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Impact of climate change on the incidences of small ruminant diseases in a pastoral area of Kenya

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Participatory epidemiological methods were used to establish local perceptions and livestock owner's knowledge, attitudes and practices (KAPs) of risk factors that impacts climate variability and the seasonal variations in incidences of livestock diseases, disease vectors, intermediate hosts and rainfall in pastoral Rift valley of Kenya. The interaction of the molecular biology of the pathogen itself; vectors (if any); farming practice, land use; zoological and environmental factors; and the establishment of new microenvironments and microclimates were important in forecasting how contagious caprine pleuronemonia, enterotoxaemia and sheep and goat pox occurred. Thus, the future for traditional pastoralists is depressing if they depend on an environment that may no longer support them. A risk assessment framework was used to examine factors directly affected by climate change or indirectly by human activity, such as land use (e.g. deforestation), transport and movement of animals, intensity of livestock farming and habitat change and their relationship with emergence of unexpected disease events. The present study recommended implementing disease management practices and policy measures to mitigate the impact of climate variability on the spread of livestock diseases.

Key words: Climate change, participatory epidemiology, incidences of small ruminant diseases, pastoral areas.

INTRODUCTION

Climate change, describes a variation in the weather, temperature and environment over a given period of time, be it manifested through changes in mean temperatures or occurrence of extreme weather events (IPCC, 2007). 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 influencing the occurrence, distribution and prevalence of livestock diseases under the changing ecological conditions. The implication is that warming means greater than the global annual mean (Alcamo et al., 2007), with drier subtropical

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regions warming than the moister tropics' (Alcamo et al., 2007). Indeed, climate variability by affecting the environmental conditions has the consequence of impacting pasture growth and quality, availability of water resources and thus the distribution of livestock diseases (Gale et al., 2008) and pastoral livelihoods (Ogunsipe and Ayoola, 2012).

Participatory appraisal (PA) methods including interviews, ranking and scoring methods, and visualization methods have been used to analyse the seasonal incidences of livestock diseases, 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 Rift valley of Kenya.

MATERIALS AND METHODS

Location

Kajiado Central District lies between latitude 1050´ 24" South of the Equator and longitude 360 47´23" East. 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 300 mm). The long rains fall between March and May while the short rains fall between October and December. Temperatures range between 10 and 34°C increasing East to West. The coolest period is between July and August while the hottest months are from November to April. (Kajiado District Development Plan, 2002-2008). 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 (MoLD Central Division Veterinary Annual Report, 2008). Enkaroni Location covers an area of 153.9 km^2. Its characteristics include a population density of 22.7 persons per km^2, 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*, *Tarconanthus* spp., *Acacia tortilis* and Acacia *xanthopholea* interspaced with star grass and Maasai red oats. In addition, the area has other natural resources such as wildlife.

Data collection

Initial meetings with the Provincial Administration, community based organizations, community leaders large and small scale producers was between August 2008 and April 2009. Qualitative and semi-quantitative data were collected using PA 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 was collected from fourteen groups of pastoralists divided into 5 to 8 persons per group. All the scoring exercises utilized 100 beans to represent 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 obtain 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 showing geophysical features, and seasonal migration patterns for livestock, human-wildlife interactions, and livelihood profiles and institutional analysis was 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 as well as resources at the 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 (Table 1). Key-informant including government representative and line ministry personnel, community leaders, development/implementation partners (Red Cross, neighbours Initiative Alliance (NIA)) and other Government officials' from Ministries of Agriculture, Water and Social Services were asked to provide information on livestock diseases, climate (rainfall) data, human population problem, food production and availability 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.

Identification and scoring of livestock species by number and importance to livelihoods

Participants enumerated the list of household livestock species and scored them based upon impact on their livelihood of the number and importance to family's survival, using pair-wise ranking. The exercises were preceded by circles representing the listed livestock species being drawn on the ground. The participants were then given beans and asked to distribute them to the circles (each representing one livestock species) depending on the question asked. A high proportion of beans was always allocated to a species that was either abundant or important in terms of livelihoods. After each exercise, the participants were notified of the outcome and asked if the scores obtained represented their perceptions. They were further asked to give reasons that could support the scores obtained.

Disease ranking

The participants were asked to give a list of diseases acquired by each of the livestock species kept over a 1-year period preceding the time of the interview. The pastoralists often used the local disease names to identify diseases. When the participants provided

Table 1. Trends and changes of events between 1970 and 2007 in Enkaroni Location, Kajiado district.

Variables	1970-1980	1981-1990	1991-2000	2001-2007
Livestock numbers	12	8	6	3
Livestock diseases	1	3	5	11
Annual rainfall received	9	8	4	2
Drought occurrences	2	4	5	10
Pastures	10	7	4	2

syndromes rather than specific names of diseases, probing using open-ended questions were done to characterize the syndrome whilst trying not to guide them. The names of 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 were used for scoring. The participants were asked to divide the beans into two, a pile representing the proportion of livestock 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 goats 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 small ruminants, that is, Ntare (mature goats/ sheep) and Ilkuo (kids or lambs less than 6 months). The five most-important diseases thus identified by the proportional pile were in a matrix with specific symptoms, season of occurrence and the cost effectiveness disease control measures, ease of application for the treatment method. The final step involved sub-dividing the piles that represented the various diseases into two. These were the proportion representing those animals that recovered and those that died. This enabled a determination of the 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, livestock diseases, pests, markets and food availability. Additionally, their daily activity log was also drawn showing the daily activities relating to their livelihood.

