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Natural hazards and farmers experience of climate change on highly populated Mount Elgon, Uganda

Marit Aalrust Ripel

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Department of
Physical Geography and Ecosystem Science
Lund University
Sölvegatan 12
S-223 62 Lund
Sweden

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Supervisor: Ulrik Mårtensson
Department of Physical Geography and Ecosystems Science

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Abstract

In general Uganda receives enough rainfall to rain-feed crops and pasture but as climate is changing the seasonal patterns are expected to become more extreme. This influences how the land can be used, and has a strong impact on the farmers who depend on their land for economic income and food security. This report has two aims. The first is to identify the farmer's experiences of climate change and extreme climate events. The second aim is to identify tendencies in variations of rainfall and temperatures in the study area. The study area is located within the two districts Manafwa and Bududa in eastern Uganda. The methods used for this study are interviews with farmers and a statistical analysis of rainfall and temperature data from the period 1991 to 2010.

The results show that most of the farmers have experienced climate change. Drought was named by the respondents, as the biggest problem followed by storms and floodings. Drought was also named as one of the major hazards for agricultural land together with soil erosion and soil infertility. From the statistical analysis the rainfall data had the most interesting variations.

Key words: Natural hazards, climate change, farmers' vulnerability, Mount Elgon, Uganda

Sammanfattning

Generellt faller det tillräckligt med nederbörd i Uganda för att naturligt bevattna grödor och djurhållning. Men med klimatförändringar har säsongsmönstren ändrat sig och blivit mer extrema. Detta påverkar hur marken kan användas och har dessutom stor inverkan på jordbrukarna som är i stor omfattning beroende av sin mark, både av ekonomiska skäl och för livsmedelssäkerhet. Denna studie har två syften. Det första är att identifiera jordbrukarnas upplevelser av klimatförändringar och extrema klimathändelser. Det andra är att identifiera tendenser i variation av nederbörd och temperatur i studieområdet. Studien har sin utgångpunkt i två distrikt, nämligen Manafwa och Bududa i östra Uganda. Metoden som studien använder sig av är intervju med jordbrukare och en statistisk analys av nederbörd och temperaturdata från 1991 till 2010.

Resultatet av studien visar att jordbrukarna upplever klimatförändringar. Torka var ett problem de flest jordbrukarna upplevde och sedan kom starka stormar och översvämningar. Torka, jorderosion och minskad bördighet i marken, framkom som de största hoten mot jordbrukarnas mark. Från den statistiska analysen har nederbördsdata de mest intressanta variationerna.

Nyckelord: Naturliga hot, klimatförändringar, bönders sårbarhet, Mount Elgon, Uganda

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1. Introduction

There have always been variations in day to day or season to season weather, and for centuries human societies have been able to adapt to climate variation occurring in their region (Houghton 2009) But today frequencies of extreme climate events such as tropical cyclones, windstorms, floods, tornadoes and drought have increased (IPCC 2012). For humans this verifies how important a stable climate is and how vulnerable we are for extreme climatic events (Houghton 2009). With globalization the awareness of environmental hazards has gone from concerning local communities to become international problems (Lidskog et al. 1997).

This report has its study area located on the slopes around Mount Elgon in eastern Uganda. Here there are high potential agricultural zones and under normal climatic conditions there should fall enough precipitation to rain-feed crops and pastures (Mukwaya et al. 2011, Nema 2010) With climate change the seasonal patterns are becoming more extreme from what they are today, this will change how the land can be used and will have a strong impact on farmers, who depend on their land for economic income and food security (Oxfam 2008). With a growing population and the high dependency on agriculture, there is a great issue that Uganda lack opportunities of non-farm employment (UNDP 2009).

1.1 Aim and study questions

The aim of this report is to investigate variations in climate during the period 1991 to 2010.

Questions to be studied are:

1. What are farmers' experiences of climate change and extreme climate events?
2. Can there be identified any seasonal or yearly change in climate to become dryer or wetter and colder or hotter?

In order to answer the second study question a hypothesis is tested. The hypothesis claims that there is no change in monthly or yearly mean rainfall and mean temperature compared to the 20 years mean rainfall and temperature.

1.2 Definition

Definitions of hazards are:

" Hazards are best viewed as a naturally occurring or human-induced process, or event, with the potential to create loss, that is, a general source of future danger."

(Smith 2004)

"A natural hazards is a natural processes or events that is a potential threat to human life and property."

(Keller et al. 2012)

An extreme climate event describes the outer limit of the potential natural hazard (Smith 2004) and can be used as indicators for climate change or climate variability (WMO 2014a). When discussing natural hazards it is important to have in mind that the hazard alone is not the danger but it becomes a danger because of human dependency of the land and its resources (Keller et al. 2012).

1.3 Similar studies

Shisanya et al. (2013) have done a similar study measuring trends and variability of rainfall and the communities' preparedness and response to these. The study was a comparison of three different agricultural zones in eastern Uganda; the farmland of Lake Victoria crescent and Mbale, the southern and eastern lake Kyoga basin and mountain highlands on Mount Elgon. Methods used in the study were: regression methods for analysing trends, coefficient of variation and ANOVA techniques for analysing variability and rainfall satisfaction index for analysing the farmers´ perceptions. The authors concluded that there could be found a significant variation in annual and seasonal rainfall distribution and that the highlands had a greater variability than other agro-ecological zones. Further they conclude that the communities perception where in line with the observed data (Shisanya et al. 2013).

2 Study area

Uganda is located in eastern Africa. The country is landlocked in between Democratic Republic of the Congo in the east, Kenya in the west, Rwanda and Tanzania in the south and South Sudan in the north (CIA 2014). Administratively Uganda is divided into regions and districts. The area to be studied in this report is a smaller part of Bubulo, Manafwa and Mbale districts in the eastern region, see map in Figure 1. Fieldwork was conducted on latitude 0.908750° and 1.023243°, and longitude 34.269462° and 34.335959 with projection system type WGS_1984_UTM_zone_36N.

