The Effect of Climate Variability and Change to the Farming Systems in Iramba and Meatu Districts, Tanzania

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Abstract

This study examined changes in farming systems in response to climate variability and change. Specifically, the study aimed to;(i) assess farmers' perceptions of climate variability and change and (ii) examine changes in the farming systems in response to climate variability and change. The study adopted qualitative (focus group discussions) and quantitative (household survey) techniques using a sample size of 150 respondents for the survey. The results demonstrated that smallholder farmers and agro-pastoralists perceived the occurrence of climate variability and change manifested through drought, rainfall variability and increased day time surface temperature. Awareness regarding climate variability and change were associated with the middle age group (18-45 years old), which perceived increased drought since the 2000s relative to other age groups. Frequent food shortage and increasing shortage of pasture were on the increase. Contrary to their expectations, smallholder farmers and agro-pastoralists were unable to adjust fully their farming systems to minimize the negative effects of climate variability and change. This means, they had little capacity to change their farming systems or simply, they were vulnerable to the effects of climate variability and change. It is therefore recommended that, through integrated effort by the government and Non-governmental Organizations (NGOs) should support smallholder farmers and agro-pastoralists to adjust their farming systems in response to climate variability and change so as to minimize the negative effects.

Introduction

Climate change and farming systems are broad concepts, which are defined differently in the literature. Some define the term as change in the long-term mean of weather conditions, or all changes in the climate system, including their drivers of change and their impacts (FAO, 2008). Meanwhile, the United Nations International Strategy for Disaster Reduction (UNISDR) refers only to human induced weather changes (UNISDR, 2008). Others use the term to refer to the natural phenomenon, which is accelerated by human activities (O'Brien *et al.*, 2006). Overall, climate change encompasses long-term changes of weather parameters including rainfall, temperature, wind, relative humidity and extreme weather events (IPCC, 2007; FAO, 2008), whereas climate variability is defined as a short-term phenomenon, involving temporal and/or spatial variations of the mean state and other statistics of the climate that go beyond individual weather events (IPCC, 2007). Meanwhile, a farming system encompasses interaction of sub-systems like crops, animals, soils, labour, capital, land, power and implements. These sub-systems are largely controlled by farming households and they are influenced by physical, political, institutional and socio-economic factors (Dixon *et al.*, 2001; Behera and Sharma, 2007). A farm and a household unit in a farming system comprise of food and cash crops, homestead gardens and animal production including various other non-agricultural activities (Dixon *et al.*, 2001).

Climate variability and change affects negatively the farming systems; more specifically sectors like agriculture, livestock, transport, forestry and water sectors (URT, 2007; Paavola, 2008) accelerate resource degradation, which ultimately leads to negative environmental, economic and social impacts. It is worth noting that Sub-Saharan Africa (SSA) is the most vulnerable sub-continent due to multiple interlocking factors including poverty, hunger and over-dependence on rainfall (IPCC, 2007). For instance, agriculture in SSA depends on rainfall by 95%, while dependence on rainfall in semi-arid environments of Tanzania is 97% (SUA, 2007; IWMI, 2010; Mongi*et al.*, 2010). In this sub-continent (SSA), agriculture is not only rain-fed but also affected by soil conditions and the prevalence of pests (insect pests, diseases, weeds), which are also associated with climate variability and change.

Smallholder farmers in Tanzania, whose livelihoods depend on farming systems particularly crop and livestock production, constitute 85% of the population and accounts for about 75% of agricultural production (URT, 2001; Salami *et al.*, 2010). Consequently, it is relevant to argue that climate variability and change will affect the biggest segment of the population in the country. Kabote *et al.* (2014) contend that warming, drought and agricultural expansion have negatively affected the rain-fed farming system in Meatu and Iramba such that, the system does not support smallholders farmers' livelihoods sufficiently as it used to be in the 1970s.

According to Kabote *et al.* (op. cit), rainfall patterns associated with un-expected heavy downpours are becoming more common. Other manifestations include less rainfall received per season, shift of seasons, un-predictable onset of rainfall and cessations as well as floods. Nonetheless, available literature does not sufficiently uncover responses of dwellers within farming systems in terms of food preference, farm implements and agricultural inputs. Such information will help development practitioners as well as local communities to understand comprehensively, how smallholder farmers adjust their farming systems in dealing with climate variability and change. This paper therefore, seeks to assess how climate variability and change affects farming systems and its implication on livelihoods. Response to climate variability and change is taken in this paper to mean any long-term, planned or unplanned adjustment or modification to the farming systems. The study discusses various aspects of farming systems and the changes, drivers for such changes and adaptation by the community members.

