Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.8, No.9, 2018

Do Smallholder Farmers Perceive Rainfall Variability the Same and Correctly? Gendered and Spatial Analysis of Perception Versus Actual Trends of Rainfall in Three Livelihood Zones in Kenya

Samuel Kimani Kiumbuku[1*] Mary Wamuyu Baaru[2] Jane Wanza Mutinda[2]
1.School of Environment and Natural Resource Management, Machakos University, Kenya.
2.Department of Environmental Studies and Community Development, Kenyatta University

This study was part of a PhD thesis at Kenyatta University – Kenya

Abstract
In this paper we compared perceived rainfall variability with actual rainfall variability using a more nuanced and mixed approach in order to understand the influence of gender dynamics and spatial location on perceptions. To be able respond effectively to climate variability people must first perceive the changes correctly. Past studies have focused on general perceptions about climate changes but have failed to ascertain the correctness of these perceptions as well as to exhaustively focus on gender dynamics and livelihood expectations that shape these perceptions. To address these gaps we focused on a more nuanced comparison between actual climate variability and gendered perception across three livelihood zones. We obtained historical Rainfall data from weather stations in the three livelihood zones which we analysed using Coefficient of Variance (CV) and Cumulative Departure Index (CDI). We then compared this with responses from inter-household survey data of 420 households that were stratified in stages depending on the zones and gender of the target respondents. Although it was not significantly different how women and men perceived the changes in rainfall (p-value above 0.05) men seemed to perceive the variations more correctly compared to women. All aspects of rainfall variability were significantly perceived differently in the three agricultural livelihood zones. Depending on specific livelihood expectations in each zone the variability of rainfall was either perceived correctly or wrongly.
Keywords: Gendered perception, spatial perception, gender, rainfall variability, livelihood zones, Kenya.

1.1. Introduction

Similar to other countries in sub-Saharan Africa, Kenya is highly vulnerable to the effects of climate change (Herrero *et al*., 2010; Bryan *et al*., 2013). This is attributed to the country's over-reliance on rain-fed agriculture, continued widespread poverty, slowed uptake of modern technologies, and under-developed markets and infrastructures (Bryan *et al*., 2013; Nyoro *et al*., 2001; Kristjanson *et al*., 2009; Odhiambo *et al*., 2004). The effects of climate variability are also being felt widely with the situation being recurrent droughts, lack of equitable land distribution and limited coping strategies (United Nations Environmental Programme, (UNEP) 2009). With such situations livelihoods for members of the communities that are dependent on climate or are resource limited are much affected. Rain-fed agriculture as the main source of Kenya's income (Bryan *et al*., 2013; Herrero *et al*., 2010; Odhiambo *et al*., 2004) contributes 98% of the country's total agricultural activities (UNEP, 2009). However it is very vulnerable to fluctuating temperatures and recurrent droughts that normally reduce productivity. This poses major threats to sustenance of rural livelihoods especially those that depend on agriculture for survival. Vulnerability to climate variability and its related impacts are not the same to all people but depends on various factors that may include, geographical regions, levels of income, means of livelihood, gender among others (Mutai *et al.,* 2010; Grimberg *et al*., 2018). Climate variability disproportionately burdens particular segments of society, with some sections being more vulnerable (UNDP, 2009). The most affected are the poor and marginalized people who live particularly low-income areas (Kaijser & Kronsell, 2013; Okereke & Schroeder, 2009), a characteristic of rural women. According to Habtezion (2012) there is a direct relationship between gender inequality, women empowerment and climate variability. Women and men might be unequally vulnerable to the impacts of climate variability and this could worsen the existing gender disparities. Men or women can also enhance the response to climate variability through the unique knowledge, perceptions and skills that they each possess (Babugura, 2010). While they are affected by natural resource degradation in different ways men and women have different abilities to manage these resources. Therefore they can as well be disadvantaged differently when there is when natural resources are lost or degraded by changing climate (Women's Environment and Development Organisation (WEDO), 2003; Burns& Patouris, 2014). All these factors can shape the perceptions differently about climate variability and its associated impacts.

1.2. Perceptions of climate variability

Perception to climate variability can be associated with both social-cultural construction and psychological dimensions (Weber, 2001; Palmer, 1996; Hansen *et al*,. 2004). From a social cultural dimension perception it is systematically determined by how people who share a common culture interpret a phenomenon that affects their livelihoods and way of life (Weber, 2001). Psychologically, perceptions may vary from person to person or from group to group. However group differences in perceptions are often larger to result to predictive differences in perception between those groups (Weber & Hsee, 1998). Such group dynamics may be due to gender, culture, livelihood activities, geographical locations, income age and level of education (Hansen *et al*., 2004). According to Grimberg *et al* (2018) perception may be shaped by social variables that include culture, political and psychological factors since they all determine how people interact with the natural environment, including their livelihood practices. In this study we focused on gender and location based livelihood activities. Understanding perceptions is crucial since they affect people's or group's decision making processes and in particular perceptions about climate variability are important in determining how individuals prepare themselves for the expected changes and how they support local policies on climate (Niles and Mueller, 2016; Weber & Hsee, 1998). People may also differ on how they respond to climate variability since they may also differ on how they perceive the changes and associated impacts on their lives (Hansen *et al*., 2004). They therefore alter their climate-related behaviours depending on perception even though perceptions are determined by a number of factors beyond what people observe daily. According to Bartels *et al* (2015) differences in perception may hinder successful implementation of interventions and initiatives related mitigation of adaptation to climate variability.

Provision of weather information, personal beliefs concerning climate and presence of infrastructure can help to shape how people experience effects of climate change influencing perceptions. Knowledge and perception on what contributes to climate change is also important in determining mitigation measures by individual since effective adaptation and mitigation requires understanding of the impacts and causes of anticipated changes and the readiness to change behaviours. However it is worth noting that perceptions may not represent what is happening in reality. Events and trends on climate can be interpreted differently or remembered wrongly due to various reasons (Niles and Mueller, 2016). Climate information is therefore important since it helps to shape the perception of the recipients. Perception of climate variability is partly dependent of the information given to an individual and its accuracy. Perception is also important as it is among the elements that influence adaptation and coping processes (Swai *et al.,* 2012). Through perception an individual can undertake measures to adapt or cope to the variable climate elements.