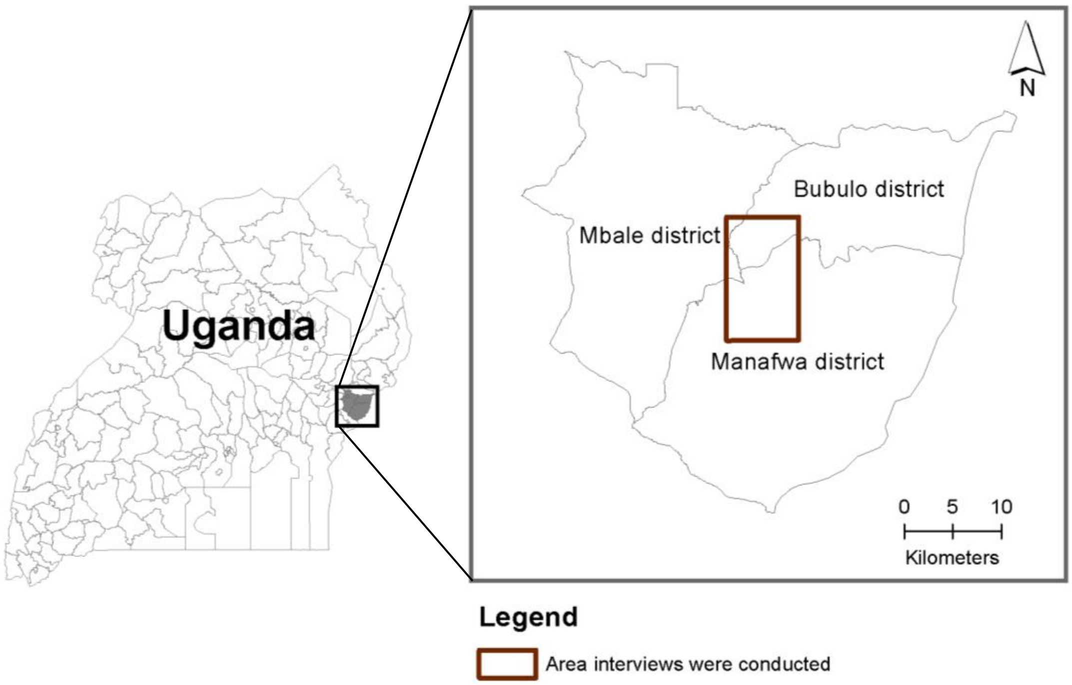


Figure 1. Map over districts in Uganda and the districts where the study area is placed. Area where the interviews were conducted is marked as a red square in the map.

2.1 Climate

According to Köppen Climate Classification System Uganda has tropical dry-wet (Aw) climate. This means that there are distinct differences between dry and wet season, while temperature varies little but is warm to hot all year (Keller and DeVecchio 2012).

The seasonal rainfall patterns are strongly influenced by the movement of the inter-tropical convergence zone (ITCZ), which can be described as a narrow belt of a low-pressure zone that forms at the equator. Depending on variations of the sea surface temperatures of the Indian Ocean and the influence of the El Nino Southern Oscillation (ENSO) the ITCZ migrates south- and northwards (Mukwaya et al. 2011, McSweeney et al. 2006). This gives Uganda a bimodal climate, with two rain seasons when the ITCZ migrates southwards in October-December and when returning northwards in March, April and May. The amount of rainfall received these months varies greatly but are in general between 50-200 mm, although it might exceed 300 mm per month (McSweeney et al. 2006). These climatic seasons have for a long time been relatively stable and predictable but lately rainfalls have been reported to be more unreliable and the distribution more uneven. Also, rains are more erratic and thunderstorms have become more frequent (Nema 2010).

The Mount Elgon mountain range is responsible for orographic rainfall on its surroundings. Orographic rainfall is known to come in phases starting with light rain that gradually increases in power and is often accompanied with thunderstorms and hail (Hess 2010). Compared to the rest of Uganda the districts around of Mount Elgon receive a relatively high amount of rainfall (Nema 2010).

2.2 Topography

The study area is located on the western side of the Mount Elgon range. Mount Elgon is an extinct volcano massif stretching from 1,000 to 4,321 meters above sea level (UNESCO 2004). Because of the high altitudes the mountains have an important function on the area giving an orographic lift to the hot and moist air that floats in towards the mountain from the hot plains below. With the high altitude the moist air will cool down and give rainfall (Uganda wild life 2012, Bamutaze 2010). The temperate climate is the base for a rich flora (Uganda wild life 2012). The Mount Elgon area was designated a national park in 1993 and to an UNESCO Man & Biosphere reserve in 2003 (UNESCO 2004).

The area can be described as very hilly, see photography in Figure 2. Studies conducted here conclude that the slopes of Mount Elgon are highly unstable and sensitive to heavy rainfall. Human activities on the hills lower the threshold of slope stability and make the risk for mass movement higher (Knapen et al. 2006; Mugagga et al. 2012). Landslides in this area are frequently reported and often with high number of deaths and missing people (BBC 2012). Soil erosion is also a reported problem. In a study on soil erosion done by Bamutaze (2010) it could be concluded that fifty-two percent of the Manafwa catchment area are hotspots for soil erosion with a soil loss >10 ton ha^{-1} yr^{-1}.

