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Socio-economic and ecological dimensions of climate variability and change for agro-pastoral communities in central Tanzania

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Abstract

A study was conducted in 2012 in Gairo district, central Tanzania with aim to assess the socio-economic and ecological factors influencing the agro-pastoral communities in responding to the prevailing climate variability and change. Both quantitative and qualitative data were collected through a combination of methods including structured interviews, focused group discussions and personal observations. Quantitative data were analyzed by means of Statistical Package for Social Sciences (SPSS) IBM 20 computer program whilst qualitative data were subjected to content analysis. A multiple regression analysis was used to explore the relationship between socio-economic factors as independent variables and perceptions on variability and change of rainfall as a dependent variable**.**

Climate variability and change was found to increase death of animals due to inadequate pasture and water especially during dry season. It was further unfolded that human conflicts due to grazing in unauthorized areas and decreased crop yield and failure incidences are increasing. Women were seen in many ways to be more vulnerable to climate variability and change than men due to their household roles and dominancy of male in decision making regarding household assets at times of famine. A number of adaption and coping strategies were spontaneously practiced across the study area to cope with water related stresses in crop and livestock production. The coping strategies include shifting cultivation, vegetable gardens, pasture trekking, digging boreholes in sand rivers, mixed cropping including earlier maturing crops (groundnuts) and drought resistant crops such as sorghum. Therefore, there is a need to undertake capacity building activities to agro-pastoral communities for increased awareness of the effects of climate changes, and improved capacity to understand and deal with climatic change impacts. Also, training in agro-ecological technologies and practices for the conservation of soil and water resources in order to improve their adaptation and mitigation capacity.

Key words: *adaptation, crop farming, Gairo, gender, livestock production, rangeland resources*

Introduction

Climate variability and change are long-term environmental issues that pose serious threats to vulnerable and impoverished agro-pastoral communities worldwide (FAO 2009). In this context, it is important for all sectors to recognize that rangelands deserve greater attention, not only for their large extent, widespread degradation and limited resilience to drought and desertification, but also for their potential capacity to sequester and store carbon in soils while supporting sustainable agro-pastoral livelihoods.

In agro-pastoral systems of central Tanzania, livestock are key assets for poor people, providing multiple economic, social and risk management functions (ILRI 2008). Livestock production, particularly cattle, is the major use for rangelands, with over 100 million head of ruminant livestock in the rangelands of eastern Africa (Herlocker 1999). The impacts brought by climate variability and change are expected to exacerbate the vulnerability of livestock production systems (Ellis and Swift 1988). Lamentably, the land tenure system in Tanzania still follows a legacy of colonial rule, with all lands being state owned but with tolerance to customary occupation and use rights (Nyongeza 1995; Shivji 1999). Thus, securing such rights of land occupancy, nomadic pastoralists have started sedentarization and crop farming in fragile dry-lands as a strategy to overcome landlessness (Brockington 2001). This change of production sytem from pastoral to agro-pastoral has made the semi –arid land more less resilient to climate related stresses such as droughts and has accelerated soil erosion and loss of biodiversity.

Direct effects of climate variability and change include increased temperatures and changes in rainfall patterns, translating in an increased spread of existing vector-borne diseases and macro parasites of animals as well as the emergence and spread of new diseases (FAO 2008). Indirect effects would be caused by changes in availability of forage, increased desertification processes, increased scarcity of water resources, and eventually reduced carrying capacity (Clarke et al 2005). Responses to climate variability and change include adaptation to reduce sensitivity to climatic changes and mitigation-to reduce the magnitude of climate change impact in the long run. However, neither adaptation nor mitigation alone can avoid all climate variability impacts. To respond to this threat, it is necessary to focus on both reducing the level of emission of gases contributing to global warming, and supporting local communities deal with the impacts (IPCC 2007).

Climate change will further create different opportunities and challenges to gender classes (men and women). In many countries, the role of women in livestock production systems is significant. Women are often responsible for most livestock keeping activities and play an active role in on-farm livestock duties including feeding, watering, fodder collecting, stable cleaning, milking and milk processing, caring of small and sick animals, poultry raising, and traditional animal health care . Men are generally responsible for marketing, shearing, animal feed purchasing, veterinary services and herding. While men's tasks are seasonal, most women's tasks are daily (Nassif 2008). Given that climate change is likely to further intensify the existing inequalities and affect differently the capacity of women and men to cope with additional stresses, more attention will be needed to ensure that adaptation and mitigation strategies are developed taking into account these differences and the increased needs of women in view of their roles as the most significant

suppliers of family labour and efficient managers at household level (IFAD 2009). While research has not given much attention to the differences between men and women within at-risk populations (Nelson and Lambrou 2007), adaptation strategies will need to address the different impacts of climate variability and change on women and must ensure that they also support women empowerment as part of building the community resilience to climate change (IFAD 2009).

However, it is important to note that local communities' capacity to adapt and mitigate the impacts of climate variability and change depends on a number of socio-economic and ecological dimensions. Despite of this need of understanding how socio-economic and ecological factors influence adaptation and mitigation strategies, potentials and capacity of agro-pastoral communities, there is still a scarcity of information. The aim of this study was therefore, to assess socio-economic and ecological factors to respond to the climate variability and change for the agro-pastoral communities in Gairo district of central Tanzania. This information is of paramount for making informed policy formulation and decision making towards effective and sustainable adaption and mitigation strategies in semi arid areas of Tanzania and elsewhere.