Theoretical and Conceptual framework

The conceptual framework as illustrated in Fig. 1 assumes that people from middle to old age – forty six years and above - can recall climate variability expressed in terms of changes in weather parameters such as drought, rainfall and day time temperature. Such parameters have been reported as the most threatening elements of the climate system in the study areas (Kabote *et al.*, 2014). It is assumed that farmers and livestock keepers will respond to the phenomena by making changes on the farming systems to minimize negative effects. This is possible largely due to experience they have accumulated over long periods of practising farming and other productive activities (Maddison, 2006). According to the farming system thinking established by researchers during the 1970s, changes in the crop and livestock sub-systems is important in order to buffer the effects of climate variability and change on people's livelihoods (Darnhofer *et al.*, 2008; 2010). In other words, changes and/or interactions of the sub-systems are considered critical, for a farming system to be sustainable, such that, it can continue supporting farmers' livelihoods over time. The farming system thinking also takes into account farmers' views regarding underlying causes of the changes in the farming system. It also purports that changes in one sub-system affects other elements of system organization (Darnhofer *et al.*, 2010). According to this conceptual framework, failure of the smallholder farmers to adjust their farming system in response to climate variability and change suggests failure of a farming system and hence the people's livelihoods as well. Failure to respond to climate variability and change will finally lead to dwindling grazing land, decrease in crop productivity and hence exacerbating food shortage and insecurity in rainfall dependent communities (Afifi *et al.*, 2014). In this study, the negative effects of climate change and variability on farming systems and livelihoods manifest as crop failure and food scarcity, lack of pasture and water bodies becoming seasonal. Where positive effects occur the reverse would be true.