There is need therefore to assess the correctness of farmers' perceptions about climate variations and their potential impacts on livelihoods with the overall aim of reducing vulnerability through informed adaptation and mitigation strategies. In order to effectively take up appropriate adaptation and mitigation measures, farmers must have the right perception and knowledge about climate variations (Maddison *et al*., 2007; Grimberg *et al*., 2018). It is also necessary to compare the perceptions of men and women their vulnerabilities and adaptive capacities in order to make gender-sensitive or gender-specific decisions to address climate related stresses. The overall aim of this study therefore was to compare the gendered and spatial perceptions of rainfall variability with the actual probabilistic rainfall variations in three agro-climatic livelihood zones of semi-arid Eastern Kenya. In achieving this aim the study sought to answer the following questions: (1) is there significant actual evidence on rainfall variability in the study area? (2) Is there significant difference in perception about rainfall variability between men and women? (3) Is there significant relationship between livelihood activities and perception of rainfall variability? (3) Is there relationship between actual and perceived rainfall variability? We suggested the vulnerability context framework in diagram 2 for exploring the determinants of perceptions to climate variability and the role of perception on climate responses.

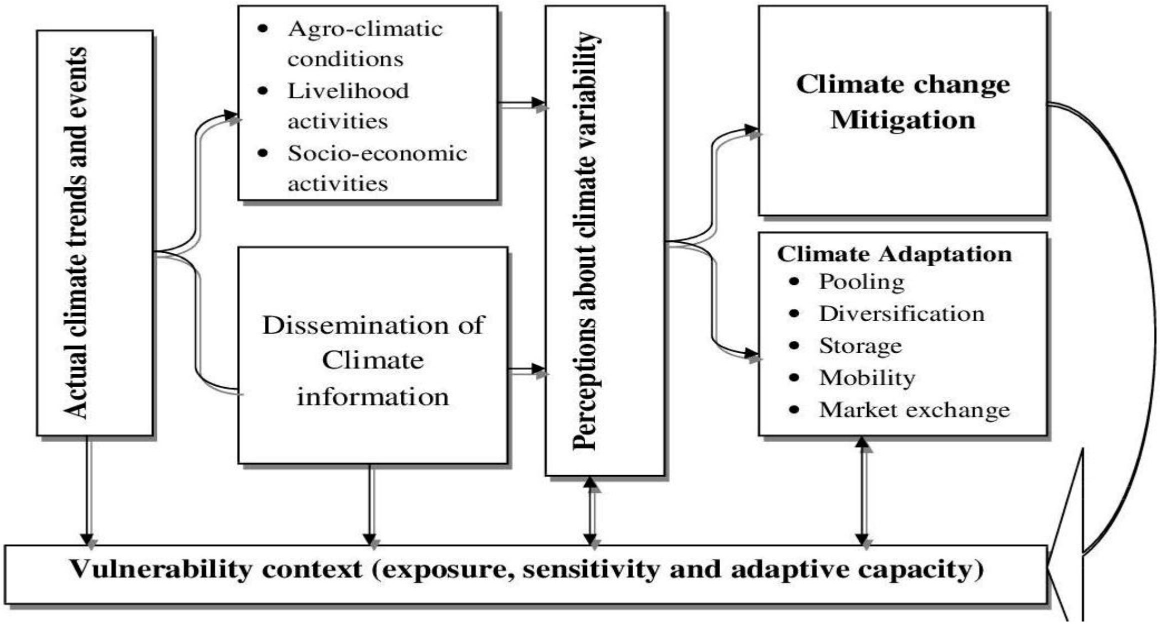

Figure 1: Vulnerability context framework showing influence and role of perception (source; authors, 2018)

2. Methodology

2.1. Sampling and data collection

The study used both purposive and multi-stage stratified random sampling techniques (Mugenda, 2011). Makueni County was purposively selected out of the 47 counties of Kenya since it is located in one of the ASAL regions in the country that is characterised with high prevalence of food insecurity, poverty and water scarcity all of which contribute to poor livelihoods in rural areas of the country. The residents of the county mainly depend on small holder rain-fed agriculture for their livelihoods. In the second stage of sampling the sub-counties were stratified into three depending of the major contrasting climatic and agro-ecological livelihood characteristics.

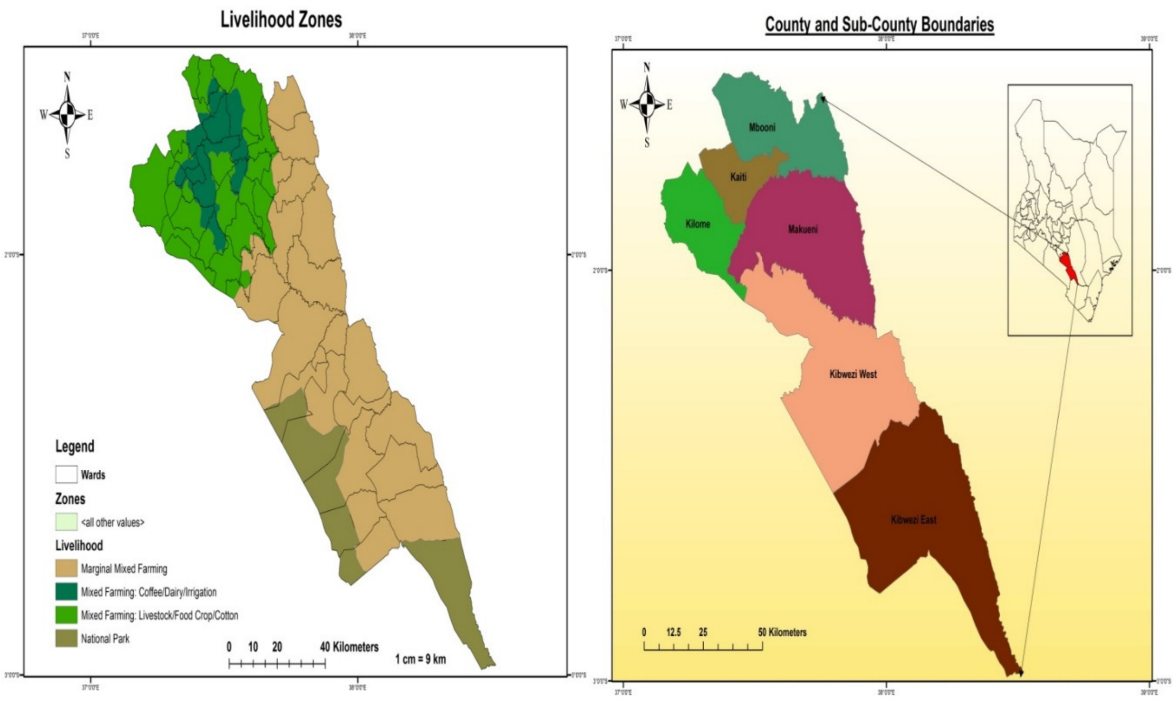

Figure 2: Study area and contrasting agricultural livelihood zones (source: authors, 2018)