Figure 2 View over the many hills within the study area. The picture is from Manafwa district. Photo: Ripel 2014

2.3 Population and socio-economics

In 2010 the total population of Uganda was 31 millions. During the last 20 years the population has increased sharply and today Uganda is one of the fastest growing populations in the world, at an annual rate of 3.4 per cent. Much because of a lower infant mortality rate due to better health care services. Uganda is found at an early stage of the demographic transition model with a high fertility rate estimated to 6.7 births per woman in 2006 (Mugagga et al. 2012).

The rural population in Uganda is 85 percent (Mugagga et al. 2012). Compared to world average were 50 per cent of global population live in urban areas (WHO 2014), the population situation in Uganda is rather unique. The eastern region is among the most populated ones with a density of 200-500 persons per square kilometre. The districts where this report has its study area is even know to have a higher population density with between 500-1000 persons per square kilometre (Mukwaya et al. 2011).

During the last twenty years Uganda has made a significant progress in social and economic development, which is achieved due to long time political stability (UNDP 2009). Among the positive developments is a reduction in extreme poverty. From 1992 to 2010 the poverty rate was reduced from 56 percent in 1992 to 24 percent in 2010, this makes Uganda one of the few countries in Africa that will reach the first Millennium goal; poverty should be halved by 2015 (Nema 2010). Despite this positive progress one of the major challenges for Uganda is the impact of climate change and the connection climate change has to poverty (UNDP 2009). Uganda is highly dependent on their agricultural sector. Not only are agricultural products Uganda's major exportation product, but just under three-quarters of the working population is engaged in the agricultural sector and has agricultural production as their primary livelihood activity (Mukwaya et al. 2011). The agricultural sector in Uganda consists of mainly of crop and animal production, forestry and fisheries (Nema 2010).

2.4 Land use

Of Uganda´s total land use area, 37 percent is covered by small scale farming while large commercial farms cover less than 1 percent (Nema 2010). In the study area subsistence farming is the most common land use and as can be seen in Figure 3 all available land is used for farming, even the hills is used as agricultural land. The main crops to be grown in eastern Uganda are maize, cassava, sweet potato, beans, food banana and groundnuts (OBOS 2010). The bimodal climate gives two growing season and crops can be harvest twice a year.

Figure 3 Land use in the study area. The topography is steep and the farmers use the hills as agricultural land. Photo: Ripel 2014

Earlier studies done in Manafwa district show that there have happened drastic changes in land use and land cover the last decades. In 1960 woodland and forest were the two dominating land cover classes covering 53 percent and 29 percent of the area, while agriculture covered 17 percent of the area. In 1995 there were minimal changes in the land use/cover, however in 2006 the trend has changed. Agriculture have become the major land use class raising up to 60 percent while woodlands and forest have dropped to below 20 percent as land cover in the area (Mugagga et al. 2012). A consequence of increased agricultural use of the land is that good and fertile soil is no longer easy available and farmers have to move uphill towards less productive soil. The forest that exists on the hills is removed for the land to be used as agricultural mark. Because of these land use changes, the area is a hotspot for land degradation such as soil erosion and soil infertility (Nema 2010, Bamutaze 2010).

3 Theoretical background

3.1 Natural hazards

Hazards as a term, is often separated in three categories based on its processing agents; natural, technological and social. Here geophysical agents influence the natural hazards, the technological hazards by man made materials and devices, and lastly social hazards by violence and war (Smith 2004, Hewitt 1997). As said, the processes behind a natural hazard are physical, chemical and/or biological. More specified these could be events happening from atmospheric, hydrological, geological, geomorphological and biological agents, common for them all is that they affect humans on Earths surface (Hewitt 1997). Alone the events are not a hazard and in normal conditions they can even be said to be an environmental resources for human activity (Smith 2004), but the events can become hazardous when interfered with humans and humans use of the land (Keller et al. 2012). The sensitivity to natural hazards is a combination of the exposure of the potential damaging threats and the human vulnerability. This can be expressed as a function of tolerance between resource and hazard where the band of tolerance is defined by the damage threshold limits. Within the band of tolerance the events is a resource, but beyond it becomes a hazard. The level of tolerance is at lowest where small physical changes can create large socio-economic impacts (Smith 2004).

3.1.1 Vulnerability, risk, disasters

The interaction of hazardous event and human beings are discussed in terms like hazards, disaster and catastrophe (Keller et al. 2012). A risk can be defined, as an unwanted happening in the future. When calculating a risk one assumes that it is possible to predict and to change the future (Hewitt 1997). A disaster as a hazardous event occurring in an area for a limited time and a catastrophe is a massive disaster costing society human life and money (Keller et al. 2012). The natural hazards that kill the most people are not necessarily the same as the natural hazards that do most property damage (Keller et al. 2012). The human vulnerability reflects the social and economic perspectives (Smith 2004). Vulnerability can be defined as relationship between to what degree the population is exposed to climate stress, the degree of sensitivity and the ability to adjust to the changes, while climate variability relates to the level to which an economy, people and livelihoods will be negatively affected by extreme climate events (Nema 2010). Four factors are important to take in consideration when discussing effects of climate change on agriculture and food production. These are; the availability of water, the carbon dioxide effect on plants when the amount of carbon increases in the atmosphere, temperature changes and at last the influence of climate extremes. Water, temperature and climate extremes give all negative effects preventing the crops from growing or by destroying the crops. While an increased carbon dioxide effects will have a positive effect in the production (Houghton 2009). However, the yearly distribution of temperature and water are key factors for the farmers in order to decide what crops to grow (Houghton 2009).