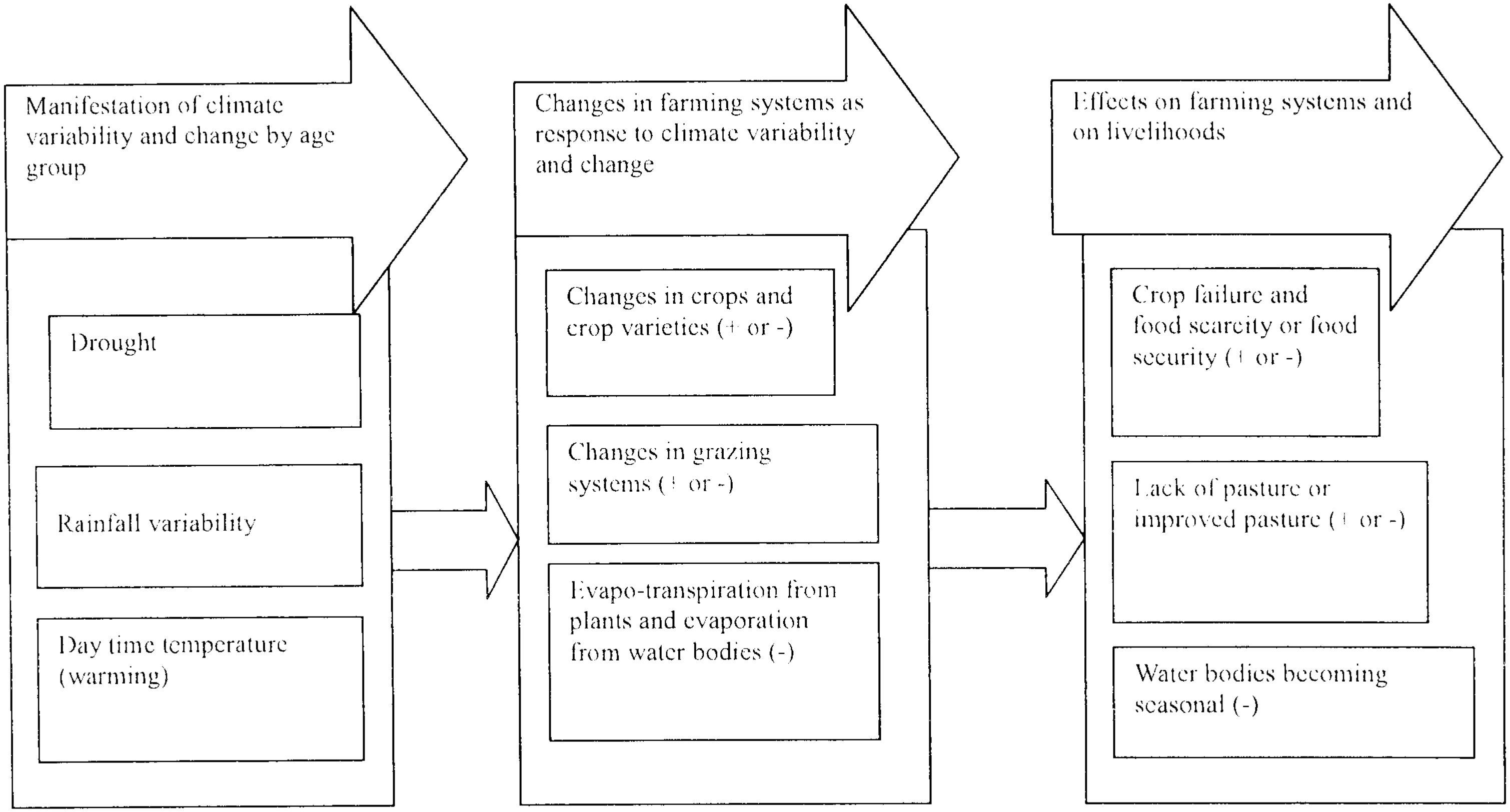

Figure 1: Responses of farming systems and peoples' livelihoods to climate variability and change

Kabote *et al.* (2014) identified rainfall variability, and changes in day time temperature as the most threatening elements of the climate system. The thinking as shown in Fig. 1 is that drought is a function of decrease in rainfall and increase in day time surface temperature, leading to crop failure and deterioration of pastures. Drought can also increase incidences of insect pests and diseases for crop and animals as reported by Synnevåg *et al.* (2015). Not only that, but drought also causes decrease in pasture availability and failure in crop productivity which result into increased food shortage and insecurity in rain fed agricultural communities (Afifi *et al.*, 2014).

The framework also assumes that increased day time temperature causes water bodies to dry, decreasing underground water levels, which in turn accelerates crop wilting as evapo-transpiration exceeds water uptake by plants from the soil. In response to climate variability and change, smallholder farmers find adaptation and other coping mechanisms to suit the needs of their farming systems' (Synnevåg *et al.*, 2015), thereby changing the farming systems.

Methodology

This study was conducted in Iramba and in Meatu Districts. Iramba is found in Singida Region whereas Meatu is found in Simiyu Region. As described by Kabote *et al.* (2013), Iramba lies between 4^0 and 4^0 3' latitudes South and 34^0 to 35^0 longitudes East. The average annual rainfall in Iramba ranges between 500 and 850 mm and the day time temperature is as high as 30^0C in October. Meatu receives annual rainfall between 400 in the South and 900 mm in the Northern parts (Iramba District Council, 2009; Meatu District Council, 2009). The vegetation is characterized by Miombo and Acacia woodlands and grasslands in Iramba whereas Meatu is dominated by scattered or clustered shrubs and thorny trees. The two adjacent districts are inhabited by different ethnic groups -Wasukuma in Meatu and Wanyiramba in Iramba. Both districts are located in semi-arid agro-ecological zones where rainfall is uncertain. Although both districts are dominated by smallholder farmers and agro-pastoralists, they represent slightly different farming systems in terms of types of crops, which provide room for comparison in the farmers' response to climate variability and change.

Three villages were selected for this study taking into account spatial distribution in order to capture differences in weather and related farming systems. Kidaru village was selected from Iramba district, representing a southern location while Mwamanimba and Mwashata were selected from Meatu district representing northern locations. Only Kidaru village was selected to represent the southern location because it was the only one having weather variations closely related to the other two (Mwamanimba and

Mwashata) villages selected from the northern location. Rainfall amount increases from the South towards the North in the study area. Villages were selected if they experienced prolonged drought, hunger and increased frequency of receiving food aid from the government and also from Non-governmental Organizations (NGOs). For example, since 2000 up to 2013, each of the selected villages received food aid at least seven times. According to the District Agricultural, Irrigation and Cooperative Officers (DAICO) in Meatu and Iramba, food aid is normally provided once per year during months of extreme food scarcity.