One sub-county was then selected from each stratum i.e. Makueni (livestock and food crop mixed farming, LM4), Kibwezi East (marginal mixed farming, LM5) and Mbooni (coffee, dairy and irrigation mixed farming, UM3) (FAO, 2014). In the third stage, two wards were randomly selected from each sub county. A sample of 420 households was randomly selected from the wards. Finally the households selected were randomly categorized into two depending on the intended gender of the respondent from each household. From the male category the husbands were selected to represent male respondents whereas the wives were selected from the female category to represent female respondents. The final sample was made of 210 adult female respondents and 210 adult male respondents. This restriction to either male of female adult in the household was done since it was assumed that they are the ones who had the capacity to make decisions concerning their households. The method of sampling was used as a precaution of not conceptualizing women or men as one homogenous group in terms of the impacts of climate change while making sure that all categories of men and women were represented in the sample (Jost *et al*., 2016). While noting that that there is distinction between inter and intra-household gender dynamics (Mersha & Van Laerhoven, 2016), other studies have focused their analysis on inter-household dynamics by stratifying households into male and female headships before sampling (Mikalista, 2015; Bryan *et al*., 2013; Mersha & Van Laerhoven, 2016). Others have focused their analysis on intra-household dynamics by focusing on married couples within the households (Ngigi *et al*., 2017). This study slightly deviated from the two approaches and has focused on a inter-household gender analysis by not only considering female and male household heads as participants in the study but randomly focusing on all categories of men and women in the study area. The respondents from the selected households were interviewed using a semi-structured interview schedules that were filled during the interviews. Random sampling was used to select the respondents to participate in the focus group discussions. A total of 12 focus group discussions were made (2 in each ward), each consisting of 5-8 participants.

2.2. Rainfall data

Daily rainfall recordings for the period 1986-2015 were obtained from Kenya Meteorology Department (KMD) and from other institutions that had stations for recording primary weather in the study area. Choice of the weather stations was purposively done based on the three livelihood zones and percentage of missing data. Weather stations that had less than 10% missing values of daily rainfall data were selected for analysis (Kisaka *et al.,* 2015; Akinsanola & Ogunjobi, 2014). Therefore three weather stations were selected; Makindu Meteorological Station in Kibwezi East sub-county; Mbooni Forest Station in Mbooni sub-county and; Kambi mawe Agricultural sub-station in Makueni sub-county (**Table** 1).

Table 1: Rainfall data

Station	*Latitude*	*Longitude*	*Altitude*	*Period of record*	*AE zone*
Makindu	-2°17'S	37°50'E	1000M	30	LM5
Kambi mawe	-1°1'S	37°40'E	1143M	30	LM4
Mbooni	-1°38'S	37°27'E	1829M	30	UM3

2.3. Data analysis

Daily rainfall was obtained and entered into MS Excel spread-sheet. From the data, monthly, seasonal, annual and number of rainy days (both annual and for short and long seasons) were computed. Any day that received more than 0.2mm of rainfall was considered to be rainy day whereas a day that had less than 0.2mm of rain was considered dry (Kisaka *et al.*, 2015). Missing data was filled through multiple imputations using Nonlinear Iterative Partial Least Squares (NIPALS) estimation method in XLSTAT software. The NIPALS method was developed by Wold in 1973 to allow Principal Component Analysis (PCA) with missing values. Once NIPALS algorithm is applied on the dataset with missing values the PCA model obtained is used to predict the missing values.

Totals for annual rainfall, long rains and short rains data were subjected to trend analysis and variability analysis using Cumulative Departure Index (CDI) based on arithmetic means for a period (30 years). Cumulative value for each year was calculated from long-term and yearly means and the standard deviation using equation.

$$\varphi = \frac{x - \bar{x}}{\sigma}$$

Where φ=Cumulative departure of rainfall, x represents actual value (mean for each year) of rainfall, $\bar{x}$ is the long term mean value of each parameters rainfall, σ is the standard deviation (Akinsanola & Ogunjobi, 2014) Coefficient of Variance (CV) was used to test level of variations from mean in seasonal rainfall amounts, annual rainfall amounts, seasonal number of rainy days and annual number of rainy days. This was done using the following equation.

$$CV = {}^{\sigma}/_{\mu} \times 100$$

Where CV represents Coefficient of Variation, σ represents standard deviation and μ represents the mean. Chi-square, binary regression, and ANOVA were used to test significance of relationships (hypothesis testing) and to make inferences about the perceptions of the population. The entire statistical tests were done at 5% (α=0.05) significance level. Qualitative data was sorted and organized thematically according to the appropriate themes of responses. It was then used to generate theoretical explanations that were used to support quantitative data.

3. Results and Discussion

3.1. Trend of rainfall events across livelihood zones.

Results in this section were analysed and presented in terms of four aspects of rainfall variability: amount, frequency, intensity, seasonal and inter-annual variability (Simelton *et al*., 2013). There was a general trend of decrease in the average amounts of rainfall although rainfall trends for the three stations showed that both annual and seasonal amounts of rainfall were inter-changeably below and above average during the study period (1986-2015) (**Figure** 3). Above average annual rainfall was more frequent in the years before 2000 after which the three areas received consistently below average annual rainfall. There was however slight increase on rainfall in Makueni from 2012 to 2015. For the three regions, a highest amount of rainfall was received in 1988, 1990 and 1998. However, Kibwezi East still received higher rainfall in 2006 (**Figure** 3).

In 1995, 2000 and 2005 the rainfall for the three regions deviated more negatively from the long term average. The results of coefficient of variation (CV) showed that the amount of annual rainfall was highly variable in the three areas. In Makueni sub-county, annual rainfall amounts were highly variable (CV=41%) than those in Kibwezi East (CV=36%) and Mbooni (CV=34%) (**Figure** 3). According to Kisaka *et al* (2015) a Coefficient of Variation (CV) greater than 30% indicates a greater variation in rainfall amounts and distribution. From these results it can therefore be deduced that agricultural livelihoods in all the zones were threatened by overall uncertainties in the amounts of rainfall that were received.