3.1.3 Climate change

The Ugandan National Environment Management Authority (Nema) has defined climate change like this:

"Climate change refers to the change in the state of climate and can be identified by changes in the mean and/or the variability of it properties, while climate variability refers to variation in the mean state and other statistics of the climate on all spatial and temporal scales beyond that of individual weather events"

(Nema, 2010)

According to WMO (2014b) human activity have influenced climate change in three ways. The first is increased amount of greenhouse gases in the atmosphere, the second is increased amount of aerosols in the atmosphere and third land use changes such as cutting down forest for agricultural land. In Uganda, signs of climate change are reported. The rain season is proved to be more erratic with heavier rain and the drought season to longer causing reduced crop yields. The influences of climate change are increasing temperatures, increased frequency and intensity of rainfall, heat waves, droughts, floods, storms etc. and all of these factors have an impact on agricultural productivity (Nema 2010). The farmers are sensitive to variations in the climate and extreme climate events that potentially affect a great amount of people (UNDP 2009).

Statistical analyses done on climate change in Uganda show that the mean annual temperatures have increased by 1.3°C since 1960 with a more rapid temperature rise of 0.37°C per decade in January and February. In the period 1960 – 2003 the frequencies of hot days and hot nights have increased significantly and the number of cold days and night decreased significantly. By defining hot and cold by temperatures exceeding or decreasing more than 10% from the recorded mean, it was found that the number of hot days and nights have increased with 74 days and 136 nights per year. June, July and August are the months with highest number of increased hot days and nights. At the same time the frequency of cold days and nights have decreased with 20 days and 42 nights per year. The months September, October and November have the highest rate of decreased cold days and the months December, January and February have the highest rate of decreased cold nights (McSweeney et al. 2006). When it comes to precipitation the trend show a significant decrease in annual rainfall. The months March, April and May have the highest rate of decreased rainfall with 6.0 mm per month per decade. However, there can not be seen a trend in heavy rainfall events, where heavy is defined as a daily rainfall exceeding 5% of rainy days in the current climate of a region and season (McSweeney et al. 2006).

3.2 Types of climate extremes found in Uganda

3.2.1 Drought

The foundation of a drought is lower levels of rainfall than normal in a region and when rainfall is absent for a long time, water for human activities and for the crops to grow will not be sufficient (WMO 2012).

One of the most serious outcomes from drought is famine. In a study on agriculture done by Ugandan Bureau of statistics (OBOS 2010), 57 percent of the studied households had experienced food shortage and of these 91 percent also said they have experienced drought. Normal surviving strategies and the response of food shortage are skipping meals, eat less preferred food, reduce size of meals, and use savings to buy food, getting assistance from family to get food. In general for Uganda the average mean calorie intake per person per day are lower than the daily intake of 2,300 kcal per adult per day that WHO recommend (Mukwaya et al. 2011).

3.2.2 Floods

Flooding of river floodplains and low-lying areas are quite normal and can happen anywhere. The occurrence can be related to the amount and distribution of a rainfall, the soils ability infiltrate the water and to the speed of surface runoff (Keller et al. 2012). In interaction with human and human use of the land floods often becomes natural hazard because of settlements along the riverbanks and at the coastline. Consequences of floods are damaged property, crop damage and destruction of cultivated land, deaths, and after a flood illness due to epidemic is common (Smith 2004). In arid and semi arid zones flash floods occur in the combination of steep topography, little vegetation and high-intensity rainfall (Smith 2004). A flash flood often comes suddenly and with a relative great volume (Keller et al. 2012). The best way to spare humans from flood hazards is by avoiding intensive land use and settlement on the floodplains. Also, human activities like deforestation had been proved to have direct influence on increased flood runoff (Smith 2004).

3.2.3 Storms

Storms are atmospheric hazardous, the extreme events can be a danger because of the great amount of energy that is release during short time (Keller et al. 2012). Thunderstorms is common at the equator, it often builds up at cold fronts were warm and humid air is forced upwards on a steep front of cold air. The greatest hazards from a thunderstorm are destructive hails (Keller et al. 2012). In areas near to mountain ranges local and hailstorm with a great intensity often occur (Smith 2004).

3.2.4 Soil erosion

Soil erosion is more a consequence of the climate extremes described above but is included in this report as a climate extreme because soil erosion is known to be one of the prime environmental problems in the world (Pimentel 2006). Most exposed to soil erosion is agricultural land where erosion has an impact on declining land value because of degradation and in the worst cases abandonment of land (Morgan 2005). Erosion has both on-site and off-site effects. The on-site effects are redistribution of the soil and breakdown of soil structure happening within a field. This will result in soil loss from the field and a decline in organic matter and soil fertility. When the soil looses its fertility the final outcome will be a lower food production, and for the farmers a high cost in fertilizers, used to compensate for the loss of soil fertility. The off-site effects are mass movement of sediments downstream or downwind, these outcomes in higher risks for flooding when the drainage capacity of rivers is reduced. Sedimentation alone can also be seen as a polluting factor leading to over-fertilizing when chemicals like nitrogen and phosphorus is brought with the sediment (Morgan 2005). The costs from on-site erosion are paid by the farmers, and chain-effects the community is higher food prices when the food production is reduced, while off-site erosion is a costs for local authorities (Pimentel 2006).

Water and wind are the two principal factors leading to erosion. Erosion from water happens in three steps. The first step is called splash erosion and occurs when soil particles are loosened from falling raindrops. Step two is when the detected soil particles are transported downhill with overflow water and lastly the third step is when the soil is deposited on a new location. The soil that is moved downhill is often the most fertile. Length and shape of the slope have an impact on the risk of erosion happening. A larger slope have greater soil erosion, also the length of the slope has an impact (Morgan 2005). Vegetation works as a protective layer between the atmosphere and the soil. A bare soil will have a higher soil loss rate than land with a plant cover. Leaves and stems can absorb energy from falling raindrops, running water and wind so it is less directed at the soil. Ground components, such as root systems, contribute to the mechanical strength of the soil (Morgan 2005).