The study combined qualitative and quantitative methods namely focus group discussions (FGDs) and a household survey for complementarity. During FGDs, brainstorming involving men and women in the common group was encouraged but also domination of men participants was controlled by dividing them into male and female groups at some point during the discussion, so as to capture the views of men and women separately. Discussions were tape recorded to enable transcriptions later on. Three FGDs were conducted, one in each village and, as recommended in literature (Masadeh, 2012), each FGD comprised of 10-12 participants. In total, 34 participants were involved in FGDs, from three villages and 16 hamlets. Participants were selected in such a way that they covered all 16 hamlets; four in Mwashata, six in Mwamanimba and six in Kidaru. Participants included male (105) and female (45) villagers who were young (aged 18-29 years), middle aged (aged 30-45) and old (46 and above) (Tables 2 and 3). This age composition assisted the researchers to obtain a wide range of information on the existing situation regarding farming systems and what climate variability changes had induced adjustment or adaptation in the farming systems. Both crop producers and livestock keepers were involved. The FGDs discussed various aspects of the farming systems and the changes especially in crop and livestock production in response to climate variability and change.

In addition to the FGD, a household survey was conducted using a semi-structured questionnaire, which was designed to capture information on rainfall and temperature variability in each village over a 15 year period since 2000. This period is considered long enough for variability to be observed. The household survey involved 150 respondents who were selected from a sampling frame for each village, consisting of all listed household heads. Systematic random sampling was applied to select at least 10% of the households as presented in Table 1 while Tables 2 and 3 present the sample composition by gender and age. Majority (70%) of respondents were male, especially in Mwanaimba and Mwashata village where male respondents comprised 82% and 75% of the sample respectively, compared to only 54% in Kidaru village.

Table 1: Sample size per village (N=150)

Village name	Total number of households	Number of households selected	Percentage of households selected
Kidaru	444	52	12
Mwashata	462	47	10
Mwamanimba	315	51	16

Table 2: Composition of respondents by sex (%): (N=150)

Respondents' sex	Kidaru (n=52)		Mwashata (n=47)		Mwamanimba (n=51)		Sample total (n=150)	
	%	N	%	N	%	N	%	N
Male	54	28	75	35	82	42	70	105
Female	46	24	25	12	18	9	30	45

Table 3: Composition of respondents by age (%): (N=150)

Age group	Kidaru (n=52)		Mwashata (n=47)		Mwamanimba (n=51)		Sample total (n=150)	
	%	N	%	N	%	N	%	N
18-45	52	27	39	18	52	26	48	71
46-60	31	16	39	18	25	13	31	47
60 and above	17	9	22	11	23	12	21	32

The questionnaire was administered through face to face interviews with the household heads, their spouses or both. Qualitative data were transcribed and then summarized based on farmers' perceptions of climate variability and change and its effect on the faming systems patterns especially crop and livestock production systems. Quantitative data were analyzed using the Statistical Package for Social Sciences (SPSS).

Results and Discussion

Perceived occurrence of climate variability and change by age groups

Focus group participants reported that climate variability and change, particularly drought, had considerably become excessive during the last fifteen years since 2000 compared to the situation during the 1980s. The frequency of drought was reported to be on the increase, particularly from the mid 2000s. Nevertheless, the meteorological data trends could not be used to validate farmers' perceptions for the period under study due to inconsistency in data recording and also due to inadequate or absence of meteorological data stations in the villages (Synnevåg *et al.*, 2015). Participants also reported that rainfall received per season had decreased. They were also concerned about increasing day time temperature. Men and women had similar views regarding the occurrence of climate variability and change. Previous studies (e.g. Swai *et al.*, 2012; Legesse *et al.*, 2013; Juana *et al.*, 2013) have reported similar findings. Perceived risks and adaptation to climate variability and change are gendered due to unequal gender relations in society (Nombo *et al.*, 2013; 2015). In this study, results from FGDs regarding the occurrence of climate variability and change, were in line with quantitative results obtained from the household survey (Table 4 up to Table 6).