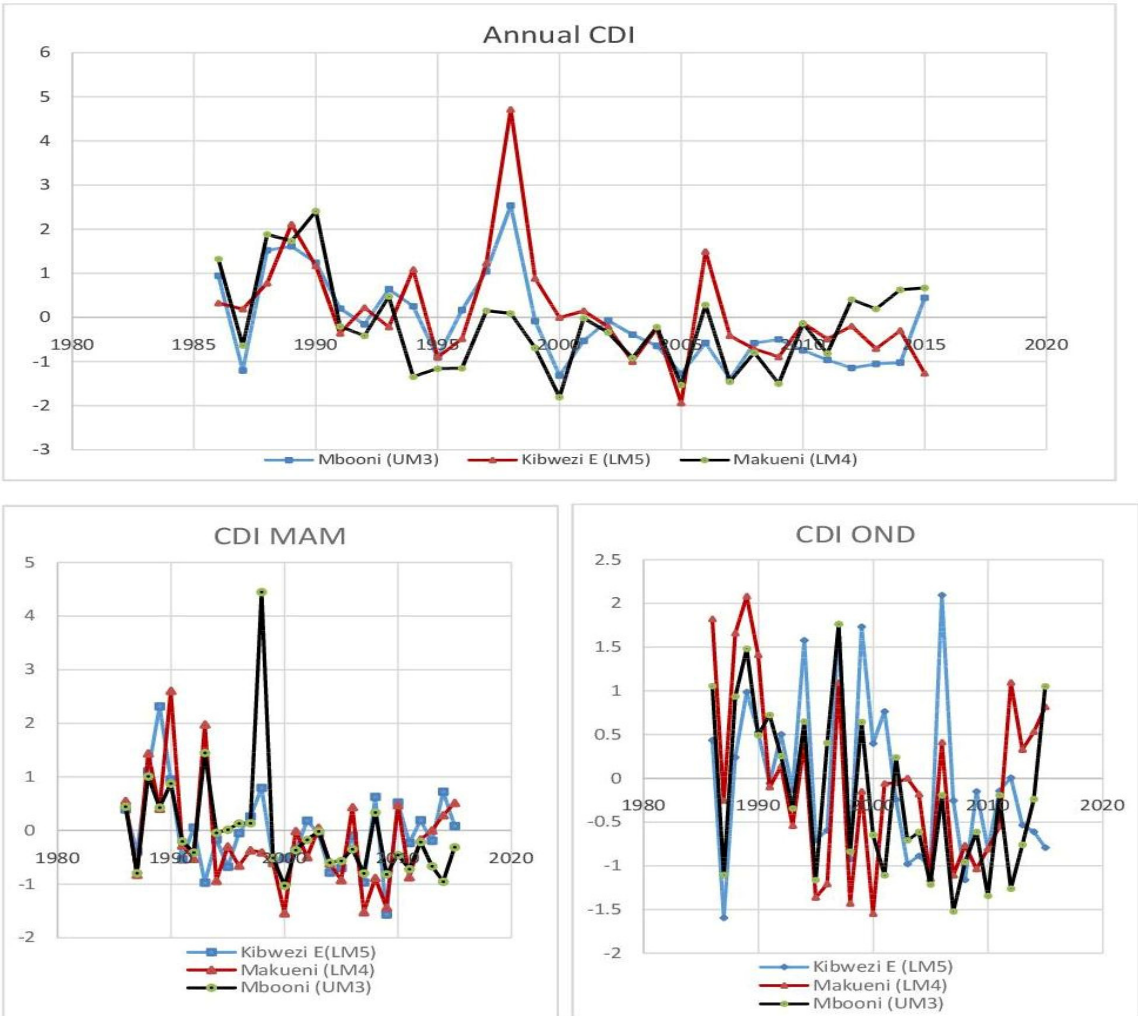

Figure 3: Annual and seasonal rains Cumulative Departure Indices

3.2. Seasonal rainfall trends and variations

Rainfall amounts and distribution during long rains season (March-April-May) were highly variable in the three regions (**Figure** 3). There were however higher incidences of negative anomalies in long rains between 1999 and 2015. Above average anomalies in long rain amounts were received between 1985 and 1999 for Mbooni with the highest positive anomaly observed in 1998 (CDI=+4.446), Kibwezi East in 1989 (CDI=+2.312) and Makueni in 1990 (CDI=+2.601) (**Figure** 3). The rest of the period (1998-2015) still had fluctuations in amounts of rainfall although the anomalies were lower compared to the previous years. Negative anomalies were higher in 2000, 2004, 2007, 2009, 2011 and 2014. There was also a general decline in long rains between 2000 and 2015 in the three zones which were exhibited by repeated negative anomalies and very low positive anomalies. Depressed long rains are attributable to desiccation of the March-to-August rains that has been happening in Sub-Saharan Africa (Nicholson, 2001; Kisaka *et al.,* 2015) (**Figure** 3). Rainfall amounts and distribution during short rains season (OND) were more variable than the long rains (**Figure** 3). This was a threat to livelihoods since short rains were more relied on by farmers for agriculture. Generally there were repeated positive and negative fluctuations in rainfall between 1986 and 2015. There was also general decline in short rains between 2006 and 2014 in the three zones which exhibited repeated negative anomalies. Short rains increased in Makueni from 2012, exhibiting a positive anomaly. Positive anomaly was only observed in 2015 since 2002 in Mbooni meaning there was a general decline in short rains in that period (**Figure** 3).

3.3. Seasonal variation in rainfall duration amounts

On average, long rains contributed 41.0%, 36.2% and 42.0% of total annual rainfall in Mbooni, Kibwezi East and Makueni respectively (**Table** 2). Short rains on the other hand contributed 55.4%, 48.7% and 47.8% mm of total annual rainfall in Kibwezi East, Mbooni (UM3) and Makueni respectively (**Table** 2). Therefore, cumulatively the two seasons contributed 91.6%, 89.8% and 89.7% to total annual rainfall in Kibwezi East, Makueni Mbooni respectively.