Material and Methods

Study area

This study was carried out in three agro-pastoral communities namely, Kinyolisi, Leshata and Mkalama villages, within Gairo district, central Tanzania in September, 2012. Gairo is one of the seven districts of Morogoro region in the country. It is located in the northwest corner of Morogoro between 36 ^{o} 45' E and 6^{o} 30' S with an altitude of about 1000 m above sea level (Figure 1). Gairo receives rainfall between 400 mm to 500 mm per year between December and April with a short dry spell from mid-January to mid-February. The dry season is between May and November. Rainfall is normally erratic and falling in storms resulting in high runoff and intensive soil erosion especially in cultivated and overgrazed areas. The study villages are inhabited by the agro-pastoral tribes including the Kaguru, Nguu and Kamba. Other emerging tribes include the Maasai and Nyaturu (Table 1). The major land use system is subsistence crop farming and keeping indigenous ruminant multi-livestock breeds comprised of cattle, goats and sheep. Dominant vegetation in the study area includes woodlands, bushes and wooded grasslands maintained by wildfire.

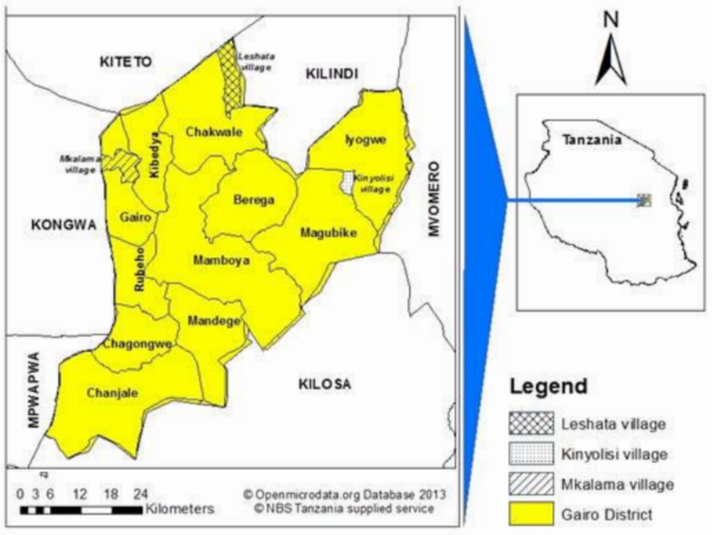

Figure 1. A map of Gairo District showing the location of the study villages

Table 1: Summary of demographic information in the study sites

Village	Ethnicity	Households	Females	Males	Total
Kinyolisi	Kaguru, Maasai, Sambaa	409	931	841	1,772
Mkalama	Kaguru, Nguu	570	2,111	1,576	3,687
Leshata	Kaguru, Kamba, Maasai, Nyaturu, Nguu	1,263	5,024	4,516	9,540
Total		**2,242**	**8,066**	**6,933**	**14,999**

Source: Kinyolisi, Mkalama and Leshata village offices, 2013.

Description of the study villages

Kinyolisi village

Kinyolisi village is registered since1993 with registration number MR/KIJ/436. The village is remotely located about 50 kilometers from Gairo town. Kinyolisi is subdivided into 5 sub-villages namely Temeke A, Temeke B, Mkwajuni, Shuleni and Matale. The main economic activities in the village are livestock keeping and farming. Main crops include maize, cassava, sweet potatoes, cotton, lablab (fiwi bean), soya beans and pigeon peas. The village had set aside areas for farming, grazing and settlements. The potential area for grazing is about 1000 ha but currently about 600 ha are effectively utilized. The different land uses are managed through a village land and environmental committee. Kinyolisi has a large population of livestock (Table 2) but lack enough improved watering points for livestock.

Mkalama Village

In a local language of inhabitants (Kaguru), "*Mkalama*" literally means "*to wait for*". Before this name, the place had a water-well where people went to collect water. Due to the small amount of water in the well, many people had to wait for a longer time before one gets a single bucket of water. The place was then given the name *Mkalama*, where later in villagilization programme (1975) it was registered as independent village (MR/KIJ/93). The village has 11 sub-villages namely Songe, Misheni, Kwambega, Kwamtitu, Kichangani, Mnyalilile, Ikulu, Mandela, Kusega, Mininga and Kibobodo. The village is easily accessed by road about 5 kilometers from Gairo town. Mkalama possesses the smallest grazing area among the three villages. The grazing area is highly degraded, mainly bare with some gully erosion, very little pasture cover and scattered Acacia trees. Most ruminant livestock are taken outside the village boundaries for grazing during farming season and brought back to graze crop residues after harvesting.

Leshata village

In Kaguru local language, "*Leshata*" means "*staying longer without moving out*". This name was purposely given to this location because; the area had fertile and virgin land that was unoccupied for a long period. Therefore, whoever moved to the area was overwhelmed to stay permanently for either crop and/or livestock production. Leshata village was registered in 1975 (MG/KIJ/78). The village is divided into six sub-villages including Chang`ombe, Magomeni, Muheza, Masugulu, Machakosi and Ngayaki. Leshata possesses vast land suitable for both grazing and forest conservation. Grazing areas are much bigger (about 485 ha) compared to those of Mkalama. The village possesses the largest number of livestock compared to other two villages (Table 2). They have a well-established livestock keeping committee with village environmental by-laws. The village has a community managed forest (about 640 ha) dominated by *Dalbegia melanoxylon* (African black wood) tree species which are highly valuable economically. The village is of mixed ethnicity including Kaguru, Nyaturu, Nguu, Maasai and Kamba. Kaguru are the original inhabitants of the area and the rest migrated to the village for several seasons including farming, grazing and small bussiness.

