

ENVIRONMENTAL MANAGEMENT & CONSERVATION | RESEARCH ARTICLE

Local communities' perceptions of climate variability in the Mt. Elgon region, eastern Uganda

Allan Bomuhangi, Gorette Nabanoga, Justine Jumba Namaalwa, Michael Gregory Jacobson and Banana Abwoli

Cogent Environmental Science (2016), 2: 1168276



Received: 20 October 2015
 Accepted: 16 March 2016
 First Published: 23 March 2016

*Corresponding author: Allan Bomuhangi, School of Forestry, Environment and Geographical Sciences, College of Agricultural and Environmental Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda
 E-mails: bomuhangi@caes.mak.ac.ug, abomuhangi@gmail.com

Reviewing editor:
 Serge Wich, Liverpool John Moores University, UK

Additional information is available at the end of the article

ENVIRONMENTAL MANAGEMENT & CONSERVATION | RESEARCH ARTICLE

Local communities' perceptions of climate variability in the Mt. Elgon region, eastern Uganda

Allan Bomuhangi^{1*}, Gorette Nabanoga², Justine Jumba Namaalwa¹, Michael Gregory Jacobson³ and Banana Abwoli¹

Abstract: In order to develop climate adaptation strategies that address location and context-specific vulnerabilities, there is need to understand how communities perceive the variability in their climate as perception of climate variability is a critical component within which climate adaptation should operate. This paper examines communities' perceptions about climate variability in relation to available meteorological data in the Mt. Elgon region. The study demonstrates that community perceptions of temperature and precipitation trends as indicators of climate variability are in agreement with meteorologically observed trends. It also reveals that local communities' perceptions of climate variability may also provide more localized contexts of climate variability which be insufficiently captured by meteorological data in communities where capture of meteorological data is not fully developed.

Subjects: Earth Sciences; Environment & Agriculture; Environmental Studies & Management

Keywords: climate variability; community perception; Mt. Elgon

1. Introduction

Adaptation to climate change is a local process (Locatelli et al., 2008) that is rooted, according to Neil Adger (1999), in the socialization, learning and understanding of climate risk. Studies on climate change risks (e.g. Kloprogge & Sluijs, 2006) have pointed out that community involvement in the identification, planning and management process is vital to the establishment of resilient communities. Lorenzoni and Pidgeon (2006) and Fernandez-Gimenez (2000) argue that community knowledge, perceptions and impacts of climate change are critical components within which climate change adaptation and mitigation should operate. This is important because a person's response to change can be strongly influenced by their knowledge and perception (Ferguson & Bargh, 2004)

ABOUT THE AUTHOR

Bomuhangi's major research interest is gender and natural resources management. He performs research on (1) Gender and climate change adaptation (2) Gender, property rights and land ownership in Uganda. This work contributes to a broader project on adaptation of people to climate change in East Africa: Ecosystems services, Risk reduction and Human well-being whose principal goal is to contribute to the development of national policies and local practices for adaptation to climate change in rural East Africa.

PUBLIC INTEREST STATEMENT

In this paper, we report the communities' perceptions about climate variability in the Mt. Elgon region. Our research demonstrates that local communities are aware of their climate and have clear opinions about changes in temperature and rainfall as indicators of climate variability which compares well with scientific data. Therefore, documenting their viewpoints can be used as an important source of supplementary climate information in developing appropriate adaptation strategies since they reflect concerns at the local scales.



Allan Bomuhangi

suggesting that, if a person has weak knowledge of an issue such as climate change, this individual may behave in a manner that exacerbates climate change. Knowing communities' perceptions has thus become a prerequisite and primordial task in climate change and disaster management (Mertz, Mbow, Reenberg, & Diouf, 2009).

Despite the existence of a rich knowledge and institutional base at community level (Berkes, Colding, & Folke, 2000; Berkes, Folke, & Gadgil, 1995) on which risk identification, management and resilience enhancement approaches can build on, a lot of work on climate change event identification continues to focus on global and national climate change simulations (e.g. Bernstein et al., 2007; Dinar, Hassan, Mendelsohn, & Benhin, 2012). Byg and Salick (2009) argue that it is erroneous to understand social ecological issues based on science alone. Less has been explored on the understanding of climate change from a community-based perspective (Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Gbetibouo, 2009). Local perceptions of climate change reflect concerns at the local scale which are dependent on factors that cannot be estimated through models derived from meteorological observations (Berkes, Mathias, Kislalioglu, & Fast, 2001).

Uganda is highly vulnerable to rainfall variability and climatic shocks like droughts and floods (MWE, 2002, 2010) and in particular the Mt. Elgon region (Mbogga, 2012). During the period 2001–2011, temperature increased by 1°C and there is evidence in the region for larger variations in temperature and rainfall in future. Climate projections based on two emission scenarios (A1b and A2) from at least five General Circulation Models indicate an increase in temperature for the next 30 years and more rainfall in the 2010–2039 periods (Eike, Roeland, Swen, Sang, & Musau, 2014; Mbogga, 2012; MWE, 2013). Micro-level studies on how rural communities perceive these changes are limited. Most studies assessing the potential effects of climate change in Africa are at regional or national scales, yet adaptation is locality/place-based and needs the use of locality specific knowledge for adaptation strategies (Deressa, Hassan, & Ringler, 2011; Kurukulasuriya & Mendelsohn, 2008; Lobell et al., 2008; Seo, Mendelsohn, Dinar, Hassan, & Kurukulasuriya, 2009). The coping capacity and adaptation strategies of the farmers depend to a very large extent on their perception about climate change. This study therefore presents the local communities' perspectives of climate change in the Mt. Elgon region and compares it to actual meteorological data. In this paper, “community perceptions” refers to the way local people identify and interpret observations and concepts (Byg & Salick, 2009). Much as climate change may bring conditions beyond previous experience, local knowledge and perceptions remain the foundation for any local response (Boissière, Locatelli, Sheil, Padmanaba, & Sadjudin, 2013). To understand how communities perceived the changes in their climate over time, perceptions were sought from the elders, adult men and women, as well as the youth.

The study objectives were;

- (1) Investigate the gender differentiated communities' perceptions of climate variability in Manafwa and Kapchorwa districts.
- (2) Compare the local communities' perceptions of climate variability with meteorological data trends.

2. Materials and methods

2.1. Description of study sites

The Mt. Elgon region in eastern Uganda is made up of eight districts divided up into two subregions (Mbale and Kapchorwa subregions). Manafwa (latitude 1°88'N, 33°33'N and longitude 34° 33'E, 33°33'E) and Kapchorwa (latitude 1°7'N, 1°36'N and longitude 34°18'E, 34°48'E) districts were purposively selected from the two subregions due to their fragility and sensitivity to climate change (Mbogga, 2012; MWE, 2013; Twinomugisha, 2005). The mid- to high-elevation areas have had landslides, siltation of rivers as well as washing away of top soil, which depletes soil nutrients hence

affecting agricultural yields (Mbogga, 2012). These districts are characterized by a mountainous terrain and their climate is affected by altitude (NEMA, 2008). The rainfall pattern is bimodal, with two rain seasons (Mbogga, 2012). The annual rainfall in the Mt. Elgon region ranges between 920 and 1,650 mm with peaks occurring in May and July and marked minimum in June (NEMA, 2008). Subsistence agriculture and livestock farming are the major occupations (MFEP, 2014).

