during the rainy season. Anthrax was associated with high mortality and occurrence in the dry season. Lumpy Skin disease was scored highly on reduction in milk yield, appearance of skin swelling and lameness. Blackquarter was associated mostly with occurrence in the rainy season, reduced milk yield and presence of skin swellings.

Table 4: Matrix scoring for cattle diseases by the severity of their symptoms

Indicator	**FMD**	**LSD**	**BQ**	**ECF**	**ANTHRAX**
Drought	4 (3-6)	-	-	6 (3-8)	5 (1-8)
Rainy	6 (5-8)	6 (4-8)	8 (6-9)	9 (6-10)	2 (1-4)
Coughing	3 (2-4)	1 (0-4)	3 (2-6)	8 (7-9)	-
Diarrhoea	-	-	-	9 (7-10)	-
Causes deaths	2 (0-4)	5 (2-7)	6 (4-7)	9 (7-10)	7 (3-9)
Lameness	8 (5-10)	7 (3-9)	6 (3-8)	-	0 (0-3)
Reduced milk	7 (5-10)	7(3-9)	7(0-10)	6 (3-8)	0 (0-3)
Loss of hair	0 (0-5)	6 (3-8)	-	-	-
Enlarged l/nodes	-	5 (2-7)	1(0-4)	8(4-10)	0 (0-4)
Skin swellings	1 (0-7)	7(6-10)	7 (5-8)	2 (0-5)	-
Salivations	8(7-10)	2(0-6)	-	8(6-9)	4(1-5)
Moves to the shade	1(0-8)	4(0-10)	3(0-8)	9(8-10)	-

Key: *The matrix score indicates the median score with numbers within parenthesis ( ) giving the range.*

Estimates of morbidity and mortality

The proportional pilings provided estimates of morbidity and mortality annual rates for the five common cattle diseases (Table 5).

East coast fever had the highest (68%) morbidity rate of all the five diseases and appeared to affect the adults - *Ngishu* (26%) than the weaners - *Olaramu* (21%) and calves -*Ilasho* (21%) Classes respectively. However, mortality was slightly more in the younger age classes. Foot and mouth disease had the second highest reported morbidity at 52% and affected slightly more of the weaners' and adults (20%) than it did the calves (15%). Mortality due to FMD appeared to be evenly distributed among the three age classes. The overall morbidity rate of LSD was estimated at 33% and was slightly more in the older age class than in the younger ones. There appeared to be no differences in LSD mortalities across the age classes.

Table 5: Proportional piling of cattle diseases by the estimates of their annual morbidity/mortality rates (%)

Livestock diseases	***Age Category***			
	<1 year (Ilasho)	**1-2 years (Olaramu)**	**>2 years (Ngishu)**	
East coast Fever	21(12)	21(11)	26(10)	68(33)
Lumpy Skin Disease	10(3)	9(3)	14(4)	33(10)
Foot and Mouth Disease	15(3)	17(3)	20(2)	52(8)
Black-quarter	5(2)	7(3)	8(1)	20(6)
Anthrax	8(3)	8(2)	11(3)	27(8)

Note: The study comprised fourteen groups of pastoralists divided into 5 and 8 persons per group (all were Maasai and each group comprised at least 50% women). An example of how proportional piling was conducted to estimate morbidity and mortality is shown for ECF (Figure 1)

Figure 1: Proportional piling for ECF

Effectiveness of diseases control measures

The perceptions by the pastoralists on the effectiveness of control measures of the five most important cattle diseases are given in Table 6. The effectiveness for the control of ECF was considered equally for the three control methods of spraying, fencing and vaccination. However, vaccination was considered slightly expensive than spraying and fencing (Table 7). Individual approach was preferred for the control of ECF to group approach. Isolation of sick animals and separation of cattle from wildlife were considered the most effective methods for the control of FMD. Treatment for FMD was perceived to be very expensive. The separation of livestock from wildlife required a group approach than an individual for effective control of the disease. Of the two control methods for LSD vaccination of livestock was favoured to spraying and a group approach was considered the best approach. Methods given for the control of BQ were isolation, treatment and vaccination that were considered to be equally effective. Individual approach to BQ control was the most favoured. Of the three methods given for the control of Anthrax vaccination and quarantine were perceived to be more effective than treatment of sick animals. Individual treatment was favoured over group management in the control of Anthrax. The pastoralists considered the cost of the control methods to be high in all the methods except for isolation of sick animals and separation from wildlife.

Table 6: Perception of pastoralists on the effectiveness of disease control measures

Disease	Control methods	Effectiveness	Financial Cost	User friendly	Group approach	Individual approach
ECF (Óltikana)	Spraying	7(6-9)	7(5-9)	7(6-9)	4(2-5)	6(6-9)
	Fencing	6(4-9)	8(6-9)	6(5-8	4(1-6)	7(3-9)
	Vaccine	6(3-8)	9(7-10)	7(4-9)	4(1-8)	8(6-9)
FMD (Oloirobi)	vaccine	8(6-9)	7(5-9)	5(3-8)	8(6-9)	3(1-5)
	Isolation	6(3-7)	3(2-6)	5(1-8)	3(1-5)	5(2-7)
	Treatment	3(1-6)	8(5-10)	5(1-9)	3(1-6)	7(5-9)
	Separation from wildlife	6(3-7)	4(1-5)	3(1-5)	8(5-9)	3(1-5)
LSD (Erirri)	Spraying	6(3-7)	7(5-8)	3(1-6)	3(2-5)	4(2-7)
	Vaccine	8(6-9)	7(3-9)	2(1-5)	7(4-9)	3(2-7)
BQ (Empuruo)	vaccination	9(7-10)	7(5-8)	6(5-8)	6(2-8)	4(2-6)
	Isolate	7(5-8)	2(1-4)	7(2-9)	2(1-4)	8(6-10)
	Treatment	8(5-9)	8(6-10)	3(1-5)	2(1-4)	8(6-9)
Anthrax (Entemelua)	Vaccination	9(7-10)	9(8-10)	7(4-9)	2(1-6)	9(7-10)
	Treatment	6(5-7)	9(7-10)	6(4-8)	2(1-4)	8(6-9)
	Quarantine	8(6-9)	4(2-6)	6(5-8)	8(5-10)	6(3-8)