Table 2: Livestock population in the study sites

Village	Cattle	Goats	Sheep
Kinyolisi	1416	971	14
Mkalama	1800	500	50
Leshata	12,114	5,724	2800
Total	**15,330**	**7,195**	**2,864**

Sampling procedure and data collection

The study was conducted in three villages out of possible six. The villages were selected based on established criteria by the research team as shown in Table 3.

Table 3: Criteria for selection of villages

Criterion	Grazing land reserve	Adequate number of livestock	Forest reserve	Village accesibility	Score
Mkalama	√	√	√	√	4
Kinyolisi	√	√	√	X	3
Leshata	√	√	√	√	4
Kitaita	X	X	X	√	1
Masimbani	√	√	X	X	2
Ndogoni	X	√	X	X	1

Legend: √*=Yes* *x=No*

A total of 64 households were interviewed in the three villages namely Kinyolisi (21 respondents), Mkalama (21 respondents) and Leshata (22 respondents). Both quantitative and qualitative data were collected through a combination of methods including interview with household heads using prepared questionnaire, focus group discussion (FGD) with selected agro-pastoralists, leaders and elders using a checklist, and personal observation method. The questionnaire and checklists included information such as perceptions on climate variability and change in livestock herd characteristics, farming, forest and water resources, range management practices, gender roles, resource access, ownership and decision making, adaptation, opportunities and barriers towards climate change.

The structured questionnaire was pre-tested before kick-starting of actual data collection. Three researchers and three trained enumerators were involved in data collection. During focused group discussions (FGDs), at least ten (10) villagers in each village were involved in discussion using prepared checklist. The village government leaders were given criteria for selecting members for participating FGDs. It was conducted in an open ended manner to gather sufficient information. Moreover, Personal observation technique was used to observe various activities of agro pastoral community in the villages including the crops grown in fields and type of pasture grazed and shrubs browsed by livestock.

Data analysis

Data collected using FGDs were analyzed by involving the communities through group discussions where immediate feedbacks were produced. The components of verbal discussions held were subjected to content analysis whereby recorded dialogue with respondents was broken down into the smallest meaningful units of information and tendencies which enabled to ascertain values and attitudes of respondents. Quantitative data was subjected to inferential statistical analysis and Statistical Package for Social Sciences (SPSS). In this case, linearity was assumed among dependent and independent variables. Though this assumption is not always correct, its adoption at least as a starting point might be valid on several grounds: first, numerous relationships have been found empirically to be linear, second, the linear specification is generally the most sparing; third, the theory is often so weak that we are not at all sure how the non-linear specification would be (Lewis-Beck, 1983). Therefore, a multiple regression analysis was used to show the relationship between socio-economic factors (Table 4) as independent variables and perceptions on climate variability and change in terms of rainfall as a dependent variable**.** The multiple regression equation was:

$$\mathbf{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots + \beta_n X_n + e}$$

where;

Y = dependent variable-perceptions on climate variability and change (rainfall)

$\mathbf{X_1}$ **to** $\mathbf{X_n}$ = independent variables - socio-economic factors

$\boldsymbol{\beta_0}$ = a constant showing intercept for regression equation

$\boldsymbol{\beta_1}$ to $\boldsymbol{\beta_n}$= independent variable coefficients

e = error term

i = 1, 2, 3…n

n = sample size (total number of respondents i.e. 64)

The descriptive power of the regression was assessed by its coefficient of determination (R^2) which showed the strength of relationship between dependent and independent variables. Regression equation developed in this study emphasized explanation rather than prediction. Similarly, multiple regression was preferred over simple regression because, first, it almost predictably offer a fuller explanation of dependent variables since very few phenomena are products of single cause. Second, the effect of a particular independent variable was made more certain for the possibilities of distorting influence from other independent variables. The actual data analysis was preceded by running the tests for removing redundant independent variables (multi-collinearity effect) using the variance inflation factor (VIF) test in SPSS IBM 20 computer program (Mansfield and Billy, 2012).

Results and Discussion

Household baseline information

Ethnicity

Around 81% of respondents were the Kaguru-the original inhabitants in all three villages. The remaining 19% were the Zigua, Nguu, Sambaa and Kamba who immigrated in search for arable land for farming and livestock grazing. Most households were headed by men. Male headed households were 57% in Kinyolisi, 67% in Mkalama and 77% in Leshata village. These findings showed slightly lower values to those reported by Selemani et al (2012) in Shinyanga rural and Meatu districts (Tanzania) where about 86% of agro pastoral communities were male headed households. These differences could be explained by the fact that in Shinyanga the dominant system of inheritance is *paternal* as compared to *maternal* for most ethnic groups in Gairo district.

Age classes

Age class distribution of respondents ranged between 18 years to 76 years (Table 4). Majority (57%) of the households' heads were aged between 18 to 45 years and 46% were between 46 to 76 years. This implies that majority were in productive age and capable to undertake agro pastoral activities. According to Nkurlu (2002) the age of a person is usually a factor that explains the level of production and efficiency.