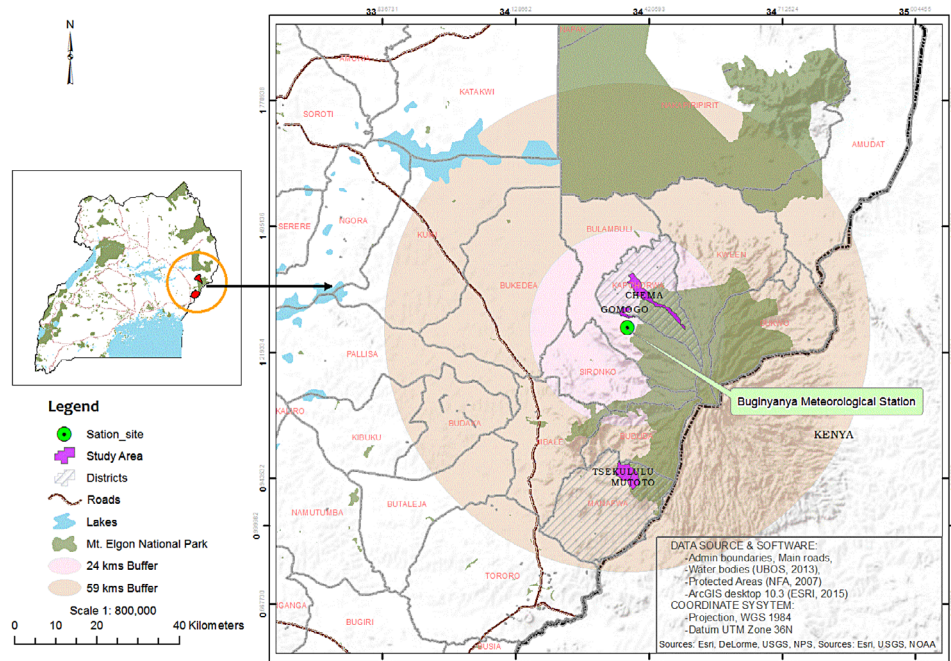
The study was conducted in two sub-counties selected from each district due to their acute vulnerability to changes in climate (Figure 1). From each sub-county, one parish was selected. Therefore, a total of four sub-counties and four parishes were covered. Tsekululu (Bunasambi parish) and Mukoto (Maalo parish) sub-counties were selected for Manafwa and Chema (Chemangang parish) and Gamogo (Kapnarwaba parish) sub-counties for Kapchorwa. While all the four selected parishes were situated along the slopes of the Mt. Elgon, Chemangang had the highest elevation while the other three (Maalo, Kapnarwaba and Bunasambi) were mid-slope communities.

2.2. Methods

Rapid rural appraisal methods were used to elicit information on patterns of climate variability and its associated events from different segments of the community. Data were collected in two phases:

In the first phase, four community-level sessions comprising of men, women, youth and elders were conducted at parish level: i.e. one community-level session comprising an average of 21 people per session per parish. A PRA protocol designed based on literature and expert consultations was used to elicit the communities' perceptions of climate variability. Data were collected on perceptions of variability in precipitation and temperature as indicators of climate variability. Several aspects were investigated including variability in daily/seasonal temperatures/precipitation, variability in duration of hot and cold periods as well as variability in amounts, duration and timing of the rains. In addition to the perceived variability in precipitation and temperature, the occurrence of different climate variability events was also investigated. Data collected at this phase revealed that the perceptions of climate variability were different among the men, women, adult and youth. There were also contradictions on the perceived years of climate variability events across the communities, in that while some communities reported only current events, others reported events that dated many

Figure 1. Map of the Mt. Elgon region showing the study sites and the location of Buginyanya meteorological station.



years back. In order to validate this, the four parishes were revisited for clarification. The period 1993–2013 was considered as base period since the community members could recall back the climate variability events with certainty to 1993.

In the second phase, one focus group discussion disaggregated age in each parish: Youth (15–29 years), Adult (equal or greater than 30 years) was held in each of the parishes of Maalo, Kapnarwaba and Chemangang while two FGD sessions disaggregated by age were held in Bunasambi parish at two different locations. This was because of the differences in population density, in that while the other three parishes were composed of 5–7 villages, Bunasambi had a total of 11 villages. We worked with a total of 10 focus groups. The FGD sessions had an average of 12 persons each, comprising of both men and women. The selection of the focus group participants was based on random sampling using a list of all households in the village. Effort was made to ensure that no household participated in more than one focus group. A PRA protocol was used to collect capture the community perceptions. While the focus group discussions were not disaggregated by sex, efforts were made to collect gendered data from these groups on the nature, intensity and timing of the variability in temperature and precipitation.

In order to understand the existence of variations between local-level perceptions and meteorological data often considered for national-level planning with regards to climate variability adaptation strategies, meteorological data on temperature and precipitation for the Mt. Elgon region were obtained from Buginyanya meteorological station for the period extending from 1993 to 2013. Buginyanya weather station (latitude 1°12'N, 48°0'N and longitude 34°23'E, 35°0'E) is the main meteorological station for the region and is approximately 21Km and 46Km straight line distance from Kapchorwa and Manafwa districts headquarters, respectively. To further verify, existence of variation between local-level perceptions and meteorological data for climate variability events observed in the region, data from the international disaster database (EMDATA) were analysed with specific focus on meteorological, hydrological and climatological events classifications.

2.3. Analysis

Qualitative data from the community level sessions and FGDs were transcribing and entered in into Nvivo 10 for data management (Bazeley & Jackson, 2013). Inductive thematic analysis was employed to identify themes (i.e. indicators of climate variability, variability in daily/seasonal temperatures/precipitation and occurrence of different climate variability events) that emerged from the transcribed data (Braun & Clarke, 2006). A hierarchal coding scheme was developed to reflect the key research questions (i.e. what are the indicators of climate variability? Has climate variability increased or decreased) which were further shaped by themes that emerged from the data. A range of advanced coding queries were used to analyse patterns in the data in order to interpret communities' underlying ideas about perceptions on climate variability.