Note: Numbers in brackets are ranges given by 14 groups

Discussion

The study assessed the perceptions of pastoral communities of the interrelationship between climate change and incidence of livestock diseases. This was done by examining the key climatic factors that affects vectors occurrence, severity of lesions and clinical signs, transmission and epidemiology. Dufour et al (2006) addressed issues such as the effect of climate change on the vector, host reservoir, characteristics and epidemiology of the pathogen to evaluate the risk of emergence and development of infectious diseases in France as a result of global warming.

Pests and parasites are important in either curtailing or proliferating the distribution and spread of diseases, pests and parasites of livestock (Gale et al 2008). Stem et al (1989), describe the potential of how climate change could lead to changes in spatial and temporal distribution of diseases sensitive to moisture. This study reports that East Coast Fever (ECF), Foot and mouth disease (FMD), Anthrax, Lumpy skin disease (LSD) and Blackquarter (BQ) are the most important disease. These findings are consistent with the results of Bedelian et al (2007).

Climate change affects the incidence of livestock diseases transmitted by direct contact due to changes in the frequency and duration of animal contacts. Changes in the degree of mixing of cattle and sheep will affect the prevalence of diseases such as MCF, which is caused by OHV and spread by direct contact (Radostits et al 2000). The migrating wildebeest are a reservoir for MCF in livestock the Amboseli National Park. The disease is transmitted through contact between infected and susceptible animals and was attributed to cold weather when animals tend to congregate. The disease reportedly occurred in both the wet and the dry seasons. The probable reason for occurrence in the dry season may be the potential congregation of animals from different herds at watering points. Extreme climatic conditions (e.g. heat stress) induced the cell-free OHV in nasal secretions combined with other farming management responses to climate change (e.g. co-mingling of cattle and sheep in response to flood) that increase direct contact could promote the spread of the disease.

The strategy considered most effective for disease control was vaccination probably because the cost was often borne by NGO's. Livestock movement control and quarantine were not popular methods for disease control as they were considered punitive. However the pastoralists felt that the methods are effective as they indicated that they normally migrate whenever disease outbreaks occurred. Moreover cattle perceived to be suffering from FMD were always watered after other animals. This indicated that they were aware of the mode of transmission.

Migration was practiced by a large proportion of the surveyed pastoralists in response to drought as well as disease outbreaks. Only a small proportion indicated that they never move and was thus considered sedentary. This latter group had other sources of livelihood that included crop production, quarrying and charcoal burning. A small proportion of pastoralists moved with the whole family as livestock were their only source of livelihood. During migrations men and young boys moved with the animals while children and women stayed back in the manyattas with recently calved cows and small stock. Similar migration pattern was observed among the pastoral community of Turkana District (Lotira, 2004)

According to the pastoralists of Kajiado District there have been marked climate changes in the area. This has led to changes in their way of life impacting negatively on their livelihoods. This information was collaborated by the climate data collected in five weather stations in the neighbourhood of Kajiado. There were marked associations between disease occurrence and climate change/variability pertaining to humidity, wind speed and direction as well as temperature. In addition many infections especially the arthropod vectors and helminthes are known to occur under wet conditions and therefore influenced by climate change. Some diseases were positively associated with certain climate elements (e.g. Helminthosis with rainfall), while others were negatively associated with other climate elements (e.g. Babesiosis with rainfall). The pastoralists felt that there was less rainfall over the last past years although the climatic data showed non- significant variations in the amount received during the same period (2001-2008).

From the results obtained from the study, it can be concluded that; pastoralists of Enkaroni Location recognized livestock diseases as a constraint in their livelihood. There has been a significant change in climate in Kajiado over the last 10 years (1997-2007). Climate change in Kajiado District is positively and significantly related to occurrence of cattle diseases. This may have led to significant increase in occurrence of cattle diseases in Kajiado District. Significant variations in certain weather elements may have modified the ecosystems of the diseases causing an increase in pathogens and vectors populations. To respond to this, it is recommended that an early warning system should be developed to predict climate changes pastoral areas and information network on targeted and strategic disease management interventions that moderate the multiplication of disease-causing pathogens and their vectors as a result of climate variability be developed. In addition, extension education should be used to enlighten the pastoralists on the importance of disease control, stocking density of animals and environmental conservation in order to mitigate against climate variability.

Conclusion

- Climatic change has adverse impact on pastoral livelihoods. This is through the potentiation of the occurrences of various viral and vector bone diseases by modifying the ecosystems of the diseases causing an increase in pathogens and vectors populations. It is imperative that early warning systems and stronger extension services are used for strategic management of disease control interventions.

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