Table 4: Socio-economic characteristics for respondents

Socio-economic characteristic		Respondents	Percentage (%)
Gender	Male	43	67
	Female	21	33
Education level	No formal education	21	33
	Adult learning program	2	3
	Primary education	41	64

Marital status	Single	4	6
	Married	54	84
	Divorced	3	5
	Widowed	1	2
	Polygamy	2	3
Household size	1-2	2	3
	3-5	16	25
	6-8	21	33
	9-10	9	14
	Above 10	7	11
Ethnicity	Kaguru	52	81
	Zigua	3	5
	Sambaa	1	2
	Nguu	3	5
	Kamba	5	8
Income per year (TAS)	0-100,000/=	6	9
	100,000-500,000/=	21	33
	500,000-1,000,000/=	16	25
	1,000,000-2,000,000/=	9	14
	Above 2,000,000/=	12	19
Farm size	0-2 acres	4	6
	3-5 acres	15	23
	5-10 acres	25	39
	>10 acres	19	30
Main occupation	Crop production (Agrarians)	37	58
	Livestock keeping (pastoralists)	1	2
	Both crop and livestock production (Agro-pastoralists)	25	39

Education level

Generally, there was high level of ignorance among the agro-pastoral communities in the study villages. About 36% had no formal education, which means had not been to formal schools. Among them, it was only 3.1% who happened to attend evening class programs (adult learning) and therefore managed to have basic reading and writing skills. One of the interviewed Maasai elder (72 years) in Leshata explained that "… *because we did not attend formal schools, we also did not let our children attend…it is only now that we have been sensitized by the Government … we have started taking our grand children to schools… even though some have to remain at home for grazing* ". The rest of the respondents (64%) ended at primary school level. There were no respondents who attained neither secondary nor tertiary education, meaning that most community members were peasants and herders as shown in Table 4.

Perceptions on climate variability and change

It was revealed that presence of climate variability and change in Gairo district is perceived by majority of respondents (98%). Temperature and rainfall were the major two variables for describing climate variability and change among agro-pastoral communities. However, male and female headed households perceived the change in different ways. For temperature, about 60% of males and 40% of females perceived that days and nights have become very hot, while 54% males and 46% of females perceived that the length of hot period (*September to February*) has increased. On the other hand, 79% of males and 21% of females perceived that the length of the cold period (*March to August*) has increased. These gender differences in the perception could be due to the different roles of male and females in household activities such as herding for men versus water and firewood collection for women. Figure 2 and 3 show annual rainfall and temperature pattens in selected parts of Tanzania. Annual total rainfall are linealy decreasing while temperatures are increasing over the past 30 to 40 years. The trend shows a sharp fall in early years of 1990s, after which there is an irregullar pattern extending through to 2010.

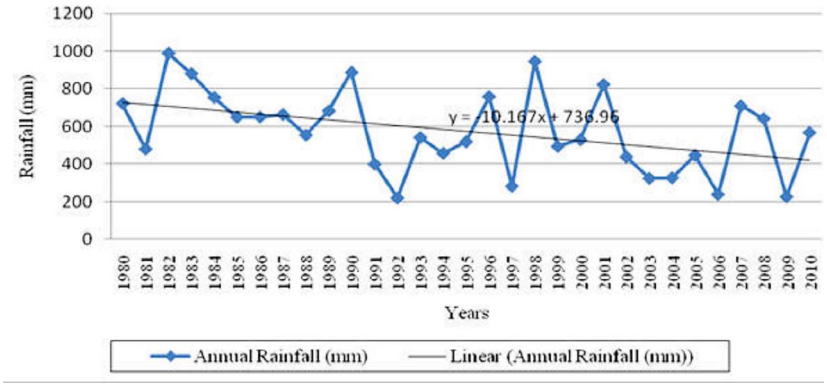

Figure 2. Total Annual Rainfall Trend from 1980 to 2010 in Central Tanzania
(Source: Chamwino District Council, Agriculture Department)