4 Method and material

4.1 Field data

The field data used in this study consists of interviews conducted with farmers in the study area. Interview is a common qualitative method that gives a deeper understanding of individuals experience and understanding of a given problem. Qualitative methods are often used when a specific type of information is demanded. An interview can be held in different forms being structured, semi-structured and less structured dialog between the interviewer and respondent. A structured interview has many similarities to a questionnaire study since all the questions asked follow a given setup and questions are predetermined, the answers results in easily comparable data (Paulsson and Björklund 2003). The answers from an interview give indications of the amount of similar values in a population (Krokan 1998).

During two field days in March 2014 interviews were held in a transection in north- and southward direction from the main road between the towns Bubulo and Bududa. The interviews were performed in five groups with students from the course Land surface processes and landscape dynamic at the Department of Physical Geography and Ecosystem science at Lund University and students from the school of Forestry, Environmental, Geography sciences at Makerere University. The students from Lund University have designed the questions and set-up of the interviews. A total of 22 questions were asked, including questions of land use, problems the farmers experience with the land, improvements made on the land, climate change, migration, income etc. See appendix 1 for the full list of questions. All interviews were held in a semi-structured form, where the interviewer followed the list of questions and the respondent made up alternatives for the answers.

The selection of individuals/families to be interviewed was randomly selected by each group. In general the question was asked to one family member but the answer ended up being the collective opinion given by all adult members of the family. A total of 37 interviews were performed. Of these, there were 15 men and 22 women in an age range between 19 to 83 years old. If possible the interviews were conducted in English, but in most cases an interpreter translated the question to the local language Lugishu.

4.2 Climate data

A description of the climate should involve appropriate weather factors where the most central are rainfall and temperature (Houghton 2009). In the statistical analyse, daily-recorded rainfall and temperature data have been used. The data comes from the Department of Meteorology of Uganda and is the same that have been used in earlier studies on soil erosion estimations done in the Manafwa catchment area by Bamutaze (2010) and Jiang (2013).

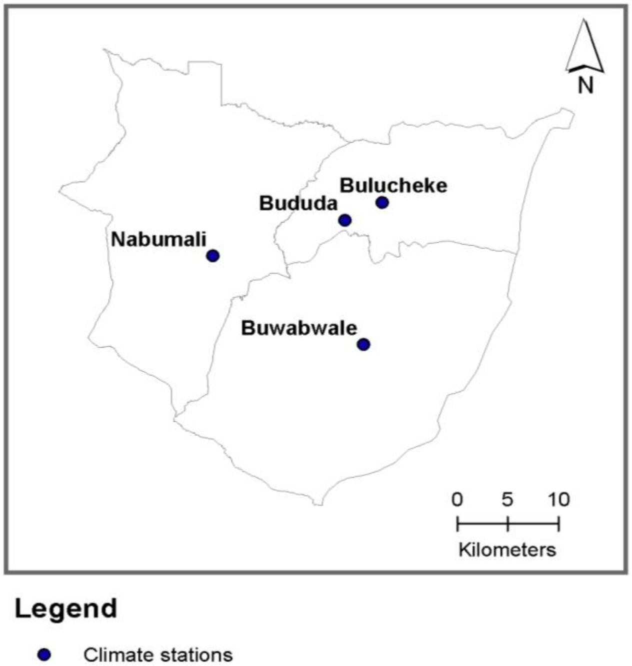


Figure 4 Map over the studied districts showing the location of the climate stations.

Table 1 Facts about the four climate stations in the study area.

Climate station	Longitude	Latitude	Elevation	Recorded years	
				Rainfall	**Temperature**
Bududa	34.333361	1.016577	1290	1991-2010	1991-2010
Bulucheke	34.366687	1.033241	1334	-	1991-2010
Buwabwale	34.350020	0.899919	1545	1991-2010	1991-2010
Nabumali	34.216685	0.983237	1200	1991-2010	1991-2010

The climate data has been recorded at four different climate stations; Bududa, Bulucheke, Buwabwale and Nabumali. Their location can be seen in the map in Figure 4. The studied period has been sat to 20 years starting from December 1990 to November 2010, see table 1. This limitation is done because this is the time period when observations are made in the used database. In the rainfall data from Bulucheke climate station there were five years with missing data from 1993 to 1998 this station has therefore been left out in the analysis of rainfall.

Uganda has a bimodal climate, where the two rainfall peaks are from March to May and from September to November. The time from December to February is the main dry period and June to July there is a less evident dry period. Since part of the aim of this report is to study differences in seasonal climate variations, the months were dived into four classes after seasonal variation. The months were classified as shown below:

1. December, January and February (DJF)
2. March, April and May (MAM)
3. June, July and August (JJA)
4. September, October and November (SON)

Yearly distribution has also been studied and is included as a fifth class, were monthly values for these five classes were summed. To give a correct seasonal connectivity of the data in DJF, the monthly values for December the year before was summed together with monthly values for January and February the following year e.g. DJF values for 2010 will include data for January 2010 and February 2010 and data for December 2009. Temperature was given in daily maximum and daily minimum values these were summed and divided to one mean value in order to get a better overview.

4.3 Analysis of the interviews

The questions found relevant for this study are question 6, 14, 15 and 21. In question 6 the respondents were asked what their main source of income was and the amount earned. All respondents answered on the first question but only fourteen out of thirty-seven gave an answer on the monthly income. Some of the respondents named two sources of income this was analysed as second source of income. A general impression of monthly income has been concluded based on the respondents answer on source of income and amount of monthly income. The results are given in Ugandan shillings.

In question 14 the respondents were asked what they experienced as the biggest problem with their land, and if they do anything to improve the problem. At first the answers were separated after how they have experienced climate change next the type of problems was specified and a percentage value calculated. The percentage value was done by dividing the value of a class by the number of people who have answered yes on the question of experienced problems with land. Worth notice is that many of respondents named various problems with their land.