In order to understand the variability in the meteorological data, trend analysis was done to reveal the general movement of the rainfall and temperature pattern. Regression analysis was done to determine the magnitude, direction and significance of the trends in annual and seasonal rainfall and in annual minimum and maximum temperature. The regression equation was defined as: $Y_i = \beta_0 + \beta_1 X_i + \epsilon$. Where Y = total annual rainfall/mean annual minimum and maximum temperature, and X = time measure in years. It was hypothesized that there is no trend in the amount of rainfall and temperature over time.

Community perspectives of climate change were qualitatively corroborated with the metrological data for the same time extending from 1993 to 2013. This comparison was important because almost all the national-level adaptation strategies are designed and planned basing on the observations of the meteorological stations, without due consideration of the localized perceptions.

3. Results

3.1. Communities' perceptions about climate variability

The communities' perceptions about climate variability were investigated by initially identifying the key variables of climate which included rainfall/precipitation and sunshine/temperature. Later, the community members did a trend analysis of the variability in rainfall/precipitation and temperature from 1993 up to 2013 as well as mapped the climatic shock/events associated with the climate variability for the same time period. A number of respondents in the communities noted a divergence of opinion regarding the existence of climate variability. The younger community members (15–29 years) tended to be more in acceptance of the phenomena of variability in temperature and rainfall because they were more likely to be knowledgeable about climate variability through academic programmes, media programmes and engagement in community training sessions on climate variability and adaptation. Whereas older members of the community (above 30 years) were more likely to be sceptical given their experience with managing natural variability in rainfall over many years. Similarly, like the younger members of the community, the women also easily accepted that there was variability in climate as opposed to their male counterparts and attributed this to their close interaction with farm activities. However, despite the divergence in opinion on the degree of variability between men and women, both men and women in the study communities had similar or identical perceptions of temperature and rainfall trends over time. The following general trends were observed in regard to precipitation and temperature variations across the communities.

3.1.1. Precipitation

The communities in Kapchorwa and Manafwa study sites reported an increase in precipitation of 90 and 75%, respectively. It was also observed that there was variability in the on-set/offset of the rains with 75% of the groups in Manafwa and 67% of the groups in Kapchorwa reporting that rains come later in the season (Table 1). About three-quarters of the groups in both districts reported shorter rainfall periods but with heavier precipitation. Only 25% (Manafwa) and 40% (Kapchorwa) reported decreased rainfall amounts.

About one-third of groups in both districts reported that the rains were more erratic (Table 1) and that the traditional wet seasons have been changing over the years (1993–2013) and were no longer consistent and reliable. Normal rains would be low in December to February when the community

Table 1. Community perception of variability in precipitation in the Manafwa and Kapchorwa study sites

| District | Perception of variability in precipitation | Percentage of groups (%) |
|-----------|--|--------------------------|
| Manafwa | Rains are more erratic | 38 |
| | Rains come earlier | 0 |
| | Rains come later | 75 |
| | Longer periods of rainfall | 0 |
| | Shorter periods of rainfall | 87 |
| | Rainfall amounts increasing | 75 |
| | Rainfall amounts decreasing | 25 |
| | Kapchorwa | Rains are more erratic |
| Kapchorwa | Rains come earlier | 0 |
| | Rains come later | 67 |
| | Longer periods of rainfall | 17 |
| | Shorter periods of rainfall | 66 |
| | Rainfall amounts increasing | 90 |
| | Rainfall amounts decreasing | 40 |

Source: Focus group discussion.

prepared their gardens ready to plant in March. High rains would then set-in in late March and April and slowdown in May, then slowdown even more in June and July until the onset of the mid/late August heavy rains which gradually reduced until December. However, due to climate variability, it was presorted that the first dry months of the years prolonged to March with high rains setting in April and May and then disappearing in June and July while the August to December rains have become shorter. While, noting variability in the rainfall timing and shorter rains (Table 1), 79% of the study groups (11 of the 14 groups) agreed that the rainfall amounts had increased.

Qualitative analysis revealed that men and women’s perception about the changes in precipitation as an indicator of climate variability were identical. Men and women noted at the community level that in the past, precipitation distribution over the seasons was normal and they could manage to plan their agricultural activities properly and effectively, knowing when to expect significant dry and wet spells. Both men and women lamented the increasing unpredictability of precipitation and claimed that there were experiencing increasing spatial precipitation variations. However, women in comparison to men could easily recall with certainty the dates for the onset or off set of rains as opposed to the men and attributed this to their traditional role of ensuring food availability in the household which made them keener on hindrances to achieving this goal. Across generations, both the elderly and the youth un unanimously agreed that the annual precipitation had been variable with some traditional wet seasons registering little or no rain at the time it was required for farming.

3.1.2. Temperature

Overall, 50 and 62% of the groups in the Kapchorwa and Manafwa study sites, respectively, reported an increase in daily/seasonal temperature. None of the groups reported decreased daily/seasonal temperature (Table 2). Similarly, 63 and 66% of the groups in Manafwa and Kapchorwa districts reported an increase in the number of hot days in a month over the 1993–2013 period. Only 15% of the groups in Kapchorwa reported more colder days in the month. In general, 64% of the study groups (8 of the 14 groups) perceived daily/seasonal temperatures to have increased over the 1993–2013 period.

Qualitative analysis revealed that men and women’s perception about the variability in temperature as an indicator of climate variability at community level were identical and generally agreed that both the daily and seasonal temperatures in the study area had increased. However, we observed that there were relatively more women who believed that temperature was increasing than men who had the same perception. Men related increase in temperature to drying of pastures and water sources sooner than later and hence were forced to move longer distances in search of better pastures and water while women related increase in temperatures to increased incidences of crop failure as well as increased incidences of diseases which were associated with new vectors such as mosquitoes. Both men and women claimed that the temperature had been increasing because of

Table 2. Community perception of variability in temperature in the Manafwa and Kapchorwa study sites

| District | Perception of variability in temperature | Percentage of groups (%) |
|-----------|--|--------------------------|
| Manafwa | More hot days in a month | 63 |
| | More cold days in a month | 0 |
| | Increased daily/seasonal temperature | 62 |
| | Decreased daily/seasonal temperature | 0 |
| Kapchorwa | More hot days in a month | 66 |
| | More cold days in a month | 17 |
| | Increased daily/seasonal temperature | 50 |
| | Decreased daily/seasonal temperature | 0 |

Source: Focus group discussion.

changing precipitation patterns, the increased frequency of droughts and increased length of the dry periods. Similarly, across generations both the elderly and youth noted that the temperatures were on the increase.

3.1.3. Climate variability events

Drought and heavy and erratic rains were the most commonly perceived extreme climate variability events with the highest magnitudes in the study districts. Communities in both districts opined that the frequency and severity of the droughts was increasing. Prolonged drought incidents were reported to have occurred during the 1995–1997 periods in Chemangang and 2001, 2002, 2006 in both Chemangang and Kapnarwaba parishes (Kapchorwa district). These communities reported that the 1995 drought was the most severe in terms of extent and duration (Table 3). In Maalo and Bunasambi (Manafwa district), droughts extended from 2001, 2002, 2003, 2008 and 2009 with the 2002 drought considered the most severe.

