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Cover Page Footnote

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DATA NOTES

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ABSTRACT

As global temperatures increase, more intense rainfall and more frequent droughts will have devastating effects on pastoral livelihoods. The aim of this study was to investigate pastoralists' perceptions on the impacts of climate variability on their livelihoods from 1971 to 2010. This study utilized household structured questionnaires. Statistical tests included t-test and Chi-square test (χ^2). Statistically significant differences occurred between pastoralists and agro-pastoralists regarding the perceived trend of rainfall. This study recommends the strengthening of local institutions to be able to deal with impacts of climate variability and change.

BACKGROUND

Climate change is happening in Kenya, and people have begun to experience its impacts on their daily lives according to the Intergovernmental Panel on Climate Change (IPCC 2001). Historical records, oral and/or written, are replete with references of droughts and floods. Even though the exact magnitude of the changes in temperature, rainfall, and extreme weather events has not been computed, based on the several General Circulation Model scenarios, the future climatic projections for Kenya indicates increase in mean annual temperature of 2.5°–5°C magnitude, and approximately 25% increase in precipitation (Mendelsohn et al. 2000). The progressive increases in mean temperatures might result in significant changes in rainfall, rise in sea level, evaporation, hydrological cycle, as well as frequency of extreme weather events (droughts, floods and storms). These would, in turn, adversely impact primary (food) production and ecological systems, with spin-offs to other socio-economic sectors such as public health.

In Marigat Sub-County, climatic changes including flooding events have been reported by the local pastoralists during the last forty years according to a research conducted by Wasonga et al. (2011) based on indigenous knowledge. In the research findings, heavy rainfall accompanied by floods were reported to be more common recently than 40 years ago. In addition, frequent and severe droughts were perceived to be responsible for the reduction in water level in Lake Baringo as well as intermittency of most rivers which had been permanent in the past. Vulnerability of most pastoralists has been made worse by the fact

that their livelihood systems have been constrained by frequent conflicts over natural resources (Rettberg 2010). Climate variability and change has heavily impacted livestock production which is the main source of livelihood to most of the pastoralists. The impacts have affected various aspects of livestock production including feed quantity and quality, animal and rangeland biodiversity, management practices and production systems changes among others (Herrero et al. 2009).

While Kenyans have considerable experience in dealing with climate variability, climate change is likely to present them with new and tougher challenges, requiring them to adopt innovative strategies to cope with new situations. "The current technologies and approaches—especially in agriculture and water—are unlikely to be adequate to meet projected demands, and increased climate variability will be an additional stress" (IPCC 2001). It is true that, as in the rest of the continent, the process of adapting to global climate change, including technology transfer, offers new development of pathways that could take advantage of Kenya's physical and human resources.

This study utilized a number of methods in trying to understand the level of vulnerability of pastoralists to climatic variability. The study particularly focused on two of the three divisions of Marigat Sub-County that are prone to climatic disasters and that have been negatively affected by such disasters in the past. The study period was 1971 to 2010.

METHODOLOGY

Study Area

The study was carried out in the Semi-arid rangeland of Marigat Sub-County of Baringo County, Kenya. This area is located between latitude 00°26'- 00°32'N and longitude 36°00'- 36°09' E and an average altitude of 900m above the sea level. It is located within agro-climatic zone IV and V (Wasonga et al. 2011). Marigat Sub-County was one of the newly created Sub-Counties from the larger Baringo County and covers an area of 1,677.45 sq. km^2 (District Development Office 2011).

The rainfall is about 30 percent reliable with high variability, receiving an average rainfall of 500 mm per annum (Wasonga et al. 2011). In normal circumstances, rainfall is bimodal with long rains starting in March to July while short rains at end of September to early November. The average annual temperature is about 27 °C. The period between January and March is the hottest. This climatic variability significantly affects the settlement patterns and economic activities in the Sub-County.

Research Design and Sampling Procedure

The study adopted both descriptive and explanatory research designs. This combination of designs enabled the study to describe relationship(s) among variables (Singleton and Straits 2005; Babbie 2010). Further, the study incorporated both quantitative and qualitative research by collecting data for both.

The study used both probability and non-probability sampling techniques. The defining property of probability sampling according Singleton and Straits (2005) is that "every possible combination of cases has an equal chance of being included in the sample." Non-probability sampling technique allows the investigator to rely on his/her expert judgement to determine representative units. The study engaged a total of 136 households for household survey.

The study population was divided into two strata based on the livelihood systems typical of the community in the area. These are pure-pastoral and agro-pastoral. The basis of this classification was that, the two groups of pastoralists could be impacted differently by the climatic variations and could also be having different coping mechanisms. However, there was a potential implication of this division on the general outcome of the study. This is particularly with regard to it not addressing the

relative contribution of geography. Stratified random sampling technique was used during data collection. Each of the two divisions was regarded as a stratum. The household questionnaires were administered randomly using pure random sampling.