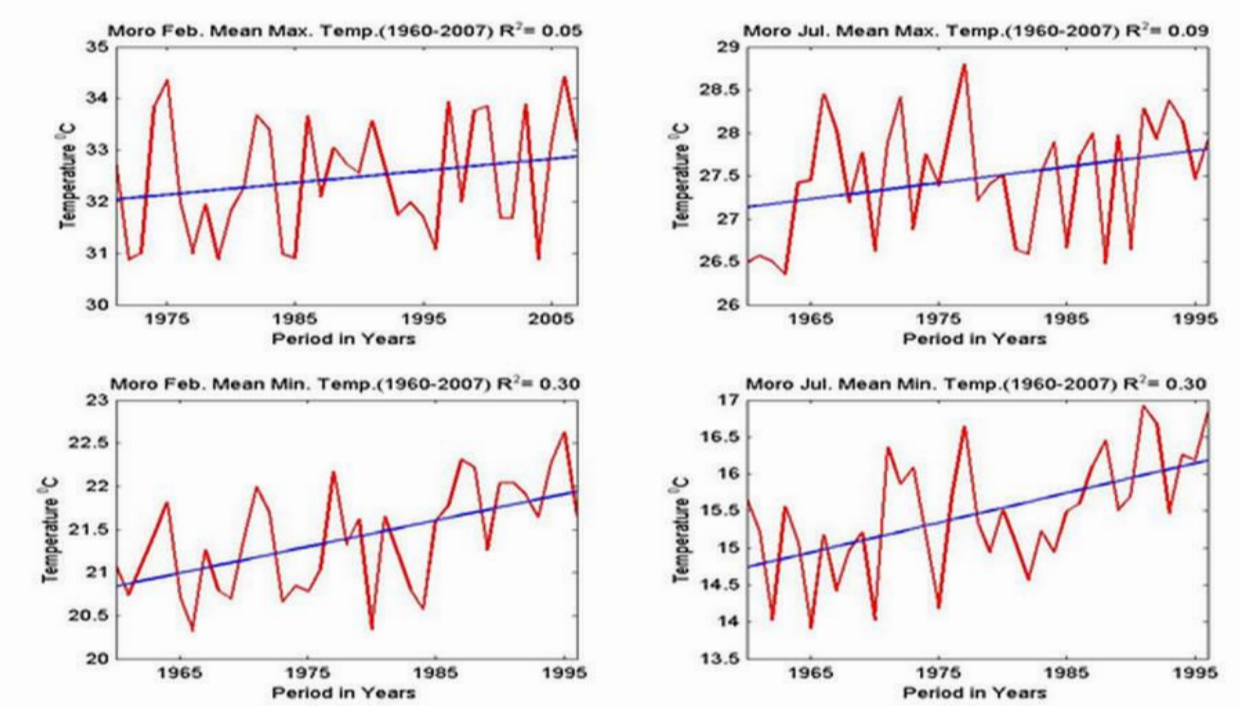

Figure 3. Maximum and Minimum Temperature patterns in Morogoro, Tanzania (*Source: Munishi 2009)*

Income generating activities

Table 5 shows that income generating activities (IGAs) was statistically significant (p=0.038) with negative regression coefficient (B=-0.75) with respect to climate change impacts (rainfall). This means that most community IGAs are rain dependent. Moreover, the survey revealed that other IGAs in the three villages were local brew, vegetable gardens, tea rooms and small shops. Most of these outlets were highly dependent on agricultural produce either as raw material or as financial assets for capital generation. These IGAs were also regarded as autonomous adaptation strategies to cope with climate stressors especially for the Kaguru ethnicity. Therefore, unpredictability of rainfall affected positively production in various community IGAs.

Income (earning) per year

Table 4 shows that most communities in Gairo district earn between TAS 100,000 to 1,000,000 per year (*One USD was equivalent to 1,600 TAS during the study period*). This was a very small amount of income implying that most households were poor, living under one USD per day. Table 5 shows that income (earning) was statistically significant (p=0.026) with positive regression coefficient (B=3.107) with regard to climate change impacts (rainfall). The same as in IGAs, income from livestock and crop production was highly influenced by the amount of rainfall. During FGDs, one Kaguru herder (56 years) was quoted saying "*... rainfall is not only for crop growers...it is important for pasture production too....*" That means, if there were reliable rainfall, income from both livestock and crop products would be relatively high.

Farmland size

Table 4 shows that most communities in the study area posses farmlands of between three to ten acres. These were relatively small to medium sized farms used for crop production. According to Table 5, farmland size showed statistical significance (p= 0.034) with a negative regression coefficient (B=-4.99) with respect to climate change impacts (rainfall). This implies that, the size of the farm for crop production do matter in the presence of climate stressors especially the amount of precipitation. As it was observed, crop growers did not have any means to intensify agriculture nor application of fertilizers in their farms. The dominant farm practice (local planned adaptation) included shifting cultivation and vegetable garden production near water sources. Shifting cultivation and vegetable gardens are both factors leading to poor soils and water conservation and extended drought conditions facing Gairo farmlands currently. Farm expansion was therefore used as an adaptation measure to the declining crop productivity. This was confirmed by a Kaguru informant saying "*... during the old days around 1970 we used to plant one acre of farmland with 20 kg of beans seeds and harvested four to five bags (1 bag =100 kg)...today we sow the same amount of seeds, in the same piece of land...and end up harvesting half to one bag of beans* ". Similar statements were given in many FGDs reflecting a significant decline of agricultural production in Gairo district and probably the same syndrome applies to the whole semi arid region of central Tanzania.

Other factors such as age, education, sex, ethnicity and occupation were statistically not significant (p>0.05) with regard to climate change impacts especially on the amount of precipitation. This implies that statistically, they are not influenced by unpredictability of

rainfall in the area. Table 5 shows a number of socio-economic factors influencing perceptions of climate change impacts in terms of rainfall patterns in the study area.