Perceptions of about erratic and heavy rains were common as compared to floods, strong winds, hailstorms and thunderstorms. Major incidents of erratic and heavy rains were reported to have occurred in 2000, 2005 and 2007 with 2007 rains considered the heaviest and most destructive. While thunderstorms and strong winds were reported in Kapchorwa study sites, they were not reported in Manafwa district. Unlike in Kapnarwaba parish where no clear explanation was given for incidence of strong winds, in Chemangang, the incidence of winds was attributed to a high level of altitude. In all the study sites, hailstorms were frequently experienced throughout the rain seasons. However, the severity of the hailstorms varied from year to year with the Kapchorwa sites reporting severe incidents in 2004, 2007, 2008 and 2012 while in the Manafwa sites, severe incidents were reported in 2005 and 2007 and these were attributed to heavy precipitation.

Table 3. Perceived climate variability events in the study sites

| Year | Climate variability event | | | | | |
|------|---------------------------|------------|---------|--------------|---------------|-------------------|
| | Heavy and erratic rains | Hailstorms | Drought | Strong winds | Thunderstorms | Floods/ Mudslides |
| 1995 | | | C | | | |
| 1996 | | | C | | | |
| 1997 | M | | C | | | CK |
| 1998 | K | | | | | |
| 2000 | BMC | | | | | CB |
| 2001 | | | KMC | | | |
| 2002 | | | CKMB | | | |
| 2003 | KBM | | B | | | |
| 2004 | CK | K | | | | |
| 2005 | MBK | M | | | | |
| 2006 | | | CK | | | |
| 2007 | CB | CB | | | | MB |
| 2008 | | C | KM | | C | |
| 2009 | | | B | C | | |
| 2010 | MB | | | | | |
| 2011 | KMB | | | C | C | KMB |
| 2012 | CKM | C | | | | |
| 2013 | M | | | | | |

Notes: Manafwa District: C = Chemangang parish and K = Kapnarwaba Parish. Kapchorwa District: M = Maalo Parish and B = Bunasambi Parish.

Source: Focus group discussion.

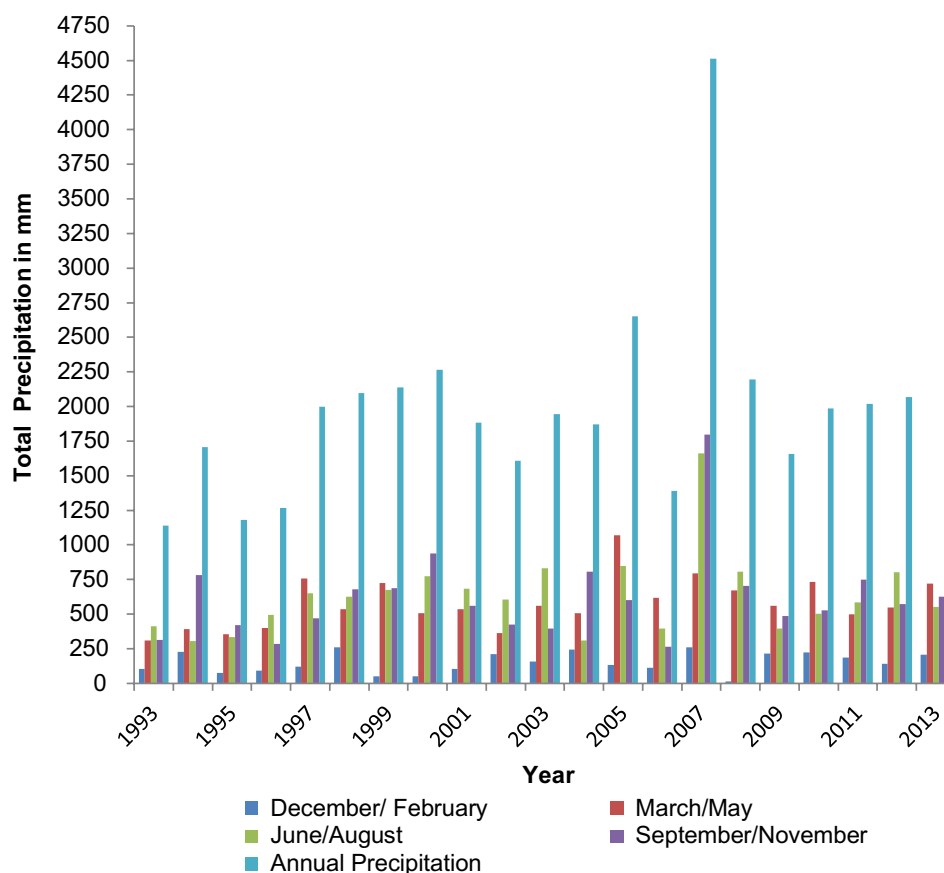
Qualitative analysis revealed that men, women and youth unanimously agreed that climate variability extreme events were on the increase and attributed these to changes in the precipitation and temperature trends. However, while all the men, women and youth reported similar events, there were differences in emphasis of the frequency and severity of the extreme events across the parishes. Men more often highlighted frequent and severe droughts whereas women more often referred to extended and erratic rains. Additionally, women in comparison to men easily recalled the climate variability events that occurred in the communities with much certainty on the periods of occurrence. Across generations (below 30 and above 30 years), the principal difference was that for older people, prolonged rains were of major concern, whereas younger people put more emphasis on extended dry seasons. However, in some communities such as Bunasambi, there were instances where there was no clear specific gender differences in the events recorded.

3.2. Meteorological data

3.2.1. Precipitation

Precipitation data were computed to obtain total annual rainfall variations for the period 1993–2003. It was observed that the annual precipitation in the Mt. Elgon region varied from 1,139.2 to 2,106.5 mm, with the highest and lowest values recorded in 2007 (4,514 mm) and 1993(1,139.2 mm), respectively (Figure 2). The four seasons recognized by communities were used to compute seasonal precipitation. That is, first season stretching from December to February, second season from March to May, third season from June to August and fourth season from September to November. Results revealed a variation in amount of annual seasonal precipitation received with some years (e.g.1993, 1995, 1996, 2004, 2006 and 2009) noticeably receiving lower than normal precipitation¹ and other years higher than normal precipitation (e.g. 1998, 1999, 2000, 2007, 2008, 2011, 2012 and 2013)². When the annual and seasonal precipitation totals were linearly regressed against time, the results

Figure 2. Trend of seasonal and annual precipitation in mm for the Mt. Elgon region.



showed statistically significant increasing trends ($p < 0.05$) in seasonal precipitation and no statistically significant variations in annual precipitation totals ($p > 0.05$) (Figure 2). The coefficients of variation for annual and seasonal precipitation were positive, indicating a general annual increment in the amount of precipitation received in the region. However, the annual increment in precipitation (9 mm) was less than seasonal variations that extended from 151 to 479 mm (Table 4). The low coefficient of variation for annual precipitation could be used to explain why annual precipitation was not significantly different during the 1993–2013 period.