Lists of households in the sub-locations were obtained from the area chiefs and assistant chiefs. The names in each list were allocated numbers -- for instance, 1 to 409 in the case of Kiserian sub-location. Using Stat Trek's random number generator, 37, 30, 28 and 41 random numbers were obtained for Sintaan, Ilngarua, Logumgum and Kiserian sub-locations respectively. This study had initially targeted a total of 127 households from four sub-locations located in two divisions of Marigat district (2 sub-locations from each of the divisions) out of a total of 1,251 households as per the 2009 census results, but due to increase in the number of households, the lists provided by the chiefs were adopted and 136 out of a total of 1,347 households were selected. The 136 households therefore represented a 10% of the total households in the four sub-locations.

Statistical Methods and Analysis

Household questionnaire data were entered and analyzed in SPSS. A number of bivariate comparisons of variables related to pastoral livelihoods were done as follows: (i) t-test was used to compare means of variable on pastoralists demographic such as age between the two strata. (ii) Chi-square test (χ^2) was used to test cross-tabulated data on variables such as perception of pastoralists on trends of climatic variables and socio-economic variables between the 2 strata. The test was used to assess for homogeneity or similarity on categorical response variables between the study groups.

RESULTS AND DISCUSSION

The household survey showed that effects of floods dominated among the various factors that resulted in the displacement of the households followed by floods and conflicts. Most of the households in the study area, particularly those in Ngambo and Ilngarua locations, have settled on the flood plains, hence displacement during extremes of climate variability -- particularly during heavy rainfall events -- is inevitable. The floods in the affected areas always result in population displacement, loss of lives and emergence of diseases. The respondents reported that floods have continued to occur in the area since 2002. Other effects of floods mentioned by the respondents included destruction of transport network, farms and crops, and other income generating activities including charcoal burning.

Trend of various climatic and environmental variables over the study period

Different respondents perceived the changes in climatic and environmental variables differently, particularly between the 2 study groups (see Table 1). Rainfall trend was perceived to be an upward one by 51% of the respondents. Therefore, most of the respondents believe that more rainfall is being experienced currently during rainy seasons than in the past years. Temperature was also said to be hotter by 72%. Of those who said that the temperature has been decreasing, some attributed the decrease to the increasing cover of mesquite (*Prosopis juliflora)*.

Floods were said to have become more frequent by 76% of the respondents. A number of respondents further highlighted that the 2002 flood was the worst and at the same time marked the start of flooding in the area because since then, floods have been experienced on an annual basis.

On the frequency of droughts, 59% believe drought has become more frequent. The 1984 drought was perceived to have been the worst in the four decades, with most of the respondents who owned livestock then losing large herds of their stock.

Water sources are believed to be more numerous now than in the past by 60% of the respondents. The

Table 1. Percentage frequencies of respondents' perception on trends of various variables over the study period (agro-pastoralists=strata 1; pastoralists=strata 2).

Variable	Stratum	Trend over the study period (% responses per stratum)			
		More	Unchanged	Less	Not Sure
Rainfall	1 (n = 67)	61	6	31	2
	2 (n = 69)	41	6	52	1
Average %	Both	51	6	42	2
		Hotter	**Constant**	**Colder**	**Not Sure**
Temperature	1 (n = 67)	58	19	22	0
	2 (n = 69)	85	10	2	3
Average %	Both	72	15	12	2
		More Frequent	**Constant**	**Rarer**	**Unchanged**
Floods	1 (n = 67)	94	3	3	0
	2 (n = 69)	59	20	19	1
Average %	Both	77	12	11	1
Droughts	1 (n = 67)	76	10	34	2
	2 (n = 69)	43	29	4	3
Average %	Both	59	20	19	2
		Numerous	**Unchanged**	**Fewer**	**Not Sure**
Water sources	1 (n = 67)	76	12	9	3
	2 (n = 69)	43	19	33	5
Average %	Both	60	16	21	4
		Expanding	**Unchanged**	**Diminishing**	**Not sure**
Vegetation	1 (n = 67)	81	2	16	2
	2 (n = 69)	11	17	69	2
Average %	Both	46	9	42	2
Agricultural practice	1 (n = 67)	70	5	25	0
	2 (n = 69)	79	4	15	2
Average %	Both	75	4	20	1
		Increasing	**Unchanged**	**Diminishing**	**Not sure**
Soil degradation	1 (n = 67)	79	3	10	8
	2 (n = 69)	85	4	7	3
Average %	Both	82	4	9	5

increase was attributed to the ongoing construction of dams, water pans, wells, and possibly the changes in seasonality of rivers due to frequent floods.