In question 15 the respondents were asked if they have experienced any climate change in recent years, and to specify what kind of change they have noticed. Also here the respondents named various types of climate changes, in total 18 different ones. Of these there were some classes with similarities and that could be merged to one class. The merged classes and what types of experienced change they include are:

- Destroyed cropping: destroyed cropping, less production
- Storms: Destructive winds, hailstorms, heavier rain, destructive rain, more rain
- Drought: Drought, longer dry season, dust

After the merging, the types of climate change experienced could be categorized in 9 classes. The percentage was calculated using the same method as previous explained.

In question 21 the respondent were asked if he or she have been contacted by the government or a NGO and informed about land degradation and methods for land conservation. From the matrix the answers could be separated in three classes.

When interpreting and categorizing the answers is important to have in mind that qualitative data can be interpreted differently.

4.4 Statistical analysis

In order to investigate tendencies in climate variation in seasonal and annual data for rainfall and temperature, statistical analysis methods have been used. In climatology it is normal to measure variability in the climate by defining a normal from a long time mean and from this estimate the variation, anomaly, from the normal state (Von Storch and Zwiers 1999, WMO 2014a). The law of large numbers states that statistical estimations become better if the amount of years in a study period increases. (Von Storch and Zwiers 1999). It has therefore been taken into consideration that a sampling period of twenty years is in terms of climatology a too short time period to make conclusions of trends in climate change. However, an analysis like this will give an impression of tendencies of the type of weather experienced during the studied period. Also, twenty years has been set as a minimum years for the analysis. Since there were missing data in the rainfall sampling, the climate station Bulucheke has therefore been removed from the analysis. In the temperature assessment Bulucheke is again included.

Standard score (z-score) is one common statistical method that describes weather a particular spatial value is equal to, below or above the population mean. In order to get the z-score first the standard deviation for all classes and all years was calculated following equation 1.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} \qquad \text{(Equation 1)}$$

Here i is the value for the seasonal class and the N number of years. Estimation of the z-score was done after equation 2.

$$Z = \frac{x-\mu}{\sigma} \qquad \text{(Equation 2)}$$

Where the mean (μ) is subtracted from the current year value (x) and divided by the standard deviation (σ). A null hypothesis has been made in order to test the statistical significance of the z-scores. The hypothesis states that seasonal and yearly mean = long time mean and will confirm that there is no change happening in the climate. While the alternative hypothesis states that seasonal and yearly mean ≠ to long time mean. A level of confidence has been sat to 95%, giving a critical z-score value at +- 1.96 standard deviations. When rejecting the null hypothesis it can be concluded that there is a statistically different value in the z-score and when failed to reject the null hypothesis spatial value is not statistically different from the mean.

Standardized precipitation index (SPI) is used to estimate drought based the availability of water. The classification system, see table 2, gives an indication of the distribution of rainfall describing the rainfall to greater or lesser mean based on standard deviations (WMO 2012). SPI is commonly used to give an early warning of drought. Z-scores for rainfall have been classifies after SPI in order to investigate tendencies of climate change.

Table 2 Definition of SPI classes

2.0 >	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
- 0.99 to 0.99	Near normal
-1.0 to 1.49	Moderately dry
-1.5 to 1.99	Severely dry
< -2.0	Extremely dry

5 Results

5.1 Interviews

The selected questions found suitable for this study were question 6, 14, 15 and 21 regarding problems with the land, climate change, source of income and contact with authorities and NGOs.

5.1.1 Income

Of the total number of respondents 81 percent named farming as their main source of income, see Figure 5. Here 13 percent said that they have no income.

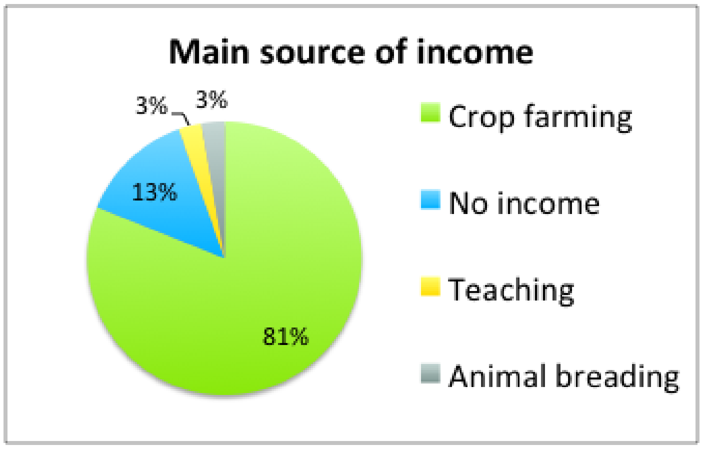
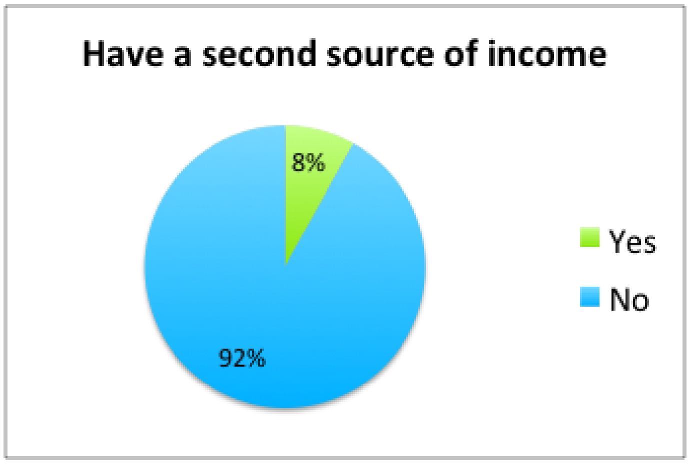


Figure 5 Graph showing the source of the main income for the respondents. (N=37)

Only 8 percent of the respondents told that they have a second source of income (see figure 6). Examples of second sources of income are manual labour on other farms, owning a shop, making and sale of clothes, income from kids or work as a carpenter.