3.2.2. Temperature

Considering the annual maximum temperature, the highest (30.5°C) and lowest (29.2°C) values were recorded in 2005 and 2012, respectively, while for the annual minimum temperature, the lowest (15.9°C) and highest (17.9°C) values were recorded in 2001 and 2005, respectively (Table 5). Data

Table 4. Linear regression analysis for precipitation over time

| Total precipitation | Coef. | Stand Err | t-stat | p-value |
|-------------------------------|--------|-----------|--------|------------|
| Annual | 9.509 | 7.02 | 1.353 | 0.192 |
| December–February (season 1) | 151.47 | 52.29 | 2.897 | 0.00486* |
| March–May (season 2) | 427.45 | 73.94 | 5.781 | 1.38e-07** |
| June–August (season 3) | 479.85 | 73.94 | 6.489 | 6.67e-07** |
| September–November (season 4) | 471.78 | 73.94 | 6.380 | 1.07e-08** |

*Significance level at $p < 0.01$.

**Significance level at $p < 0.001$.

Source: Meteorological data.

Table 5. Trend of annual temperature in (°C) for the Mt. Elgon region

| Year | Mean annual maximum (°C) | Mean annual minimum (°C) | Mean annual (°C) |
|------|--------------------------|--------------------------|------------------|
| 1993 | 30.33 | 17.08 | 23.70 |
| 1994 | 29.24 | 16.80 | 23.02 |
| 1995 | 29.86 | 17.05 | 23.45 |
| 1996 | 29.49 | 16.97 | 23.23 |
| 1997 | 29.28 | 16.76 | 23.02 |
| 1998 | 29.07 | 16.63 | 22.85 |
| 1999 | 29.97 | 17.38 | 23.68 |
| 2000 | 29.38 | 17.02 | 23.20 |
| 2001 | 29.74 | 15.98 | 22.86 |
| 2002 | 29.94 | 16.88 | 23.41 |
| 2003 | 29.92 | 16.80 | 23.36 |
| 2004 | 29.98 | 16.74 | 23.36 |
| 2005 | 30.51 | 17.98 | 24.25 |
| 2006 | 29.65 | 17.74 | 23.70 |
| 2007 | 29.47 | 17.50 | 23.48 |
| 2008 | 29.68 | 16.98 | 23.33 |
| 2009 | 30.23 | 17.37 | 23.80 |
| 2010 | 29.69 | 16.89 | 23.29 |
| 2011 | 29.32 | 16.88 | 23.10 |
| 2012 | 29.20 | 16.94 | 23.07 |
| 2013 | 29.32 | 16.87 | 23.09 |

Source: Meteorological data.

Table 6. Linear regression analysis temperature over time

| Temperature | Coef. | Stand Err | t-stat | p-value |
|---------------------|-----------|-----------|--------|---------|
| Mean annual | 0.003201 | 0.01264 | 0.253 | 0.803 |
| Mean annual maximum | -0.005439 | 0.01521 | -0.372 | 0.714 |
| Mean annual minimum | 0.01184 | 0.01521 | 0.778 | 0.466 |

Source: Meteorological data.

also showed that the average mean annual temperature for the Mt. Elgon region was 23.34°C for the period 1993–2013. However, data showed that 2005 average annual temperature was the highest at 24.2°C over the 1993–2013 period (Table 5).

Although the descriptive statistics showed variation in the mean annual, mean annual maximum and minimum temperatures, when these were linearly regressed against time, the results showed no statistically significant variation trends ($p > 0.05$) (Table 6). Despite the fact that temperature variations were not significant, it was observed that the coefficient of variation for mean annual maximum temperature was negative. This implied that the mean annual maximum temperatures were decreasing although the change in temperature was not significant. The coefficient of variation for mean annual minimum was positive which signifies an increment in temperature thus warmer days.

3.3. Comparison between community perspectives and meteorological data

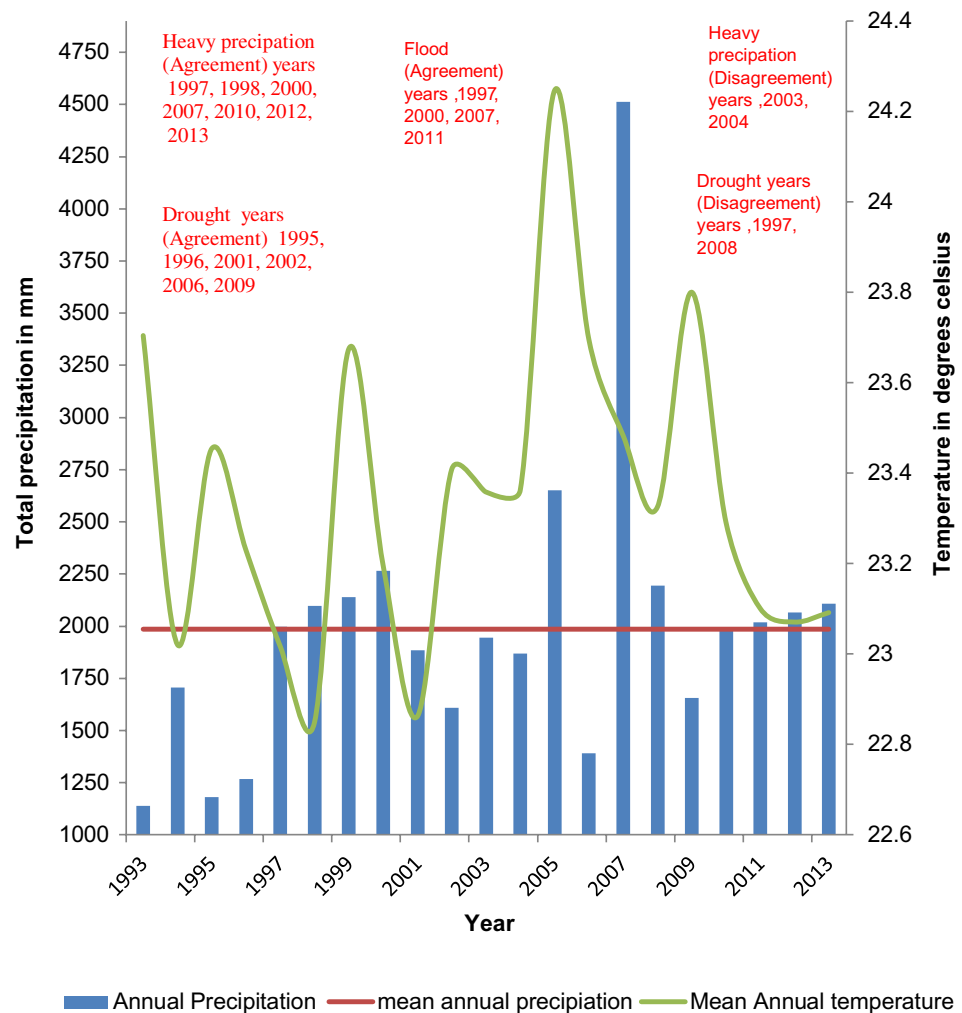
3.3.1. Variability in precipitation and temperature

The validity of the community perspectives of climate change was assessed by qualitatively comparing their perceptions of long-term changes (1993–2013) in temperature and precipitation with meteorological data for the same time period. Both community perspectives (79% of the groups) and meteorological data (9.5-mm coefficient of variation) indicate general increment in annual precipitation. However, while variations in annual precipitation for meteorological data were not significantly different for the 21-year period ($p > 0.05$), there were significant variations in seasonal precipitation ($p < 0.05$). This was in tandem with the community perspectives.