RESULTS

Impact of climate variability on the occurrence of livestock diseases

A historical profile/trend of the location revealed an increase in the incidence of drought, a corresponding decrease rainfall that became increasingly erratic. 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 cycle appears to be frequent in occurrence (Table 1). Major livestock disease epidemics that occurred during this period include blue tongue in sheep and goats in the year 2000 (Table 2).

Economic impact of small ruminant diseases

The five diseases of sheep and goats in decreasing order of importance were CCPP, footrot, sheep and goat pox, enterotoxemia, orf and helminthosis (Table 3).

Matrix scoring of the severity of their symptoms

The pastoralists ranked the important small ruminant diseases against the severity of their symptoms (Table 4). Tables 5 and 6 show the perceived seasonal occurrence of sheep and goat diseases, respectively. The perceived occurrence of sheep diseases indicate that enterotoxaemia, diarrhoea, sheep pox and FMD occur more in the wet season (Table 6). FMD, goat pox and enterotoxaemia were 100% associated with the wet season while CCPP occurred in both the wet and dry seasons (Table 8).

Estimates of morbidity and mortality

Proportional piling of the five sheep and goats diseases ranked important from disease ranking indicated that CCPP had the highest morbidity of 80% affecting adults (*Ntare*) more at 54% than the young (*ilkuo*) at 26%. Enterotoxaemia had the second highest morbidity at 68% and affected the *Ntare* (44%) more than the *Ilkuo* (24%) (Table 7). Sheep and goat pox was reported with the third highest morbidity at 58%, followed by foot-rot at 33% and Contagious ecthyma (ORF) at 25%. The morbidity for all diseases was higher in the *Ntare* than the *Ilkuo*. Mortality was reported to be highest in CCPP at 49%, followed by Enterotoxaemia at 32%, sheep and goat pox at 23%, Orf at 5% and foot-rot at 4%. The Ntare (adult) age class was affected more than the Ilkuo (young) age class for all the diseases.

Effectiveness of disease control measures

The perceptions by the pastoralists on the effectiveness of control measures of the five most important cattle diseases are given in Table 9. The effectiveness for the control of ECF was considered equally for the three

Table 2. Historical events related by pastoralists in Enkaroni Location, Kajiado district.

Year	Events
1970-1980	1st FMD vaccination Severe Drought, 1974 High livestock deaths *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 *Enkaroni* group ranch started
1991-2000	Severe drought 2000 Migration to Tanzania Migration to Nairobi 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

Table 3. Pair-wise ranking of diseases of sheep and goats of Enkaroni Location, Kajiado district, 2008.

Pair-wise ranking	FMD	CCPP	BQ	ENT	HEL	POX	ORF	F/ROT	Score	Rank
FMD		CCPP	FMD	ENT	HEL	POX	ORF	ROT	1	7
CCPP			CCPP	CCPP	CCPP	CCPP	CCPP	CCPP	6	1
BQ				ENT	HEL	POX	ORF	ROT	0	8
ENT					ENT	POX	ENT	ROT	4	4
HEL						POX	ORF	ROT	2	6
POX							POX	ROT	5	3
ORF								ROT	3	5
ROT								ROT	6	1

ROT- Foot-rot; FMD- Foot and Mouth disease; POX- Sheep/goat pox; BQ- Black quarter; ENT- Enterotoxaemia; CCPP– Contagious Caprine Pleura Pneumonia; HEL- Helminthiasis; ORF- Contagious ecthyma.

control methods of spraying, fencing and vaccination. However, vaccination was considered slightly expensive than spraying and fencing (Table 9). Individual approach to control of ECF was preferred. Isolation of sick animals and separation of livestock 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 approach for effective control of the disease. LSD vaccination of livestock was favoured as a control as compared to spraying, and a group approach was considered the best approach. Methods

Table 4. Matrix scoring for sheep and goat diseases by their indicators of Enkaroni Location, Kajiado district.

Variables	CCPP	SG POX	ENTEROTOXAEMIA	ORF	FOOT ROT
Drought	3(2-5)	3(1-8)	1(0-2)	1(0-2)	0(0-1)
Rainy	6(3-8)	4(3-8)	9(7-10)	6(4-8)	9(8-10)
Coughing	9(7-10)	0(0-4)	-	-	-
Diarrhea	5(3-7)	0(0-1)	6(5-7)	0(0-3)	0(0-1)
Causes death	7(5-10)	3(0-10)	1(0-3)	-	0(0-1)
Lameness	0(0-2)	0(0-3)	-	-	9(6-10)
Mouth swelling	-	3(2-8)	-	6(5-8)	0(0-3)
Skin lesions	0(0-4)	6(4-8)	0(0-2)	5(0-7)	1(0-4)
Tearing	5(0-8)	3(1-6)	1(0-2)	2(1-3)	0(0-1)
Salivation	3(0-4)	2(0-3)	5(3-6)	2(0-4)	0(0-1)
Loss of hair	4(0-8)	6(3-8)	1(0-3)	0(0-2)	0(0-4)

Table 5. Occurrence of sheep diseases and their seasonal distribution in Enkaroni Location, Kajiado district.