Figur 6 Graph showing the percentage of respondents that have a second source of income. (N=37)

Fourteen of respondents specified a value on their monthly income and from this a very general connection between source of income and monthly income could be made (see table 4). What can be understood from the table is that farming gives a highly varied amount of income, and that a professional work, such as teaching, will improve the monthly income drastically. The respondent who answered none to the main source of income were 70 and 82 years old, and relied on receiving money from their family. 2500 Ugandan shilling = 1 USD (XE 2014)

Table 4 The respondents source of income and monthly income in Ugandans shillings.

Source of income	Monthly income (UGX)
None	1600 - 4000
Farmer	8000 - 60 000
Teacher	300 000

5.1.2 Problems with land

Of the total number of respondents 89 percent say they experience problems with their land, (Figure 7). There are 6 percent that have no problems and 5 percent that have not answered the question.

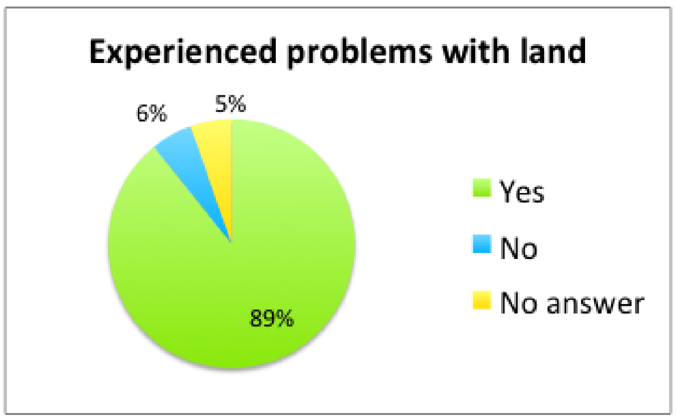


Figure 7 Graph showing the percentage of respondents that have experienced problems with their land. (N=37)

Figure 8 shows the specified problems that the respondents who answered yes are experiencing. The most common problem is soil infertility, second come drought and soil erosion and third come flooding. Also here the respondents could mention more than one problem.

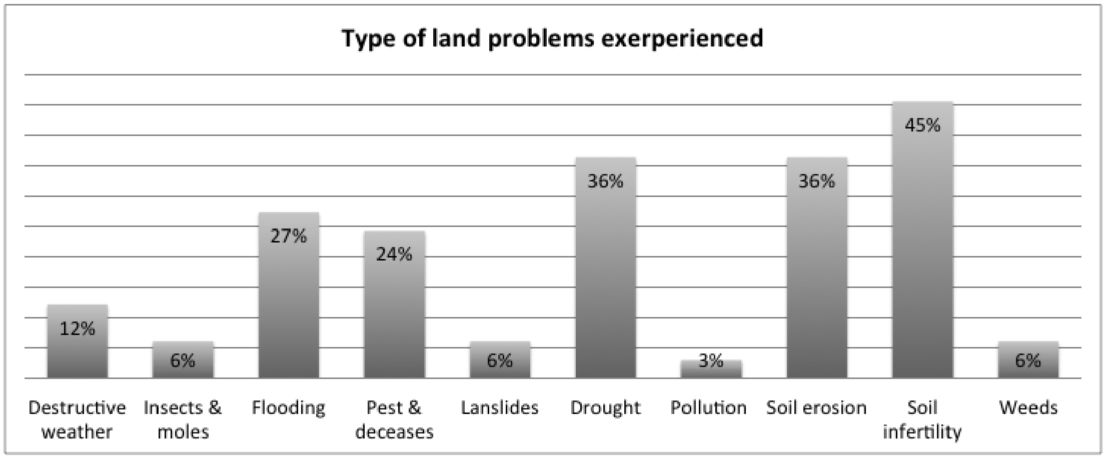


Figure 8 Graph showing type of climate change the respondents have experienced. (N=33)

5.1.3 Experience of climate change

A total of 87 percent of all the respondents say they have experienced climate change (Figure 9) 5 percent say they have no experience of climate change and 8 percent had no answer to the question.

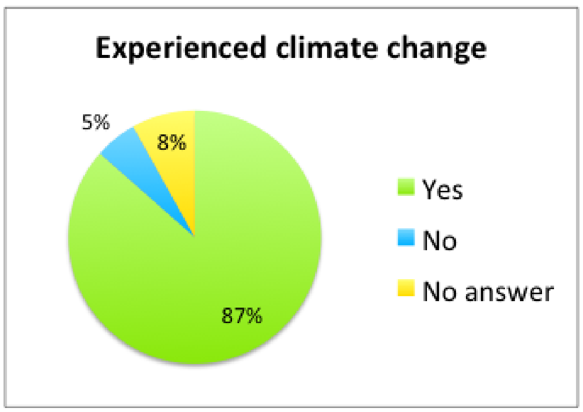
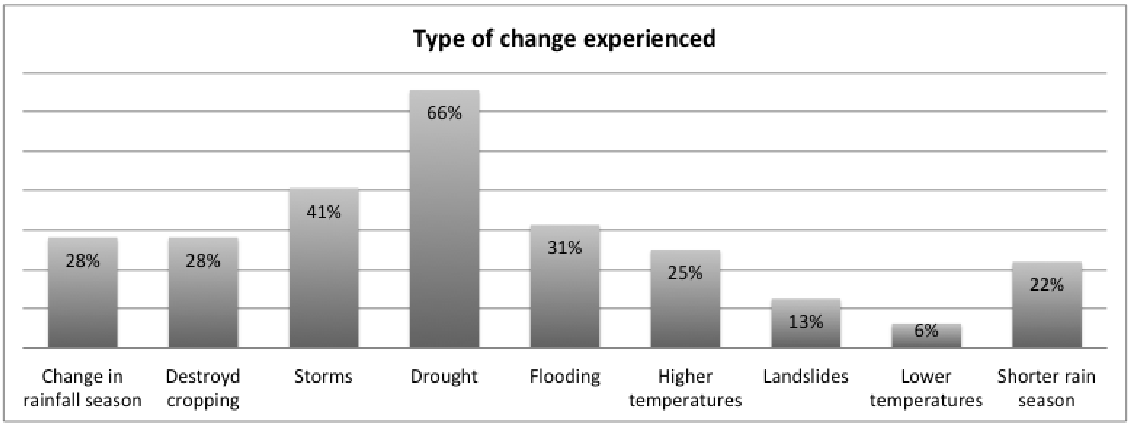