Table 4: Percent responses on changes in rainfall since the 2000 (N=150)

Age group	Direction of the changes	Kidaru (n=52)		Mwashata (n=47)		Mwamanimba (n=51)		Sample total (n=150)	
		%	N	%	N	%	N	%	N
18-45	Increasing	12	6	0	0	8	4	7	10
	Decreasing	88	46	100	47	92	47	93	140
46-60	Increasing	13	7	0	0	31	16	15	23
	Decreasing	87	45	100	47	69	35	85	127
60 and above	Increasing	0	0	10	5	18	9	9	14
	Decreasing	100	52	90	42	82	42	91	136

Data from the household survey shows that there was a variation between age and responses on whether drought had increased, decreased or not changed since the year 2000. Within the category of young respondents (18 to 45 years), majority of respondents (93%) reported that rainfall had decreased (Table 4) and more than 60% reported increasing frequency of drought (Table 5). In fact, all age groups presented similar trend of responses regarding changes in rainfall variability (Table 4), frequency of drought (Table 5) and changes in day time temperature (Table 6), which was said to have increased. This implies that all age groups were able to notice the rainfall and temperature variability. This can be interpreted to mean that the phenomena of climate variability and change were serious such that all respondents who were involved in this study were able to observe it. These results agreed partly with meteorological data trends reported by Kabote *et al.* (2013) in the same study area, which showed that there were six dry years in Meatu and Iramba over a period of 10 years since 1994.

Table 5: Percent responses on frequency of drought since the 2000s (N=150)

Age group	Direction of the changes	Kidaru (n=52)		Mwashata (n=47)		Mwamanimba (n=51)	
		%	N	%	N	%	N
18-45	Increasing	64	33	61	29	64	33
	Decreasing	16	8	33	16	28	14
	No change	20	10	6	3	8	4
46-60	Increasing	81	42	61	29	54	28
	Decreasing	9	5	39	18	38	19
	No change	0	0	0	0	8	4
60 and above	Increasing	56	29	70	33	64	33
	Decreasing	11	6	30	14	36	18
	No change	33	17	0	0	0	0

Table 6: Per cent responses on day time temperature variability since the 2000s (N=150)

Age group	Direction of the changes	Kidaru (n=52)		Mwashata (n=47)		Mwamanimba (n=51)		Sample total (n=150)	
		%	N	%	N	%	N	%	N
18-45	Increasing	92	48	93	44	100	51	95	143
	Decreasing	8	4	7	3	0	0	5	7
46-60	Increasing	93	48	88	41	92	47	91	136
	Decreasing	7	4	12	6	8	4	9	14
60 and above	Increasing	78	41	100	47	73	37	83	125
	Decreasing	22	11	0	0	27	14	17	25

Changes in crops and crop varieties in response to climate variability and change

Table 7 presents a summary of major food and cash crops grown in the study area and the dominant farming systems as synthesized during FGDs. The results demonstrated that bulrush millet and sorghum were regarded as "hunger crops" because they are drought tolerant and were grown to safeguard farmers against food shortages.

Table 7: Crops grown and dominant farming systems

Village	District	Major food crops	Major cash crops	Dominant farming system
Kidaru	Iramba	Bulrush millet and sorghum	Sunflower	Bulrush millet/sorghum/sunflower/livestock
Mwamanimba	Meatu	Sorghum and sweet potatoes	Cotton	Cotton/sorghum/livestock
Mwashata	Meatu	Maize	Cotton and paddy	Maize/cotton/paddy/livestock

It was not surprising that bulrush millet and sorghum were grown mainly in Kidaru and sorghum in Mwamanimba where annual rainfall was 500 mm and 400 mm per year, respectively. Bulrush millet rainfall requires 350-500 mm of rainfall per annum (Yadav, 2012) while for sorghum requires 400-800 mm (Smith and Frederiksen, 2000); and for this matter bulrush millet is more drought tolerant when compared to sorghum. Maize and paddy were grown mainly in Mwashata, which is located in northern Meatu where the average annual rainfall is higher (900 mm). The results also showed that cotton was dominant as a cash crop in Mwamanimba whereas farmers at Mwashata grew paddy in addition to cotton for cash income. Paddy and maize had become important in Mwashata village because they serve both as cash and food crops hence important for ensuring household food security as well as livelihood.