Community perspectives and meteorological data suggest that 1997, 1998, 2007, 2010, 2012 and 2013 were characterized by heavy precipitation³. However, while the community had also reported 2003 and 2004 as heavy precipitation years, meteorological data showed that these years received relatively low precipitation⁴ (Figure 3). However, further analysis of the seasonal precipitation distribution for the period 2003–2004 meteorological data; it was revealed that while total annual precipitation was generally low, the distribution of precipitation throughout the wet seasons was even. This may have influenced the communities' perception for increased precipitation for that period. Similarly, the fact that the previous year 2002 was characterized by very low precipitation (1,609 mm) could have influenced their thinking that the precipitation registered in 2003–2004 could have been high.

With regards to temperature variations, the community perspectives were similar to what was portrayed by the meteorological data. While about 57% of the study groups had reported increase in temperature, the meteorological data showed a positive coefficient of variation for mean annual and mean annual minimum temperatures which signified increment in temperature and consequently warmer days. However, on the whole, meteorological data showed that variation in mean annual temperature was not significant ($p > 0.05$).

Figure 3. Comparison between community perspectives and meteorological data.



3.3.2. Occurrence of climate variability events

Descriptive analysis revealed that the study region received a series of climate related events. Both community and meteorological data indicated that 1995, 1996, 2001, 2002, 2006 and 2009 were associated with drought⁵ (Figure 3). While, the International Emergency Disaster Database did not record these years as associated with drought (Table 7) possibly because their magnitude wasn't high enough to warrant their classification as disasters, meteorological data for these years showed that the mean annual precipitation for the 6 years was 1,498 mm which was far below the general mean annual precipitation for the 21-year period of 1,985 mm. Contrary to some community perspectives that reported 2005 to be characterized by drought, meteorological data showed that the year actually had higher than normal precipitation. Seasonal precipitation distribution revealed that the 2005 precipitation was unevenly distributed, in that while some months got exceptionally very low precipitation (24 mm) other months got exceptionally very high precipitation (508 mm). This uneven distribution could have influenced the community perspectives to thinking that the year was a drought year.

In addition to occurrence of drought which was depicted by the variations in precipitation data from the meteorology unit, the community also provided opinions about other climate variability events that were not captured in the meteorological data. Such climate change events included floods/mudslides, data on wind, recurrent hailstorms and thunderstorms. The community opined

Table 7. Climate variability events recorded for the period 1993–2013

| Year | | Description of climate event | District affected |
|-----------|----------------|------------------------------|----------------------------------|
| 1993–1996 | Nil | No event recorded | No event recorded |
| 1997 | Hydrological | Flood | Mbale, Kapchorwa region |
| 1997 | Hydrological | Mass movement/landslide | Mbale region |
| 1998 | Climatological | Drought | Across the country |
| 2002 | Hydrological | General flooding/mudslide | Mbale, Kapchorwa, Manafwa |
| 2003 | Hydrological | General flooding/mudslide | Mbale region |
| 2007 | Hydrological | General flooding | Across the country |
| 2008 | Climatological | Drought | Eastern Uganda |
| 2010 | Hydrological | Mass movement/landslide | Mbale region, Bududa |
| 2011 | Hydrological | General flooding/mudslide | Mbale region, Kapchorwa, Manafwa |

Source: EM-DAT (2014).

that 1997, 2000, 2007 and 2011 as characterized with floods/mudslides in conformity with the International Emergency Disaster Database (Table 7).

4. Discussion

One of the prerequisites to adapt to change is recognition that actually change is taking place. In the context of climate variability, communities must first perceive that changes are in fact taking place (Mubiru, Agona, & Komutunga, 2009). The study demonstrates that communities in the Mt. Elgon were aware of their climate and had clear opinions about changes in temperature and rainfall as indicators of climate variability. The perceptions of men, women and youth indicated similar or identical observations of temperature and precipitation trends over time. However, there were variations on the exact nature and magnitude of change in precipitation and temperature. Majority of the community members perceive that temperature and precipitation in the Mt. Elgon region is increasing over time. This finding is generally in line with the data gathered at the meteorological station. Mbogga (2012) provides similar evidence for climate variability in the Mt. Elgon region for the 1960–2010. While there has been an increase in both temperature and precipitation in the region, actual variations within the mean annual precipitation, mean annual maximum and minimum temperature for the 21-year period (1993–2013) were not significantly different. We argue therefore that, what is being experienced in the region are in-season variations in temperature and precipitation rather than annual variations thus implying that the climate in the region may not have changed but rather has become more variable.

The study also indicates that men, women and youth’s perceptions of climate variability may be linked with gender division of labour. We found that men and women related climate variability to the different roles they perform within the communities. In this regard, women’s traditional role of ensuring food security, made them keener on observing changes on the precipitation patterns as its availability of influenced when to start preparing for cropping or when to plant. This observation arguments Aaron (2010) who reports that women are modestly more concerned about climate variability issues than are men as they are greatly impact by it in bid to perform their roles. We argue therefore that because women are more engaged with farm activities in their quest to ensure household food security, they may be better climate variability detectors than men at farm level. Consequently, design of climate variability response interventions need to engage both men and women so as to get a holistic understanding of community perceptions.

Comparison of community perceptions and meteorological data revealed the communities’ perceptions of temperature and rainfall trends were generally in unison with meteorological data trends, however there were some variations especially with precipitation trends for the period 2003–2005. Two arguments could be presented to explain this variation. First, given the fact that the

communities perceived the previous two years (2001–2002) to be associated with drought, the perception for high precipitation in the period 2003–2004 could have been made in reference to the past drought years. Secondly, meteorological data also revealed strong seasonal variations for the period 2003–2004. While the first and third seasons were characterized by low precipitation; the second and fourth seasons which are the cropping seasons were characterized by even distribution of rainfall. Nyanga, Johnsen, and Aune (2011) reports that farming household's perceptions of climate variability are usually linked to the amount and distribution of precipitation during the cropping season which have direct impact on the growth and how the crops will do rather than the total amounts. We therefore argue that the distribution of precipitation during the cropping seasons in the period 2003–2004 could have influenced their perception for registering the respective years as heavily precipitated.