Table 2: Seasonal rainfall variability

	Long Rains				Short Rains			
Station	**RA**	**CV**	**RD**	**CV**	**RA**	**CV**	**RD**	**CV**
Kibwezi East	204.4(36.2)	71	13.69	38	313.0(55.4)	54	22.43	44
Makueni	239.64(42.0)	53	19.0	35	272.3(47.8)	46	23.0	42
Mbooni	409.2(41.0)	61	23.0	42	485.3(48.7)	32	29.0	38

**RA Rainfall Average; CV Coefficient of Variation; RD Rainy days*
**Percentage of total annual average in parentheses*

Results of Coefficient of Variability (CV) indicated significant variations in seasonal rainfall amounts for both long and short rains and for the three regions. This was based on threshold used by Kisaka *et al*, (2015) and Araya and Stroosnijder, (2011) that a CV greater than 30% indicates large variability of rainfall amounts. Generally, for the three regions, long rains were highly variable compared to short rains. This made the short rains more reliable than the long rains. Kibwezi East had the highest variability in the amounts of long rains (CV=71%) and short rain (CV=54%) (Refer to **Table** 2).

In terms of rainy days Mbooni sub-county had the longest duration of both rainy seasons (**Table** 2). There was significant variability in terms of seasonal number of rainy days which was greater for short rains compared to long rains, apart from Mbooni. Comparatively, duration of short rains was highly variable in Kibwezi East (CV=44%) and Makueni sub-counties (CV=42%) compared to Mbooni sub-county (**Table** 2). On the contrary, Mbooni sub-county had the most variable duration of long rains (CV=42%). From the results of average seasonal rainfall amounts, average rainfall amounts and number of rainy days it can be concluded that only few rainy days contributed the largest amounts of rainfall received.

3.4. Monthly variations in rainfall amounts and duration

Understanding monthly variations in rainfall amounts and number of rainy days is very crucial in enhancing adaptation and coping strategies (Kisaka *et al.,* 2015). The information guides on the choice of crop varieties to grow, planting time and water management. Rainfall amounts for the seasonal months (March-to-May and October-to-December) were highly variable exhibited by CV values much greater than 30% (**Table** 3).

Table 3: Monthly rainfall variability

	Mar	Apr	May	Oct	Nov	Dec
Mbooni (UM3)						
RD	6.38	10.1	6.46	3.96	15.04	10.3
CV-RD	0.66	0.50	0.68	0.93	0.27	0.71
RA (mm)	99.83	180.7	83.60	52.46	261.0	165.1
CV-RA	0.88	0.57	0.70	1.15	0.43	0.74
Kibwezi East (LM5)						
RD	5.00	6.50	2.82	2.24	10.67	9.30
CV-RD	0.55	0.50	0.87	1.02	0.40	0.60
RA (mm)	74.80	76.0	24.04	21.22	146.99	112.0
CV-RA	0.78	0.64	1.09	1.50	0.64	0.67
Makueni (LM4)						
RD	5.54	8.00	3.46	2.64	12.43	8.88
CV-RD	0.70	0.51	0.71	0.85	0.30	0.57
RA (mm)	68.6	104.0	22.6	22.5	156.0	89.4
CV-RA	0.99	0.73	1.02	1.44	0.43	0.91

****RD** number of rainy days; **CV-RD** Coefficient of variation in number of rainy days; **RA** (mm) Rainfall amounts in millimetres; **CV-RA** Coefficient of variation in amounts of rain*

It was noted that several Coefficient of Variance values were abnormally high in May and October (Transitional offset month for long rains and onset month for short rains respectively). The CV-RA values were notably higher (more than 1) in October for the three regions (Mbooni, Kibwezi East and Makueni) (**Table** 3). This was replicated in terms of CV-RA for May (1.02) in Kibwezi East, CV-RD (1.02) in Kibwezi East for October and CV-RA (1.09) in Kibwezi East for May (**Table** 3). These Very high Coefficient of Variance values in the two months (May and October) implied that offset of long rains and onset of short rains were highly variable and therefore not reliable or easily predictable by farmers. In some years these months did not receive any rains despite being regarded as rainy months. Least variability of rainfall amounts was in the month of April for long rains and November for short rains (**Table** 3).

The rainy months also had significantly high variation in the number of rainy days in the three areas. Coefficient of Variations for rainy days were relatively higher in Kibwezi East compared to Makueni and Mbooni. April and November had the lowest variations in rainy days for long rains and short rains season respectively (**Table** 3). Variation in monthly number of rainy days was notably high for the onset and offset months. This implied late onsets or early offsets of the rainy seasons. Combining the results of the amounts of rainfall and number of rainy days it was observed that both were more consistent in April and November but highly variable in May and October **(Table** 3). On average Mbooni had the highest monthly rainfall and rainy days in all seasonal months. This implied that rainfall was relatively distributed over longer periods of time.

3.5. Gender and spatial dimensions of perception about rainfall variability

When asked whether they had experienced any variations in rainfall trends in recent years, majority of respondents (97.9%) had the perception that rainfall had generally varied with time (**Table** 4). This comprised of 98.1% male respondents and 97.6 female respondents. There was no significant difference in responses between men and women (χ^2=0.114, p=0.736) (**Table** 4). The respondents were asked whether they had noted any variations of rainfall in the past ten years in terms of duration and amounts. Majority of them (97.9%) responded that they had actually noted some changes in rainfall pattern. This comprised 98.1% and 97.6% of male and female respondents respectively who reported past changes in rainfall patterns and increased occurrences of droughts Variability of rainfall was perceived by respondents in relation to onset and offset of rains, the duration of rainy season or cessation as well as amounts of rainfall (**Table** 4). They felt that rainfall had varied in the following ways; onset are getting late (63.3% male respondents and 67.0% female respondents); offset are coming early (48.1% male respondents and 42.9% female respondents), rains have become less (61.4% male respondents and 61.0% female respondents), length of the rainy seasons have decreased (83.3% male respondents and 88.6% female respondents) and that rainfall has become erratic and unpredictable (80.0% male respondents and 86.2 female respondents) **(Table** 4).