Other crops grown in the study villages were groundnuts, simsim, green gram, bambaranuts, groundnuts, cowpeas, watermelon and pumpkins. Sweet potatoes were mentioned to be an important crop in Mwamanimba because it helped smallholder farmers during food shortage periods, which normally occur between February and March just before harvesting period. The older participants during FGD recalled crops that were grown way back during the 1940s. These included sorghum (*Nkolongo*), maize, finger millet, cotton, bambaranuts, bulrush millet, sweet potatoes and groundnuts. Due to weather conditions most of these crops are currently cultivated along seasonal river valleys particularly River Ndurumo in Kidaru and near River Simiyu in Mwashata.

Food preferences differed by ethnic groups as presented in Table 8, but farmers could eat anything available during periods of food shortage, which was not the case in the 1980s. In 1970s and 1980s the Government provided enough food during food shortage periods. Results from FGDs showed that 25% of respondents in each village had adopted improved short-term crop varieties. For instance, smallholder farmers in Kidaru had - since the 1990s - adopted a short term variety of sorghum, which is drought resistant. Similarly, FGDs participants in Mwamanimba reported a change from long-term sorghum variety to short-term varieties. This happened due to failure of traditional sorghum varieties to withstand climate variability and change particularly drought and rainfall variability. The food preference is the indicator of what has been produced and harvested in the farming systems.

The changes from long-term to short-term varieties were also reported for maize in Mwashata. These results were in line with the literature which shows that early maturing crops are desired in water-deficit semi-arid areas (Parry *et al.*, 2005). The short-term maize crop varieties, which had been adopted, include SEEDCO-Pundamilia, SEEDCO-Simba and DK. This study indicates that the most important drivers for the changes in sorghum and maize crop varieties grown by farmers in these villages were drought and rainfall variability. A shift from long-term to short-term crop varieties was necessary because short-term varieties mature earlier relative to long-term varieties. Hence short-term varieties helped farmers to reduce risks of crop failure and food shortage.

Table 8: Ethnic groups and food preferences

District	Village	Ethnic group	Food preference
		Nyiramba (dominant)	Sorghum stiff porridge
		Nyaturu	Sorghum stiff porridge
		Sukuma	Maize stiff porridge Sorghum stiff porridge Sweet potatoes
Iramba	Kidaru	Taturu	Meat, milk Stiff porridge of maize, millet and sorghum
		Barbaig	Meat, milk Stiff porridge of maize, millet and sorghum
		Nyisanzu	Stiff porridge of maize, millet and sorghum
	Mwamanimba	Sukuma (dominant)	Maize stiff porridge Sorghum stiff porridge Sweet potatoes
Meatu		Nyaturu	Sorghum stiff porridge
		Nyiramba	Sorghum stiff porridge
		Nyisanzu	Sorghum stiff porridge
	Mwashata	Sukuma (dominant)	Maize stiff porridge Sorghum stiff porridge Sweet potatoes
		Nyiramba	Sorghum stiff porridge
		Nyaturu	

The results show that adoption of drought resistant crop varieties was low due to high price of improved seed. Considering that majority of the respondents were poor they could not afford improved seed. Using participatory wealth ranking, Nombo *et al.* (2013) reported that more than 80% of the households in the study area are living in poverty, more so, female headed households (FHHs). This figure is higher than the incidence of basic needs poverty at the national level, which stood at 28.2% in 2012 (NBS, 2014). Moreover, improved varieties were not available in local shops (FG participant at Mwashata village). Villagers in Mwashata had to travel approximately 90 km to Mwanhuzi or 60 km to Bariadi to obtain improved seeds, which contributed to their poor adoption. All these facts, suggest that smallholder farmers hardly adopted improved varieties to cushion climate variability and change impacts.

At Kidaru, the level of soil fertility was reported to be poor in most of the farms, yet the use of organic fertilizers was low because of drought, which, according to Kabote *et al.* (2013) occurred seven times in a period of ten years since 1994.This had resulted into low crop yield and food shortage coupled with decrease in household income.