The respondents had varied opinions on the trend of vegetation over the study period. The agro-pastoral respondents (Sintaan and Ilngarua sub-locations)

perceived that vegetation has been increasing, with pastoralists saying that vegetation has been decreasing. This can be attributed to the invasion of agro-pastoral areas by *Prosopis juliflora*; this species is not very common in pure pastoral areas. But generally, it was perceived to be expanding by 46% and diminishing 42% of the respondents.

In all the areas, agricultural practice seems to be growing, with 75% of the respondents saying that land under agriculture has been expanding over the study period. Most of the pastoralists are now adopting crops production in the face of climatic variability.

With the increasing frequency of floods, soil degradation seems to be a problem in the study area with 82% of the respondents saying that it has been increasing. Some of the respondents attributed the increase in soil degradation to the increase in *Prosopis juliflora*. They argue that since this invasive species does not allow any undergrowth, it makes the soils more vulnerable to erosion.

According to IPCC's fifth assessment report, the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The report emphasizes that the period from 1983 to 2012 was most likely the warmest 30-year period out of the last 1400 years (IPCC 2014).

Trend of various climatic and social variables towards the future

Most of the respondents (62%) believe that temperature will increase towards the future (Table 2). Also, the future of rainfall, floods, droughts and diseases was predicted to increase by 38%, 75%, 54% and 75% of the respondents, respectively. There was a strong statistically significant difference between agro-pastoralists and pastoralists on the trend of rainfall and floods towards the future (Rainfall: $\chi^2 = 41.230$, df = 3, p= 0.000 and Floods: $\chi^2 = 24.903$, df = 3, p = 0.000). In all the variables, the respondents differed on their perceptions depending on the location of their home (strata).

All the climatic variables including rainfall, temperature, floods, and droughts were said to have been increasing over the study period. Other environmental variables including vegetation, agricultural land, and soil degradation were also said to have been increasing. However, of the climatic variables, only rainfall is perceived to decline in future while temperature, drought, and floods events would possibly increase in future according to the respondents. At the global scene, temperature is expected to rise by between 1.0 ^{o}C and 3.5 ^{o}C by 2100 (Githeko et al. 2000). The fifth assessment report of the IPCC confirms the pastoralists' perception that earth temperature and severity of both the flood and drought events are likely to increase towards the future (IPCC 2014).

Effects of climatic variability and change on income, food security, people and livestock

Most of the respondents (55%) mentioned a general decline in their income over the study period as a result of climate variability and change. In addition, less food availability, less harvest output and more food diversity was mentioned by 80%, 74% and 24% of the respondents, respectively. Duration in months in a year with enough food was agreed to be 0-3 months by 59% of the respondents. At the same time, most of the respondents (56%) spend between Kshs. 1,001 and Kshs. 5,000 in treating their livestock annually whereas 14% spend less than 1,000, 14% spend between Ksh. 5,001 and 10,000, 8% spend more than Ksh. 10,000, 2% were not sure while 6% said they have no livestock. The data for these socio-economic variables was not valid for a chi-square test to be performed due to the fact that some cells had expected count of less than five.

Climate variability has had various effects on the economy of the area under study. The major effects included decline in income and food availability and reduced harvest output, hence resulting in a general decline on the duration with enough food and a variation in the amount

Table 2. Percentage frequencies of respondents perception on trends of various climatic and health variables towards the future (agro-pastoralists=strata 1; pastoralists=strata 2).

Variable	Stratum	Trend towards the future (% responses per stratum)			
		Increase	Constant	Decrease	Uncertain
Temperature	1 (n=67)	39	12	39	9
	2 (n=69)	84	4	3	9
Average %	Both	62	8	21	9
Rainfall	1 (n=67)	64	9	22	5
	2 (n=69)	12	15	55	19
Average %	Both	38	12	39	12
Floods frequency	1 (n=67)	93	6	0	2
	2 (n=69)	58	10	17	15
Average %	Both	75	8	9	8
Droughts frequency	1 (n=67)	43	5	46	6
	2 (n=69)	65	9	10	16
Average %	Both	54	7	28	11
Diseases	1 (n=67)	76	2	15	8
	2 (n=69)	74	9	1	16
Average %	Both	75	5	8	17

of money used to treat livestock annually. As expected, heavy rainfall and flooding causes damage and hinders income generating activities, resulting in a general decline in income. Food security is also hampered due to low harvest output and reduction in food availability. IPCC's assessment of many studies covering a wide range of regions and crops showed that negative impacts of climate change on crop yields have been more common than positive impacts (IPCC 2014).