Table 4: Gendered perceptions about rainfall variability

Variable	Men (%)	Women (%)	Variance	χ^2	p-value
Have noticed any variations in rainfall	98.1	97.6	0.5	0.114	0.736
Can anything be done?	90.5	86.2	4.3	1.871	0.171
Type of variation				**f-value**	**p-value**
Onset comes late	63.3	67.0	-3.7	0.623	0.434
Offset comes early	48.1	42.9	5.2	1.160	0.282
Amounts of rain have reduced	61.4	61.0	0.4	0.010	0.920
Length of rainy seasons have reduced	83.3	88.6	-5.3	2.388	0.123
Rain has become erratic	80.0	86.2	-6.2	2.879	0.091

There was however no significant difference in how men and women perceive rainfall variability (at 0.05 level of significance), although comparatively higher proportion of women perceived most of the impacts more compared to that of women. This researcher attributed this to gendered roles of women that highly exposed them to climate risks compared to men. Both male and female respondents had similar perceptions of how rainfall was changing with time. According to Moron *et al* prediction of seasonal rainfall onset is very crucial to farmers than other anomalies (Moron *et al.,* 2015). Rainfall onset prediction is particularly an important factor since it affects the crops calendar for farmers, fixing sowing dates and enabling options of adaptation. Any variation on onset dates was therefore highly perceived by respondent. It was also noted that livelihoods were more affected by overall inadequacy of rainfall amounts rather than just by delayed onsets.

Rainfall variability was also perceived in terms of its impacts on livelihoods, specifically crop performance, animal health, pasture availability, crop health and productivity and water availability. Qualitative information from focus discussion groups sowed that there was a general perception that in the last 5-10 years rains have been setting on late than it used before. Most respondents indicated that long rains season used to begin around 15th of March while short rains season began around 15th October of each year. According to respondents the situation had changed since rains are starting later than these dates. Respondents attributed a lot of agricultural failures to unpredictable rains. As one participant responded:-

> *"Initially we used to plant our crops with some certainty that rains would start at a particular date but in the last few years this has not been possible due to rains being erratic". (KI14)*

Participants in an FGD also indicated that rainfall patterns are hard to predict in the last fifteen years. They explained in agreement that due to scarcity of rains both in amounts and duration, they were affected by repeated crop failures associated with stunting and drying of crops before maturity. They also incurred losses when rains delayed upon sowing their seeds in anticipation of rain. The seeds were reported to either be destroyed by rodents, excess heat and rotting. This situation forced them to replant when the rains set in. A female discussant in Nzaui/Kalamba ward had this to say when asked to describe how rainfall had varied in the past:-

> *"Onset is late and unpredictable; therefore farmers do not know when to plant. Rainfall distribution is poor and the number of rainy days decreased followed intense temperature thus very poor yields are realized leading to cyclic food insecurity"* (FGD603).

A conversation from a male focus groups discussion in Thange ward illustrates various dimensions of rainfall variability that were perceived by the participants in connection to how their crops were affected;

> ***Enumerator****: What can you say about rainfall in this area?*
> ***FGD1104****: "….the rains are getting less and less since 1980s…before then we used to get enough rains but these days people are sowing their seeds expecting the rain but it fails to start on time or ceases earlier than expected and the crops get destroyed…"*
> ***FGD 1102:*** *"…even the crops do not mature….we do not even harvest…"*
> ***FGD1104:*** *"…there is no harvest…"*
> ***FGD 1107:*** *"…crops do not yield since the rains are less, do not start in time or ceases earlier…"*
> ***FGD 1103:*** *"…we also have livestock but as you can see the condition is very dry and there is no pasture…"*

Rainfall variation was perceived differently by the respondents in the three sub-counties (see table 5). This was attributed to wide variety of experiences of historic events and livelihood system in the three sub-counties. Respondents from Mbooni sub-county perceived the variations more compared to respondents from Makueni and Kibwezi East sub-counties (**Table** 5) despite the fact that from meteorological analysis Kibwezi East had the highest variation. Respondents from Makueni sub-county perceived late onset of rainfall (ß=-0.934, p=0.001), early offset (ß=-1.456, p=0.001) and unpredictability of rains (ß=-0.982, p=0.002) more significantly than in Kibwezi East sub-county. However, less rainfall (ß=1.154, p=0.001) and shortened rains (ß=1.133, p=0.001) were perceived more in Kibwezi East sub-county compared to Makueni sub-county (**Table** 5).

Table 5: Relationship between gender, livelihood zone and perception about rainfall

	ß	SE	p-value	R^2	χ^2	p-value
Onset comes late				**0.137**	**43.936**	**0.001**
Mbooni (UM3)	-1.764	.286	0.001			
Makueni (LM4)	-.934	.246	0.001			
Rains have become less				**0.185**	**61.612**	**0.001**
Mbooni (UM3)	-1.872	.287	0.002			
Makueni (LM4)	1.154	.247	0.001			
Offset comes early				**0.224**	**76.999**	**0.001**
Mbooni (UM3)	-2.305	.288	0.001			
Makueni (LM4)	-1.456	.274	0.001			
Rains have become erratic				**0.59**	**14.976**	**0.001**
Mbooni (UM3)	-1.092	.335	0.001			
Makueni (LM4)	-.982	.317	0.002			
Length has decreased				**0.073**	**17.454**	**0.001**
Mbooni (UM3)	-.136	.430	0.752			
Makueni (LM4)	1.133	.351	0.001			

a) Reference category is: Kibwezi East (LM5).
b) Significant at $p \leq 0.005$

Agricultural households make sense of climate variability through the perceptions of potential risks they encounter in their livelihood systems (Marion *et al.,* 2013). Through these experiences and memories, respondents are able to categorise between “normal” and abnormal climatic events and patterns. Livelihoods in Mbooni sub-county depend on mixed farming that involves exotic dairy farming and irrigation farming. These livelihoods were more sensitive and therefore easily affected by rainfall and temperature variations. This made them to highly perceive any change that affected their livelihoods. Livelihoods in Makueni sub-county were largely based on mixed farming where they grew food crops, fruits, and kept livestock. Due to aridity of the area households had embraced keeping and growing drought tolerant breeds of livestock and crop varieties. These livelihoods were therefore not be easily affected by rainfall variations although this happened during extreme harsh conditions. Livelihoods in Kibwezi East sub-county were based on marginal mixed farming but predominated by livestock keeping (pastoralism). These livelihoods were more resilient to rainfall variations and were able to withstand extreme rainfall scarcity. Effect of rainfall and temperature variability on these livelihoods was therefore not immediately perceived.