Results from FGDs also demonstrated that some smallholder farmers practiced gardening for crops such as tomatoes and okra using small-scale traditional irrigation method along River Ndurumo in Kidaru and River Simiyu in Mwashata. Six smallholder farmers at Kidaru have been practicing small-scale irrigation since 2011 using small water pumps, but such methods were not sustainable due to water deficit, during most of the dry season. Small-scale irrigation farming systems had emerged during recent years to overcome rainfall variability and drought to improve food security. Yet, lack of capital to purchase water pumps and water deficit were serious constraints, which suggests the need for mediation of agricultural inputs from the government and other development actors. The results from FGDs also demonstrated progressive increase in crops attack by various insect pests, diseases and birds since 2000s, which is higher compared to the 1980s. This was coupled with inadequate knowledge to address the problem.

Farm labour and implements, agricultural production and climate variability and change

Focus group discussion participants reported that 75% of the smallholder farmers at Mwamanimba and Mwashata used an ox-plough for tillage. However, at Kidaru, dependence on the hand hoe was 75%. Before 1980s where the farming systems in the study area were dominated by use of the hand hoe. The ox-plough for tillage have been introduced after 1980s. In addition, the findings show that labour exchange system whereby farmers without an ox-plough provided labour to farmers who had ox-ploughs in return to tilling services on their farms. The use of the ox-plough and labour exchange were increasing in order to expand the size of farms in response to climate variability and change impacts. Yet, due to long-standing drought and rainfall variability, coupled with farmers' limited coping strategy to adjust their farming systems as reported by Kabote *et al.* (2014), crop yields showed a decreasing trend compared to the situation before the 1980s (Table 9). This implies that the villages in the study area were likely to face in food crisis.

Table 9: Yield trends between 1980 and 2012

Type of Crops	Yield (bags per "Nkwa")			
	1980s		2012	
	Bags per "Nkwa"	Bags per Hectare	Bags per "Nkwa"	Bags per Hectare
Maize (*Zea mays*)	10	47.6	0 to 5	0 to 23.8
Sunflower (*Helianthus annuus*)	3 to 4	14.3 to 19.0	2	9.5
Green gram (*Vignaradiata*)	-	-	1	4.8
Sorghum (*Sorghum bicolor*)	5	23.8	2.5	11.9

The yields are reported on a local unit of measurement known as "Nkwa", 1 Nkwa = 15 by 140 adult walking steps (15m x 140 m = 2,100 m^2 = 0.21 Ha). 1 walking adult step ≈ 1 m. 1 bag = 100 kg for maize, sorghum and green gram and 60 kg for sunflower.

The results from FGDs were in line with the responses from the household survey, which also demonstrated decreasing crop production due to climate variability and change (Table 10). Crop production is a series of activities requiring various skills such as agronomy, mechanics, biology and marketing and it covers a variety of operations throughout the season. Decreasing crop production due to climate variability and change was reported by all age groups suggesting failure of the cropping system. Water bodies also shrunk, especially Lake Kitangiri, which is located at the border between Meatu and Iramba. The Lake provides water and fish to support people's livelihoods. Participants also reported decreasing fish cache and species variability in the Lake Kitangiri. These results were in line with Patt and Gwata (2002) who reported the decrease of resources availability due to climate change.

Further, the results show that 50% of all households at Kidaru experienced food scarcity. The problem has been more serious since the 2001 especially during October to March. Participants in FGDs reported that, before the 1980s, food shortage was not as serious and not frequent in the study area, and they were able to re-call after a short discussion among themselves. Notably, during data collection for this study, food shortage coincided with higher food prices.

Table 10: Percent responses on whether climate variability and change has reduced crop production (N=150)

Age group	Effect	Kidaru (n=52)		Mwashata (n=47)		Mwamanimba (n=51)		Sample total (n=150)	
		%	N	%	N	%	N	%	N
18-45	Yes	48	25	61	29	56	29	55	83
	No	44	23	39	18	44	22	49	73
	Don't know	8	4	0	0	0	0	3	4
46-60	Yes	50	26	65	31	62	32	59	89
	No	50	26	35	16	38	19	41	61
	Don't know	0	0	0	0	0	0	0	0
60 and above	Yes	44	23	50	24	54	27	49	74
	No	44	23	25	12	31	16	34	51
	Don't know	12	6	25	12	15	8	17	26

Changes in livestock in response to climate variability and change

According to FGD, the species of livestock kept (Table 11) had not changed over the previous three decades since the 1980s. However, agro-pastoralists had started to keep pigs at Kidaru, in response to market demand from the village and a nearby town at Kiomboi district headquarters. In addition, the number of cattle owned by the households had decreased due to shortage of pastures caused by drought. Before the 1970s, the communities in Meatu used to set aside reserve pasture for grazing locally known as "*ngitiri,*" to be used during the dry season. However, respondents for this study noted that it was currently difficult to set aside areas for pastures because demand for land was high. Farmers have expanded their farm to mitigate crop failure which may occur due to climate variability and change. Expansion of crop production has consequently led to so dwindling grazing areas. As such, some agro-pastoralists had to pay for animal feeds obtained from maize stalks, especially during dry periods from July up to November.