The year 2005 was perceived to have had low levels of precipitation probably because there was uneven distribution of rainfall within the seasons. The fourth season (September to November) which is usually the most precipitated and better season for crop production had low levels of precipitation. We therefore argue that the community's perceptions about the changes in precipitation are as a result of the seasonal variations rather than the total amount of precipitation received in a year. This argument further reinforces observations by Moyo et al. (2012) and Nyanga et al. (2011) who reported that farmers were more concerned about within season's precipitation variability than inter year variation. Also Yengoh, Armah, Onumah, and Odoi (2010) and Kemausuor, Dwamena, Bart-Plange, and Kyei-Baffour (2011) noted that precipitation variation within seasons influences farmers timing of agronomic practices such as when to start preparation of land for cultivation or when to plant. Any uneven distribution of precipitation distorts their agronomic calendar, consequently reorienting their perception on precipitation trend for the year. Given these observations, we therefore argue that instances where community perceptions differ from meteorological data, the opinions of the community should not always be taken as wrong but rather, effort should be made to understand the circumstance under which these perceptions are made as these could provide more contextualized data needed to inform the design adaptation programmes.

In concurrence with Ferrier and Haque (2003), the study showed that farmers remember the extremes in climate. Osbahr, Dorward, Stern, and Cooper (2011) opine that while community perceptions may be socially constructed, communities do have good memories of climatic events in their environment that relate to scientific data. The community perceptions on extreme events were generally in tandem with meteorological data. Similarly, our findings corroborate with Kansime (2012) and Mbogga (2012) who report that the Mt. Elgon region has experienced more frequent occurrences of climate-related extreme events in the last decade. While some of the extreme events were not registered by the International Emergency Disaster Database possibly because their magnitude wasn't high enough to be considered as disasters, we argue that there is need to pay attention to the local contexts under which these perceptions are made as these are not usually captured by meteorological data.

Based on the study findings we argue therefore that in understanding climate variability scenarios for communities, local communities' perceptions of climate variability could be good sources of complimentary climate variability information especially where climate information is incipient since they reflect concerns at local levels which may not be estimated through models derived from meteorological observations. Secondly, they provide additional climatic information needed by development agencies and practitioners in order to develop effective responses which are location specific, and yet contextualized to wider landscapes which is often lacking in areas where scientific climate data are underdeveloped.

5. Conclusions

The community perceptions of temperature and precipitation trends as indicators of climate variability were in agreement with meteorologically observed trends. However, there were also variations in perceptions across different segments of the community. Women were also observed to be better detectors of climate variability because of the strong interaction with farming activities. The study

also demonstrated that the local communities' perceptions of climate variability may also provide more localized contexts of climate variability which be insufficiently captured by meteorological data in communities where capture of meteorological data is not fully developed.

We recommend therefore that, in areas where meteorological data are still incipient, there is need for greater investment in education particularly of farmers in recording weather data, recording local agricultural performance and being able to detect trends as these could supplement the insufficient climatic information. Similarly, government efforts could be focused on improving outreach and science education in remote areas, particularly areas of high sensitivity like Mt. Elgon.

Funding

The authors received no direct funding for this research.

Cover image

Source: Authors.

Author details

Allan Bomuhangi¹

E-mails: bomuhangi@caes.mak.ac.ug, abomuhangi@gmail.com

Gorette Nabanoga²

E-mail: goret69@gmail.com

ORCID ID: <http://orcid.org/0000-0002-1243-2703>

Justine Jumba Namaalwa¹

E-mail: namaalwa.justine@gmail.com

Michael Gregory Jacobson³

E-mail: mj2@psu.edu

Banana Abwoli¹

E-mail: banana@forest.mak.ac.ug

¹ School of Forestry, Environment and Geographical Sciences, College of Agricultural and Environmental Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda.

² School of Agricultural Sciences, College of Agricultural and Environmental Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda.

³ Department of Ecosystem Science and Management, College of Agricultural Sciences, Pennsylvania State University, University Park, PA 16802, USA.

Citation information

Cite this article as: Local communities' perceptions of climate variability in the Mt. Elgon region, eastern Uganda, Allan Bomuhangi, Gorette Nabanoga, Justine Jumba Namaalwa, Michael Gregory Jacobson & Banana Abwoli, *Cogent Environmental Science* (2016), 2: 1168276.

Notes

1. Mean annual precipitation for the six years of 1,417 mm was below the mean annual precipitation for the 21-year period of 1,985 mm per annum.
2. Mean annual precipitation for the eight years of 2,451 mm per annum was above the mean annual precipitation for the 21-year period of 1,985 mm per annum.
3. Mean annual precipitation for the seven years of 2,415 mm per annum was above the mean annual precipitation of 1,985 mm for the 21-year period.
4. Mean annual precipitation for the two years was 1,907 mm which was below the mean annual precipitation of 1,985 mm for the 21-year period.
5. Mean annual precipitation for the six years of 1,498 mm was below the mean annual precipitation of 1,985 mm for the 21-year period.

References

Aaron, M. M. (2010). The effects of gender on climate change knowledge and concern in the American public. *Population and Environment*, 32, 66–87. doi:10.1007/s11111-010-0113-1

Bazeley, P., & Jackson, K. (Eds.). (2013). *Qualitative data analysis with NVivo*. Thousand Oaks, CA: Sage.

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, 10, 1251–1262. [http://dx.doi.org/10.1890/1051-0761\(2000\)010\[1251:ROTEKA\]2.0.CO;2](http://dx.doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2)

Berkes, F., Folke, C., & Gadgil, M. (1995). *Traditional ecological knowledge, biodiversity, resilience and sustainability* (pp. 281–299). Dordrecht: Springer Netherlands.

<http://dx.doi.org/10.1007/978-94-011-0277-3>

Berkes, F., Mathias, J., Kislalioglu, M., & Fast, H. (2001). The Canadian arctic and the oceans act: the development of participatory environmental research and management. *Ocean and Coastal Management*, 44, 451–469.

Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., Davidson, O., & Yohe, G. (2007). Climate change 2007: Synthesis report. In *Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change* (22 pp.). Geneva: IPCC.

Boissière, M., Locatelli, B., Sheil, D., Padmanaba, M., & Sadjudin, E. (2013). Local perceptions of climate variability and change in tropical forests of Papua, Indonesia. *Ecology and Society*, 18, 13. doi:10.5751/ES-05822-180413

Braun, V., & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77–101. ISSN 1478-0887. <http://dx.doi.org/10.1191/1478088706qp063oa>

Byg, A., & Salick, J. (2009). Local perspectives on a global phenomenon—Climate change in Eastern Tibetan villages. *Global Environmental Change*, 19, 156–166. <http://dx.doi.org/10.1016/j.gloenvcha.2009.01.010>

Deressa, T. T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science*, 149, 23–31. <http://dx.doi.org/10.1017/S0021859610000687>

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, 19, 248–255.