3.6. Comparison between actual and perceived rainfall variability

There was direct connection between the actual climate variability and the perceived rainfall variability by a greater proportion of respondents. Both male and female respondents had similar perceptions of how the rainfall trends were changing with time (**Table** 6). From the results majority of respondents (62.2%), both male and female, perceived that the rainfall had reduced with time. This was also indicated through meteorological evidence from the actual rainfall data that showed a general decline in Cumulative Departure Indices (**Table** 6) of amounts of rainfall between years and seasons. A constant decline of rainfall (annual, short and long rains) over the years was exhibited through more repeated negative anomalies over the last fifteen years. This was observed in the three sub-counties that were considered in the study.

Table 6: Comparison between perceived and actual rainfall variability

Perceived aspect of variability	Percentage (%) of respondents	Evidence of variability from actual data
Rainfall is variable	97.9	Fluctuation Cumulative departure indices and higher Coefficients of variance
Onsets of rain are coming late	62.5	Greater Coefficient of Variation in number of rainy days and amounts of rainfall on seasonal onset months
Offsets of rain are coming early	45.5	Greater Coefficient of Variation in number of rainy days and amounts of rainfall on seasonal offset months
Amount of rain has reduced	62.2	Fluctuating Cumulative Departure Indices of annual and seasonal rainfall.
Length of the rainy seasons has reduced	86.0	General decline in numbers of annual and seasonal number of rainy days. Higher coefficients of variance in amounts of rain and number of rainy days
Rainfall has become erratic	83.1	Fluctuation in number of rainy days and amounts of rainfall numbers of rainy days. Higher coefficients of variance in amount of rain and number of rainy days

It was also observed from the actual analysis of rainfall variability that there were annual, seasonal and monthly variances in rainfall. Variation was observed through repeated negative and positive rainfall anomalies. This caused the rains to be erratic and unpredictable. The situation was perceived similarly by significant number respondents (83.1%) who reported that the rains had become erratic. Unreliability of rainfall was also reported to be caused by late onset (reported by 62.5% of respondents) and early offset (reported by 45.5% of respondents) (**Table** 6). The responses were supported by actual rainfall data that exhibited higher Coefficients of Variation in seasonal offset and offset months of rain (**Table** 6). Preliminary rainfall data indicated varied dates for onset and offset of seasonal rainfall, although actual start and end dates were not analysed.

Similar congruence between perceptions and actual rainfall variability was obtained in a previous study that was conducted in Southern Africa (Simelton *et al*., 2013). However it is also worthy to note that there was a considerable proportion of respondents who did not perceive some of the changes as they had actually occurred. This can be explained by the fact that perceptions may not represent what is happening in reality and that actual climate anomalies may not mean "optimal" variation from resident's point of view (Moron *et al.,* 2015). Events and trends on climate can be interpreted and remembered differently based on personal experiences (Niles and Mueller, 2016).

Conclusion

The main aim of this study was to compare the perceived gendered and spatial versus observed evidence of rainfall variability in the area of study. It was evident from the study results that rainfall and temperature had repeatedly fluctuated over the period of study (1986-2015). These variation were perceived similarly by both male and female respondents who reported that the rainfall varied as follows; amounts had reduced, kept fluctuating over time, were unpredictable, had delayed onsets and earlier offsets. These responses corroborated with the analysis results of recorded actual rainfall amounts. However rainfall variability was perceived differently in different livelihood zones. The variations repeatedly led to unprecedented severe conditions that included shortage of rainfall and prolonged droughts. Agricultural livelihoods were therefore affected differently depending on level of exposure and adaptive capacity and sensitivity. This helped to shape the perceptions of people about rainfall variability. There is therefore need for innovative methods to disseminate climate information, extension and advisory services targeting both men and women based on access. The climate information should be tailored to the need of different users and decision makers. The study recommends increased use of vernacular/local radio stations and mobile phone-enabled information delivery technology. Mobile phone-enabled information delivery has been recognised to have the potential of reducing information gap across gender and addressing resource constraint for women while increasing decision making capacity (Mittal, 2016; Huyer, 2016). There is need for collaboration between meteorology department and various extension agents to transform weather information to actionable agro-advisories for farmers. This should also be accompanied by increased provision of accurate weather and adaptation information to both men and women.

References

Ahmed, S., Stepp, J., Orians, C., Griffin, T., Matyas, C., Robbat, A., Cash, S., Xue, D., Long, C., Unachukwu *et al*. (2014). Effects of extreme climate events on tea (Camellia sinensis) functional quality validate indigenous farmer knowledge and sensory preferences in tropical China. *PLoS ONE* 2014 (9), 109–126.

Akinsanola, A., & Ogunjobi, K. (2014). Analysis of rainfall and temperature variability over Nigeria. *Global journal of human-social science: B Geography, geo-sciences, environmental disaster management,* 14(3), 1-18.

Araya, A., & Stroosnijder, L. (2011). Assessing drought risk and irrigation needs in Northern Ethiopia. *Agricultural Water Management,* 151, 425–436

Babugura, A. (2010). Gender and climate change: South Africa case study. Cape Town: Heirich Boll Foundation.

Banda, K. (2005). Climate change, gender and livelihoods in Limpopo Province. NOVAFRICA.

Bartels, W., Furman, A., Diehl, D., Royce, F., Dourte, D., Ortiz, B., Zierden, D., Irani, T.A., Fraisse, C., Jones, W. (2013). Warming up to climate change: A participatory approach to engaging with agricultural stakeholders in the Southeast US. *Regional Environmental Change,* **2013** (13), S45–S55.

Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M., Silvestri, S. (2013). Can agriculture support climate change adaptation, green house gas mitigation and rural livelihoods? Insights from Kenya. *Journal of climate change,*118 (2013), 151-165.

Burns, B. and Patouris, J. (2014). United Nations Framework Convention on Climate Change (UNFCCC) decisions and conclusions: Existing mandates and entry points for gender equality. New York: WEDO.

Chipanshi, A., Chanda, R., & Totolo, O. (2003). Vulnerability assessment of maize and sorghum crops to climate change in Botswana. *Journal of climate change 61 (3), 339-360.*

Clewett, J. F., Cliffe, N., Drosdowsky, L., George, D., O'Sullivan, D., Paull, C., *et al*. (2000). Building knowledge and skills to use seasonal climate forecasts in property management planning. In G. L. Hammer, N. Nicholls, C. Mitchell (Eds.), *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems: The Australian Experience* (pp. 291-307). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Denton, F. (2002). Climate change vulnerability, impacts, and adaptation: Why does gender matter? *Gender and Development,* 10 (2), 10 – 20.