Table 5. Factors influencing community perceptions on climate change impacts in terms of rainfall in Gairo, Tanzania

	R^2 =0.99			
X_i	B	SE	t value	P value
(Constant)	21.3	1.57	13.6	.047
Age of Respondent	.089	.007	12.1	.053^{ns}
Education level	-2.07	.199	-10.4	.061^{ns}
Sex of Respondent	-3.37	.450	-7.44	.085^{ns}
Ethnicity of respondent	-.500	.180	-2.72	.224^{ns}
Main occupation	-1.88	.150	-12.5	.051^{ns}
Income generating activities	-.75	.045	-16.9	.038*
Earning per year	3.11	.130	24.3	.026*
Farmland size	-4.99	.260	-18.9	.034*

Note:
Dependent Variable: perceptions on climate variability and change in terms of rainfall

Xi = Independent variables: (Socio-economic factors)
B = Regression coefficients
SE = Standard Error
t = Student's t-test
P = Significance level
R^2 = Regression of determination
** = Statistically significance at 0.05 level*
ns =Statistically non-significant at 0.05 level

Effects of climate variability and change

Around 38% of the respondents acknowledged that they have been noticing an overall decreasing trend of rainfall amount within the past few decades and with poor distribution/coverage in time and space. More than 52% respondents explained the tendency of rainfall unpredictability and the rest 6% and 3% reported aspects of early onset and late onset of rainfall respectively. Figure 4 shows multiple responses on major effects of climate variability and change for agro-pastoral communities in their localities. It seems that death of animals is a major effect in Mkalama and Leshata villages. There were also increased human conflicts in Mkalama probably due to possession of a small area for grazing which leads to finding alternative pasture in farmlands or outside the village boundaries. The main stress perceived in Kinyolisi village was uncomfortable hot weather for both human and livestock. This led to drying up of water sources and decline in crop productivity. In Leshata, respondents perceived poor human and animal health that was associated with eruption of several diseases. Chronic malaria was the major human disease reported while for livestock contagious bovine pleuropneumonia (CBPP), east coast fever (ECF) and anaplasmosis diseases were highly pronounced at 35%, 26% and 15% respectively.

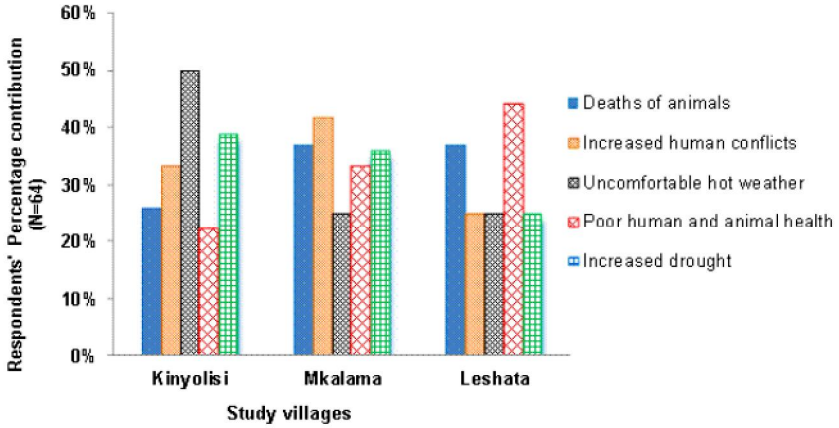

Figure 4. Effects of climate variability (multiple responses)

Generally, most respondents in the study area agreed that there was substantial decline in crop production in the district because of various reasons including climate variability and change. As Table 6 shows, the three agro-pastoral communities had different perceptions on what caused decline in crop yield. Leshata villagers were more concerned on pests and diseases which led to crop wilting and drying up. In Mkalama, they were concerned with high costs of agricultural inputs of which they could not afford to pay together with instability to drought for crops grown. For instance, one farmer in Mkalama argued "… *a major reason to declining crop yield in our village is the fact that many crops now do not withstand the drought conditions…temperature has increased and the amount and duration for rainfall has declined …*". This implies that farmers in semi arid regions need to engage in specific adaptation initiatives such as drought resistant crops including root crops and mixed cropping. On the other hand, Kinyolisi farmers perceived the need for

adaptation techniques including changing timing of farming activities such as land preparation, planting and weeding of agricultural crops.

Table 6: Reasons for decreased crop yield (multiple responses)

Reasons	Villages (% responses)		
	Kinyolisi	Mkalama	Leshata
Increased farming costs	50	50	0
Increased pest and diseases	41	33	35
Wilting or drying of crops	42	26	32
Instability of species grown	0	100	0
Change farming timing	71	29	0
Increased dry spells	33	35	32

According to Figure 5, a number of alternative livelihood options at a time of severe drought were practised in the study area. More than 20% of households sold some of their valuable assets to buy food and about 40% of those with no assets had to borrow from others in order to make a living. A proportion of respondents had to sell labour and others especially the pastoralists had to migrate to other areas with less hazardous situation.

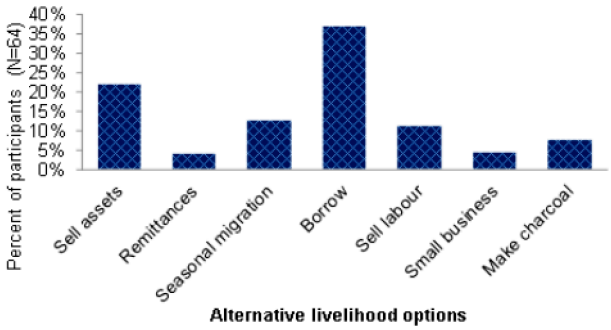

Figure 5. Responses on the alternative livelihood options at the time of famine following severe drought

Range management practices

In general, about 60% of all agro-pastoralists in the study area do practice few range management activities, though they do haphazard grazing (Figure 6). Rotational grazing and improvement of watering points are moderately practiced by some headers probably because of the increased drought. Some headers agreed to have been using fire as a range management tool together with grazing on crop residuals after crop harvest. Grazing on crop residuals was a common practice in the area especially in Mkalama village. However, Figure 6 represents this practice in a low profile probably because it is normally practiced for a short period of time. During FGDs, it was also revealed that management practice through fire is not a common practice in the area. However, the small percentage represents the few *Maasai* (immigrants) in Kinyolisi and Leshata who are used to this practice. According to IFAD (1995), there are no range management strategies in east Africa to promote sustainable livestock production with explicitly measures to support local communities to adapt to or mitigate the effects of climate change. Agro-pastoralists traditionally manage risk by moving their livestock on a daily and seasonal basis to follow changes in the quality and quantity of pasture (Gillson and Hoffman 2007).