Dinar, A., Hassan, R., Mendelsohn, R., & Benhin, J. (2012). *Climate change and agriculture in Africa: Impact assessment and adaptation strategies*. London: Routledge.

Eike, L., Roeland, K., Swen, B., Sang, J., & Musau, J. (2014). *Climate change impacts on ecosystems of Mt. Elgon* (AdaptEA Project Technical Report). Bogor Barat: World Agroforestry Centre/CIFOR/Rockefeller Foundation.

EM-DAT. (2014). *The OFDA/CRED international disaster database*. Brussels: Université catholique de Louvain. Retrieved from www.emdat.be.

Ferguson, M. J., & Bargh, J. A. (2004). How social perception can automatically influence behavior. *Trends in Cognitive Sciences*, 8, 33–39. <http://dx.doi.org/10.1016/j.tics.2003.11.004>

Fernandez-Gimenez, M. E. (2000). The role of mongolian nomadic pastoralists' ecological knowledge in rangeland

- management. *Ecological Applications*, 10, 1318–1326.
[http://dx.doi.org/10.1890/1051-0761\(2000\)010\[1318:TR OMNP\]2.0.CO;2](http://dx.doi.org/10.1890/1051-0761(2000)010[1318:TR OMNP]2.0.CO;2)
- Ferrier, N., & Haque, C. E. (2003). Hazards risk assessment methodology for emergency managers: A standardized framework for application. *Natural Hazards*, 28, 271–290.
<http://dx.doi.org/10.1023/A:1022986226340>
- Gbetibouo, G. A. (2009). *Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa* (Vol. 849). Washington, DC: Intl Food Policy Res Inst.
- Kansiime, M. K. (2012). Community-based adaptation for improved rural livelihoods: a case in eastern Uganda. *Climate and Development*. doi:10.1080/17565529.2012.730035
- Kemauisor, F., Dwamena, E., Bart-Plange, A., & Kyei-Baffour, N. (2011). Farmers perception of climate change in the Ejura-Sekyedumase district of Ghana. *ARPN Journal of Agricultural and Biological Science*, 6, 26–37.
- Kloprogge, P., & Sluijs, J. P. V. D. (2006). The inclusion of stakeholder knowledge and perspectives in integrated assessment of climate change. *Climatic Change*, 75, 359–389.
<http://dx.doi.org/10.1007/s10584-006-0362-2>
- Kurukulasuriya, P., & Mendelsohn, R. O. (2008). *How will climate change shift agro-ecological zones and impact African agriculture?* (World Bank Policy Research Working Paper Series, Vol. 4717). Washington, DC: World Bank. doi:10.1596/prwp
- Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. L. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science*, 319, 607–610.
<http://dx.doi.org/10.1126/science.1152339>
- Locatelli, B., Kanninen, M., Brockhaus, M., Colfer, C. P., Murdiyasar, D., & Santoso, H. (2008). *Facing an uncertain future: How forests and people can adapt to climate change* (p. 97). Bogor Barat: CIFOR.
- Lorenzoni, I., & Pidgeon, N. F. (2006). Public views on climate change: European and USA perspectives. *Climatic Change*, 77, 73–95.
<http://dx.doi.org/10.1007/s10584-006-9072-z>
- Mbogga, M. S. (2012). *Consultancy report: Climate profiles and climate change vulnerability assessment for the Mbale region of Uganda*. Kampala: UNDP.
- Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*, 43, 804–816.
<http://dx.doi.org/10.1007/s00267-008-9197-0>
- MFEP. (2014). *Housing and population census*. Kampala: Author.
- Moyo, M., Mvumi, B. M., Kunzekweguta, M., Mazvimavi, K., Craufurd, P., & Dorward, P. (2012). Farmer perceptions on climate change and variability in semi-arid Zimbabwe in relation to climatology evidence. *African Crop Science Journal*, 2, 317–335.
- Mubiru, D. N., Agona, A., & Komutunga, E. (2009). Micro-level analysis of seasonal trends, farmers' perception of climate change and adaptation strategies in eastern Uganda. In *International Conference on Seasonality* (pp. 8–10). Brighton: Institute of Development Studies, University of Sussex.
- MWE. (2002). *Initial national communication of Uganda to the conference of the parties to the United Nations framework convention on climate change*. Ministry of Environment. Retrieved March, 2015, from <http://unfccc.int/resource/docs/natc/uganc1.pdf>
- MWE. (2010). *National statement at the 4th national climate change forum, Uganda*. Author. Retrieved February, 2015, from http://unfccc.int/files/meetings/cop_16/statements/application/pdf/101208_cop16_hls_uganda.pdf
- MWE. (2013). *Integrated territorial climate plan 2014–2029 for Mbale region Uganda (Bududa, Manafwa and Mbale district)*. Kampala: Author.
- Neil Adger, W. (1999). Social vulnerability to climate change and extremes in coastal Vietnam. *World Development*, 27, 249–269.
[http://dx.doi.org/10.1016/S0305-750X\(98\)00136-3](http://dx.doi.org/10.1016/S0305-750X(98)00136-3)
- NEMA. (2008). *State of environment report for Uganda*. Kampala: Author.
- Nyanga, H. P., Johnsen, F. H., & Aune, J. B. (2011). Smallholder farmers' perceptions of climate change and conservation agriculture: Evidence from Zambia. *Journal of Sustainable Development*, 4, 73–85. doi:10.5539/jsd.v4n4p73
- Osbahr, H., Dorward, P., Stern, R., & Cooper, S. (2011). Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. *Experimental Agriculture*, 47, 293–316. <http://dx.doi.org/10.1017/S0014479710000785>
- Seo, S. N., Mendelsohn, R., Dinar, A., Hassan, R., & Kurukulasuriya, P. (2009). A Ricardian analysis of the distribution of climate change impacts on agriculture across agro-ecological zones in Africa. *Environmental and Resource Economics*, 43, 313–332.
<http://dx.doi.org/10.1007/s10640-009-9270-z>
- Twinomugisha, B. (2005). *A content analysis reports on climate change impacts, vulnerability and adaptation in Uganda*. International Institute for Environmental Development. Retrieved from <http://pubs.iied.org/pdfs/10011IIED.pdf>
- Yengoh, G. T., Armah, F. A., Onumah, E. E., & Odoi, J. O. (2010). Trends in agriculturally-relevant rainfall characteristics for small-scale agriculture in Northern Ghana. *Journal of Agricultural Science*, 2, 3.



© 2016 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.

You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