Food and Agricultural Organisation (FAO). (2014). Seed security assessment in the South-Eastern Livelihood zones in Kenya.

Grimberg, I., Ahmed, S., Ellis, C., Miller, Z., & Menalled, F. (2018). Climate change perceptions and observations of agricultural stakeholders in Nothern Great Plains. *Sustainability,* 2018(10), 1687-1704

Habtezion, S. (2012). Gender and adaptation. New York: UNDP.

Hansen, J., Sabine, M., & Weber, E. (2004). The role of climate perceptions, expectations and forecasts in farmer decision making: The Argentine Pampas and South Florida. New York: International Research Institute for climate prediction (IRI).

Herrero, M., Ringler, C., Van de Steeg, J., Thornton, P., Zhu, T., Bryan, E., Omolo, A., Koo, J., Notenbaert, A. (2010). Climate variability and climate change and their impacts on Kenya's agriculture sector. International Livestock Research Institute (ILRI), Nairobi

Howe, P., Mildenberger, M., Marlon, J., Leiserowitz, A. (2015). Geographic variation in opinions on climate change at state and local scales in the USA. *Natural Climate Change,* **2015**(5), 596–603.

Huyer, S. (2016). An analysis of progress in gender equality at COP21, (February), 1–4.

Huyer, S. (2016). Closing the gender gap in agriculture. *Journal of gender, technology and development,* 20(2), 105-116.

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M.,Tapio-Bistrom, M., Nelson, S., & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development, 8*(2), 1–12.

Kaijser, A. & Kronsell, A. (2013). Climate change through the lens of intersectionality. *Journal of environmental politics,* 23 (3), 417-433.

Kisaka, O., Mucheru-Muna, M., Ngetich, F., Mugwe, J., Mugendi, D., & Mairura, F. (2015). Seasonal rainfall variability and drought characterization: Case of Eastern arid region: in Filho, W., Esilaba, A., Karunturi, P., & Gummodi, S. (eds). Adapting African agriculture to climate change: transforming rural livelihoods. Switzerland: Springer International Publishing.

Kristjanson, P., Mango, N., Krishna, A., Radeny, M., Johnson, N. (2009). Understanding poverty dynamics in Kenya. *Journal of international development*, 22(7), 978-996.

Maddison, D. (2007) The Perception of and Adaptation to Climate Change in Africa. Washington, DC: World Bank.

Marion, S., Duru, M., and Martin-Clouaire, R. (2013). Use of productivity-defined indicators to assess exposure of grassland-based livestock systems to climate change and variability. *Journal of crop and pasture sciences, 2013(64), 641-651.*

Mersha, A . & Van Haerhoven, F. (2016). A gender approach to understanding the differentiated impact of barriers to adaptation: Response to climate change in rural Ethiopia. *Journal of regional environmental change,* 16 (2016), 1701-1713.

Mikalitsa. S. (2015). Intrahousehold allocation, household headship and nutrition of under-fives. *Journal of food* *agriculture, nutrition and development, 15(1), 9708-9721.*

Mittal, S. (2016). Role of mobile phone enabled climate information services in gender-inclusive agriculture. *Journal of gender, technology and development,* 20(2), 200-217.

Moron, V., Boyard, J., Camberlin, P., Hernadez, V., Leclerc, C., Mwongera, C., Phillippon, N., Riglos, F., and Sultan, B. (2015). Ethnographic context and spatial coherence of climate indicators for farming communities: a multi-regional comparative assessment. *Journal of climate risk management, 8(2015), 28-46.*

Mugenda, A. (2011). Social science research: theories and principles. Nairobi: Acts publishers.

Mutai, C., Ochola, S., Mukiira, H., Gachimbi, N., Otieno, M., King'uyu, S., and Marigi, S. (2010). Climate Change and Variability. State of the Environment in Kenya Report. Nairobi: Ministry of Environment and Natural Resources.

Ngigi, M., Mueller, U., & Birner, R. (2017). Gender differences in climate change adaptation strategies and participation in group-based approaches: An intra-household analysis from rural Kenya. *Journal of ecological economics,* 138 (2017), 99-108.

Niles, T., and Mueller. N. (2016). Farmers perception and climate change: Associations with observed temperature and precipitation trends, irrigation and climate beliefs. *Journal of global environmental change,* 39 (2016), 133-142.

Nyoro, J., Wanzala, M., Awour, T. (2001). Increasing Kenya's agricultural competitiveness: farm level issues. Tegemeo Institute of Agricultural Policy and Development and Kenya Agricultural Research Institute, Nairobi, and Michigan State University, East Lansing

Odhiambo, W., Nyangito, H., Nzuma, J. (2004). Sources and determinants of agricultural growth and productivity in Kenya. Discussion Paper No. 34. Kenya Institute for Public Policy Research and Analysis, Nairobi

Okereke, C. and Schroeder, H. (2009). How can justice, development and climate change mitigation be reconciled for developing countries in a post-Kyoto settlement?, *Climate and Development,* 1 (1), 10–15.

Rodenberg, B. (2009). Climate Change Adaptation from a Gender Perspective. Bonn: German Development Institute.

Simelton, E., Quinn, C., Batisani, N., Dougill, A., Dyer, J., Fraser, E., Mkambisi, D., Sallu, S. and Stringer, L. (2013). Is rainfall really changing? Farmers perception, meteorological data, and policy implications. *Climate and development.* Taylor and Francis: London.

Swai, O., Mbwambo, J. and Magayane, F. (2012). Gender and perception on climate change in Bahi and Kondoa Districts, Dodoma Region, Tanzania. *Journal of African Studies and Development,* 4 (9), 218–231.

United Nations Development Programme (UNDP). (2009). Resource guide on gender and climate change. Mexico: (UNDP).

United Nations Environmental Programme (UNEP). (2009). Kenya: Atlas of Our Changing Environment. Division of Early Warning and Assessment (DEWA). Nairobi: United Nations Environment Programme (UNEP).

Weber, E. (2010). What shapes perceptions of climate change? *WIREs climate change,* 2010(1), 332-342

Women's Environment and Development Organization (WEDO). (2003). Common Ground, Women's Access to Natural Resources and the United Nations Millennium Development Goals. New York: WEDO.