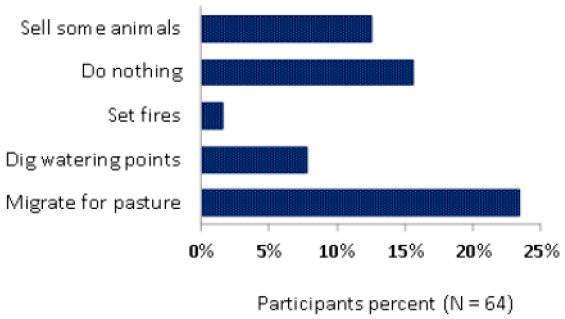

Figure 6. Rangeland management practices performed for improved productivity

Gender roles with respect to climate variability and change

Generally, Gairo rural women were seen in many ways to be more vulnerable to climate variability and change than men due to their household roles. Their direct reliance on ecosystem services for food security, through agricultural production, natural resources use and other gender specific activities places them at greater risks to the negative effects and stressors of climate change. Taking an example of fetching water for the household consumption, a considerable amount of Mkalama women were at risks of spending most of their day and night time (*five to eight hours per day*) to work on a single household activity (Table 7). Too much time spending in water

collection has caused many conflicts in marriage life across Tanzania to the extent of divorce (personal observation, 2009), something that escalates stressors for women.

Table 7: Time spent in fetching water (dry season)

	Village		
	Kinyolisi (%)	Mkalama (%)	Leshata (%)
1-2hrs	77	71	100
3-4hrs	24	6	0
5-6hrs	0	18	0
7-8hrs	0	6	0
Total	**100**	**100**	**100**

Globally, women are already affected by several issues that make them more vulnerable to food insecurity and environmental change, and affect their capacity to cope with climate stressors. Andolan (2008) reports a number of issues impacting women. These include denial of land rights (tenure security), biased government attitude against women, lack of access to information and new knowledge, lack of credibility and access to market and financial services, limited presence in political power and lobbies and lack of opportunity for their voice to be heard.

Results further show how men and women participate in household activities in the three villages (Figure 7). It is observed that fetching of water, fuel wood collection and cooking activities were practiced by both men and women except cooking for Kinyolisi village. Extreme scenario was also found in Mkalama where most men were involved in fuel wood collection than women. Generally Figure 7 shows that most household activities were pioneered by women across the three villages.

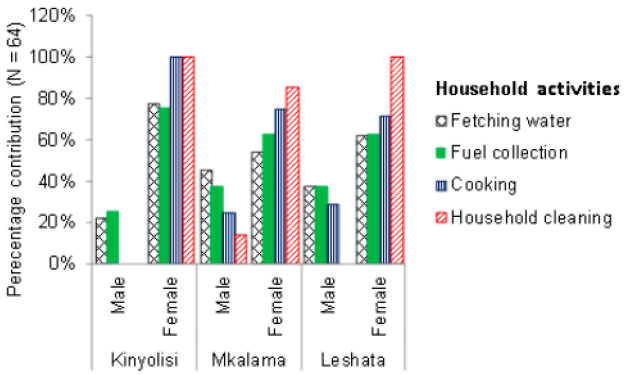

Figure 7. Gender specific roles in household activities

Another gender comparison was done for productive activities within households. According to Figure 8, the most important economic and productive activities were crop farming, grazing and milking. These were done by both men and women in the household except in Leshata where women were not involved in grazing. However, general observation revealed that most of these three productive activities were led by men across the study villages.

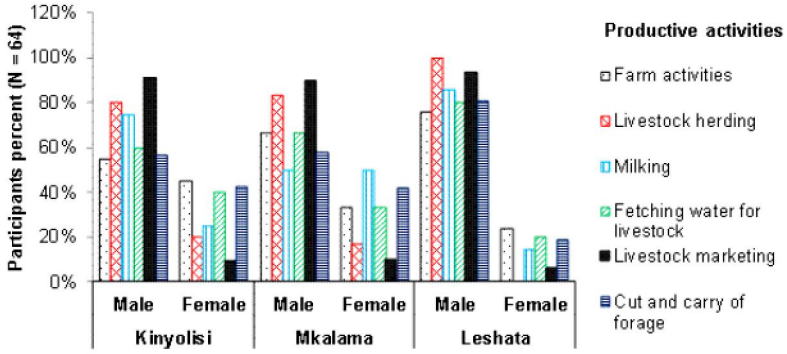

Figure 8. Gender specific roles in household productive activities

Adaptation measures in crop farming and livestock production

Agro-pastoral communities in Gairo have traditionally adapted to climate variability and change by building on their in-depth knowledge of the environment in which they live. A number of adaption measures (Table 8) have been spontaneously used across the

study area to cope with water related stresses in crop farming. Among many, deep hoe soil turning, use of ox ploughs and farming in water valleys (nutrition gardens) were identified as the most used coping strategies for farmers across the study sites.