Table 11: Types and number of livestock

Livestock	Kidaru	Mwamanimba	Mwashata
Cattle	1548	1761	3341
Goat	503	2716	1492
Sheep	322	1230	1059
Donkey	64	109	5
Chicken	-	1234	2918
Ducks	-	-	209
Guinea fowl	-	-	0
Pigs	80	0	16

Source: Village records for livestock census conducted in 2012

The study also demonstrated that during the dry seasons agro-pastoralists had to move their herds to neighbouring areas and even to distant districts and regions in search of pastures and water. Although the practice has been common for many decades, prolonged drought now requires agro-pastoralists to move their livestock for longer periods, sometimes spanning across years if the drought occurs during two consecutive seasons or more. Compared to the situation in the 1970s, agro-pastoralists now stayed at the temporary locations for one or two months before the rains began.

Findings from this paper show that crop failure has forced agro-pastoralist to sell livestock at a lower price to address food shortages, but also to avoid the loss of animals in case of acute water shortage. Respondents for this study also reported that livestock diseases were increasing - lung diseases and foot and mouth disease being the most common. All these contributed to a decrease in the number of livestock. Even though, as reported during FGDs, the herds were big with some families owning up to 1000 cattle. Similar results were also observed by Thornton and Mario (2008).

From FGD, it has been reported that the problem of climate variability and change has increased livestock diseases and insect pests. Meanwhile, there were no agro-vet shops in the villages to provide agro-pastoralists access to drugs for treating their livestock. It was also observed that dipping facilities were not available in the study area. For example, livestock keepers at Kidaru had to take their livestock to Luono village which is about 5km away for dipping. All this is happening when there is evidence to show that livestock keepers have insufficient indigenous knowledge to control all the livestock diseases and pests as was reported from the study areas. As an adaptation strategy against these challenges, some households have started keeping guinea fowls, which lay up to 120 eggs per cycle of 4-6 months. The species is also less susceptible to diseases that attack birds. In general, animal diseases appear to be increasing with climate variability and change as reported by Synnevåg *et al.* (2015).

Conclusions and Recommendations

This paper examined the effects of climate variability and farming systems in selected villages in Iramba and Meatu Districts situated in semi-arid areas. Based on the findings, the paper concludes that climate variability and change, particularly rainfall variability, drought and increased day time surface temperature since the mid 2000s had negatively affected the farming systems. This includes a change in the farming systems, for example, a change from traditional crop varieties to short-term improved varieties. However, majority of smallholder farmers were poor and had limited resources to support changes in the farming systems. Although farmers live in adjusted districts their farming systems differ in their response to climate variability and change. Consequently, they should be backed up by an appropriate policy and institutional framework in areas they do not do better so as to sustain their livelihoods. It means that resources have to be mobilized at the household level, local government level or at the national level to support the adjustment responding to climate variability and change. Female headed households were more at risk because poverty was high among them. The reported changes in the farming systems patterns and climate variability and change had negative effects on people's livelihoods. The changes in the farming systems were not sufficient to buffer the effects of climate variability and change and that smallholder farmers were vulnerable to the phenomena.

The government and non-governmental efforts should support smallholder farmers and agro-pastoralists to ensure that they are able to adjust their farming systems. The framework to support smallholder farmers and agro-pastoralists needs a special focus on the following areas:(i) access and affordability to improved seeds which are drought resistant, pests and disease resistant through subsidies; (ii) supporting small-scale irrigation farming system; (iii) capacity building in livestock pests and disease control; (iv) price control mechanism for both food and cash crops through government intervention, monitoring and tax reduction in food items; and sustainable land use management. Smallholder farmers and agro-pastoralists also need capacity building on livestock husbandry education to enable them reduce the number of livestock to improve the quality; give room to pasture establishment and management which would fetch better market price of beef and dairy products.

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