Disease	Wet season (%)	Dry season (%)	Both wet and dry season (%)
Enterotoxaemia	76.6	16.9	6.5
Diarrhoea	66.7	33.3	-
Sheep pox	100.0	-	-
Foot and mouth	43.2	21.1	35.8
CCPP	50.0	50.0	-
Trypanosomoses	33.3	33.3	33.3
Anthrax	66.7	33.3	-

– Indicates that no response was given.

Table 6. Goat diseases and their seasonal distribution in Enkaroni Location, Kajiado district.

Diseases	Wet season	Dry season (%)	Both wet and dry season (%)
CCPP	11.8%	38.2	50.0
FMD	100%	-	-
Goat pox	100	.-	-
Enterotoxaemia	100%	-	-
Eye infection	55.6%	22.2	22.2
Anthrax	-	66.7	33.3
Fleas	-	100.0	-

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

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.

The methods given for the control of CCPP were vaccinations and quarantine whose effectiveness was considered to be equal. Vaccinations, quarantine restriction, spraying, deworming and cleanliness were all considered effective for the control of the various diseases (Table 8). However, the financial implications for the methods were perceived to be high with an exception of quarantine restrictions and hygienic standards in the pens. A rather surprising result was that group approach to the control of most sheep/ goat diseases was favourable than individual approach unlike the case for the control of the cattle diseases (Table 9). Individual approach was preferred for foot-rot and enterotoxaemia.

Table 7. Proportional piling estimates of morbidity (mortality) annual rates (%) of sheep and goat diseases in Enkaroni Location, Kajiado district.

Disease	Annual % morbidity (mortality) by age class		Overall morbidity (mortality)
	<6 months (*Ilkuo*)	adults (*Ntare*)	
Contagious Caprine Pleuropneumonia (CCPP)	26(10)	54(39)	80(49)
Sheep and goat pox	20(7)	38(15)	58(23)
Enterotoxaemia	24(8)	44(24)	68(32)
Contagious ecthyma (ORF)	10(2)	15(3)	25(5)
Foot rot	11(1)	22(3)	33(4)

Table 8. Effectiveness of sheep and goat diseases control measures.

Disease	Control methods	Effectiveness	Financial (cost)	User friendly	Group approach	Individual approach
CCPP (Olkipei)	Vaccinations	8(7-9)	9(6-10)	8(5-10)	8(5-9)	2(1-5)
	Quarantine	7(5-9)	7(5-9)	8(6-10)	7(5-9)	3(1-6)
S/G pox (Erirri)	Spray	6(4-7)	8(5-9)	6(4-7)	7(4-9)	3(2-6)
	Quarantine	7(5-9)	2(1-5)	6(3-9)	8(6-10)	3(1-5)
Enterotoxaemia (Olbus)	Deworming	6(2-8)	7(5-9)	7(5-9)	4(2-5)	7(5-8)
	Vaccinations	7(5-8)	9(7-10)	7(5-9)	7(4-9)	4(2-8)
Foot rot (Elelei)	Clean pens	9(6-10)	3(1-6)	9(7-10)	2(1-3)	9(7-10)

Numbers in brackets are ranges given by 14 groups.

DISCUSSION

This 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, pathogen biology, transmission and epidemiology. Bedelian et al. (2007) 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), described the potential of how climate change could lead to changes in spatial and temporal distribution of diseases sensitive to moisture as an etiological factor.

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. 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 rather than the individual. 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, animals perceived to be suffering from FMD were always watered after other animals. This indicated

Table 9. Perception of pastoralists on the Effectiveness of Cattle Diseases control measures in Enkaroni Location, Kajiado District, 2008

Disease	Control methods	Effectiveness	Financial Cost	User friendly	Group approach	Individual approach
ECF (oltikana)	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)

Numbers in brackets are ranges given by 14 groups

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 which have led to changes in their way of live impacting negatively on their livelihoods. There were marked associations between disease occurrence and climate change/variability pertaining to humidity, wind speed and direction as well as temperature. Many infections, especially the arthropod vectors and helminths are known to occur under wet conditions and influenced by climate change. Some diseases were positively associated with certain climate elements (e.g. Helminthiasis with rainfall), while others were negatively associated with other climate elements (e.g. redwater with rainfall). 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. Climate change in Kajiado District is positively and significantly related to the occurrence of livestock diseases. This may have led to a significant increase in occurrence of livestock 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 in 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. 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 be used for strategic management of disease control interventions (Speranzaa, 2010).

Conflict of Interests

The authors have not declared any conflict of interests.

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