Table 8: Adaptation techniques applied to overcome water stress in farmlands

Village	Deep hoe soil turning	Use early maturing varieties	Use ox ploughs	Farm in valleys	Shifting cultivation	Mixed cropping	Crop rotation	None	Total
Kinyolisi	10	3	4	2	0	0	0	1	20
Mkalama	7	3	9	1	0	1	0	0	21
Leshata	5	0	6	4	4	1	1	1	22
Total	**22**	**6**	**19**	**7**	**4**	**2**	**1**	**2**	**63**

On the other hand, agro-pastoral groups and communities in Gairo had several strategies to cope with climate stress related to livestock production (Table 9). When pasture and water resources were insufficient due to drought, they were united to dig water holes/pits in valleys for livestock watering and when the later were completely dry, they used to emigrate to other nearby or even far away areas with their livestock. According to one of the key informants (livestock extension officer), breeding strategies could be a better way to cope with climate change impacts. He explained that "*... many local breeds are already adapted to their harsh conditions. However, we have very little knowledge and technology on livestock breeding which might help to speed up adaptation.... traits like tolerance to heat and ability to survive and reproduce in conditions of poor nutrition, parasites and diseases challenges, could be very crucial at this moment...* .". Hoffmann (2008) also reported improving local genetics through cross breeding with heat and disease tolerant breeds. However the author argued that if climate change is faster than natural selection the risk of survival and adaptation of the new breed becomes greater.

Table 9: Strategies applied to overcome climate stress for livestock

Village	Emigrate with animals	Dig watering points	Move animals to other places	None	Total
Kinyolisi	2	15	3	0	20
Mkalama	8	6	1	2	17
Leshata	10	9	0	3	22
Total	**20**	**30**	**4**	**5**	**59**

Further results showed that sometimes back, for example in late 1990s both crop and livestock production failed in one season. Under this scenario, a well planned community based adaption measures were necessary. Table 10 shows some of innovative adaptation activities that agro-pastoral communities undertook across the study sites. In most cases, they sold animals to reduce the risks of death, despite the low prices fetched. Whatever income obtained through sale of livestock, was used to buy food for survival. Table 2 above, revealed that there were almost twice and five times the number of cattle in the study sites compared to those of goats and sheep respectively. This was also another challenge in adaption struggle. Small ruminants are thought to be more adapted because of their small size which reflects amount of pasture and water intake and type of feeding (e.g. browsers versus grazers). Therefore, while de-stocking animals through sale, less priority should be given to cattle (after all, they have higher prices) than goats and sheep which are already limited in number.

More vulnerable communities also found jobs in households that were better off to earn cash for buying food to make a living. Others who owned few assets had opportunities to borrow cash from better off households but those who did not own many assets especially herders emigrated to other regions.

Table 10: Combined adaptation measures for climate stress when both farming and livestock production fail

Village	Sell assets	Borrow	Emigrate	Open small business	Remittances	Reduce meal	Sell labour	Sell animals	Total
Kinyolisi	3	2	2	1	1	1	7	3	20
Mkalama	3	4	3	2	0	0	4	5	21
Leshata	0	3	2	3	0	0	2	12	22
Total	**6**	**9**	**7**	**6**	**1**	**1**	**13**	**20**	**63**

Conclusion and recommendations

- Socio-economic, ecological and other environmental factors have direct influence to adaptation mechanics of agro-pastoral communities living in semi arid region of central Tanzania. Men and women have different perceptions with regards to adverse effects of climate variability and change due to different productive and household roles within their families. In consistency with African culture, productive activities were broadly undertaken by men while household based activities were done by women. Range and agricultural improvement practices which were thought to lessen the climatic hardship were found unpracticed except very few ones across the study sites something that amplifies the problem. Most adaption strategies in crop farming and livestock production were anticipatory and spontaneous rather than planned. Low level of knowledge and technology was found to reduce adaptation capacity of vulnerable agro-pastoralists across the study sites. Therefore a number of recommendations were made as follows:
    - There is a need for agro-pastoralists to regulate their herd composition in order to balance between the large ruminants which are considered as " *bank accounts* or *security deposits"* with the small ruminants such as goats and sheep which are

more adapted to harsh environmental stressors.

- Given that climate change is likely to further intensify the existing inequalities and affect differently the capacity of women and men to cope with additional stresses, more attention will be needed to ensure that adaptation strategies are developed taking into account these differences and the increased needs of women in view of their roles as the most significant suppliers of household labour and men as efficient managers of household production.
- There also a need to diversify productive roles of women in the household like keeping local chicken which are easy to handle and adopted to local conditions.
- There is a need to improve management of water resources through the introduction of simple techniques for localized irrigation (e.g. drip and sprinkler irrigation), accompanied with infrastructure to harvest and store rainwater, such as small superficial and underground dams, tanks connected to the roofs of houses.
- There is a need to undertake capacity building activities to agro-pastoral communities across central Tanzania for increased awareness of global changes, and improved capacity of agro-pastoralists to understand and deal with climatic stressors. Training in agro-ecological technologies and practices for the soil and water conservation will improve the supply of both crop and range resources.

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