Effects on livestock markets

Livestock prices are more affected by droughts than floods. The average prices during droughts and floods events are described in Table 3 below. Under normal circumstances, the average prices are usually Kshs. 15,000 for a cow, Kshs. 2,000 for a sheep and Kshs. 2,500 for a goat according to the respondents.

Livestock mortality was highest during the 1984 drought with 846 cattle, 867 sheep, and 191 goats

Table 3. Descriptive analysis of livestock prices during different climatic variables in Marigat District.

	N	Minimum	Maximum	Mean
Average cattle prices during floods	73	3000	20000	9575
Average sheep prices during floods	79	400	4500	1596
Average goats prices during floods	79	600	5000	2073
Average cattle price during droughts	78	1500	15000	5128
Average sheep price during droughts	79	400	2500	959
Average goats price during droughts	79	500	4000	1389

Table 4. Case summaries for number of deaths resulting from droughts.

Drought year	Number of people dead	Number of cattle dead	Number of sheep dead	Number of goats dead
1973	2	55	13	24
1980	0	25	7	10
1984	0	846	867	191
1990	0	13	0	0
1994	0	293	221	206
2000	0	377	270	121
2009	0	222	132	63

Source: Household questionnaire

reportedly dead from the surveyed households (Table 4). The least number of livestock deaths occurred in the 1990 drought with only 13 heads of cattle reported by the respondents to have died. In all the droughts mentioned by the respondents to have occurred over the study period, only the 1973 drought claimed human lives from the surveyed households.

The effects of floods were more pronounced in 2002 with respondents mentioning 5 human deaths. Goats were the most affected by these floods in almost all the flood years with the highest number of deaths being recorded in 2002. Of the five major floods whose effects were recounted by the respondents, the 2004 flood had the least number of deaths with only a cow, 9 sheep and 18 goats being reported by the respondents to have died (Table 5).

In addition, the reduction in livestock prices during droughts and floods leads to a drop in income and increased destitution. According to the respondents, the prices drop as low as Ksh. 1,500 for a cow, Ksh. 500 for a goat, and Ksh. 400 for a sheep during droughts.

In view of the responses given, both droughts and floods seem to take a toll on livestock lives. In addition to loss of livestock, particularly the small stock during floods, human lives are also lost. The 1984 drought and the 2002 floods were perceived to have been the worst in terms of severity, with a large number of livestock being lost during these two climatic events.

Basic strategies for reducing drawbacks of climatic variability

The respondents gave a number of basic strategies that can be used to reduce the drawbacks of climate variability in this area. The strategies can be categorized into five major sub-divisions on the basis of the targeted activity. These include livestock-based, crop farming-based, infrastructure-based, environmental-based, and pastoral welfare-based activities.

Table 5. Case Summaries for number of deaths resulting from floods in Marigat District over the study period.

Flood Year	Number of people dead	Number of cattle dead	Number of sheep dead	Number of goats dead	Number of chicken dead
1994	0	9	156	164	7
2002	5	114	236	299	244
2004	0	1	9	18	12
2011	0	3	11	22	30
2012	0	4	22	20	2

Source: Household questionnaire

1) Livestock-based strategies include improvement of animal health structures, e.g., cattle dips, dipping livestock, improvement on veterinary extension, training farmers on animal health, destocking during impending droughts, keeping sizeable number of livestock/proper stocking rate, creation of grazing zones, timely treatment of animals, encouraging zero grazing to reduce overgrazing, and migration during droughts.
2) Crop farming-based strategies include holding agricultural seminars for farmers in the area, assistance in ploughing of the land by the government, early ploughing and planting, educating farmers on timing of planting, setting up irrigation schemes, enhancing farming activities, distribution of free seeds to the farmers during planting seasons, employment of more extension officers, planting of cover crops in steep areas to reduce surface runoff, proper food storage, introducing drought resistant varieties in the area, storage of food reserves, spraying of crops, setting up irrigation schemes and cultivating away from river banks.
3) Infrastructure-based strategies include construction of dams, construction of pit latrines, digging wells, improve transport network, improving water supply/tapping water, construction of bridges to reduce flooding, construction of underground tanks, land demarcation, and improving water reservoirs.
4) Pastoral welfare-based strategies include supplying of mosquito nets, awareness creation on flood prone areas, enhancing Food For Work (FFW) activities, financial support by the government and other financial institutions, supplying relief food during climatic disasters, resettling in safer grounds, increasing medical supplies, exploring alternative sources of income, increase health facilities, avoid living near river banks, and improving health institutions.
5) Environmental-based strategies include discourage felling of trees, weather observations, elimination of *Prosopis juliflora* trees to reduce flooding and improve pasture, building gabions and terracing to control soil erosion, improving and adhering to Early Warning Systems (EWS), encouraging traditional prediction of weather, and planting more trees in the area.

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