Figure 9 Graph showing the percentage of respondents that have experienced of climate change. (N=37).

The respondents that answered yes were asked to specify what kind of changes they have experienced. The results can be seen in Figure 10. The change that most of the respondents mentioned was drought, second comes storms, and third is flooding. The least mentioned change was lower temperatures. The total number of respondents on this question was 32 persons and respondent had the possibility to mention more than one experienced change.



Figur 10 Graph showing what type of climate change the respondents has experienced. (N=37)

5.1.4 Contact with authorities

A total of 51 percent of all the respondents answered that they have not been in contact with or informed by authorities/NGOs about land degradation and conservation practices, see figure 11. 43 percent sad they have had contact with government/NGOs and 6 percent gave no answer to the question.

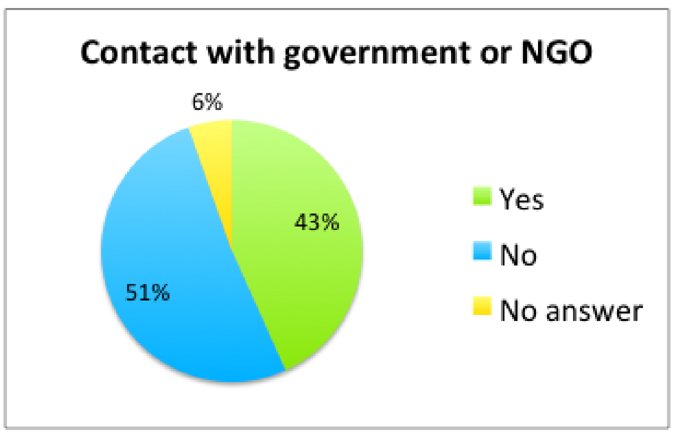


Figure 1 Graph showing the percentage of respondents that have been in contact with the government or a NGO. (N=37)

5.2 Statistical analysis

The following figures show tendencies of wetter or drier and warmer or colder climate for all the four climate stations relative to the sampled mean from 1991-2010. For better comparison of tendencies for the whole area the figures are classified after seasonal patterns DJF, MAM, JJA, SON and yearly mean. In this way it is possible to distinguish local variation between the climate stations.

5.2.1 Rainfall

In Figure 12 the z-scores for rainfall in DJF for the stations Bududa, Buwabwale and Nabumali are shown. Nabumali have a statistical significant score indicating wetter climate in 1991, Buwabwale have the same in 1992 and Bududa in 2004.

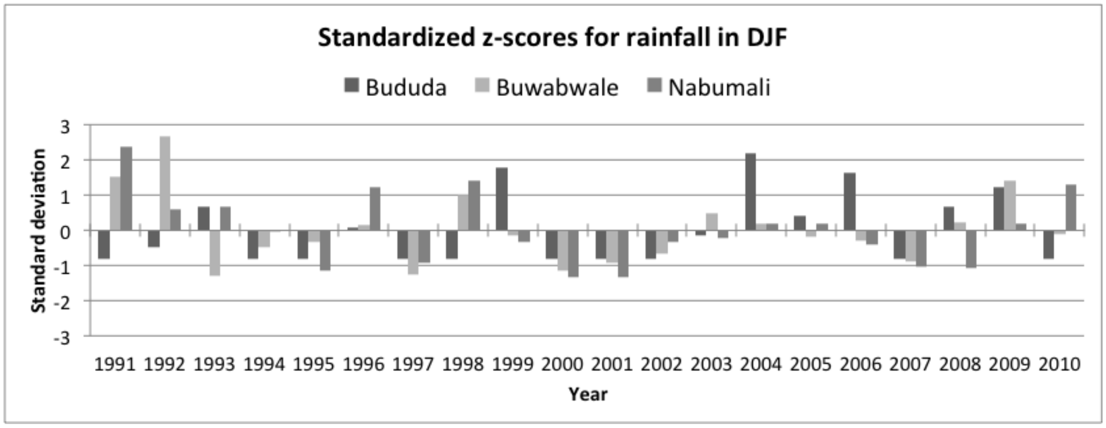


Figure 12 Graph showing tendencies in wetter/drier climate during the months of DJF relative to the mean rainfall in DJF from 1991 to 2010. The graph is classified after the three climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

Figure 13 shows the z-scores for rainfall in MAM. 1992 is a year being statistically dryer than the mean for the climate stations Buwabwale and Nabumali. In the graph there can be seen are local variations between the different stations, as in 2005 where Bududa have tendencies of being wetter than normal and Buwabwale as dryer. Whereas, the tendencies have changed in 2006 and Bududa is dryer than normal, while both Buwabwale and Nabumali are wetter than normal.

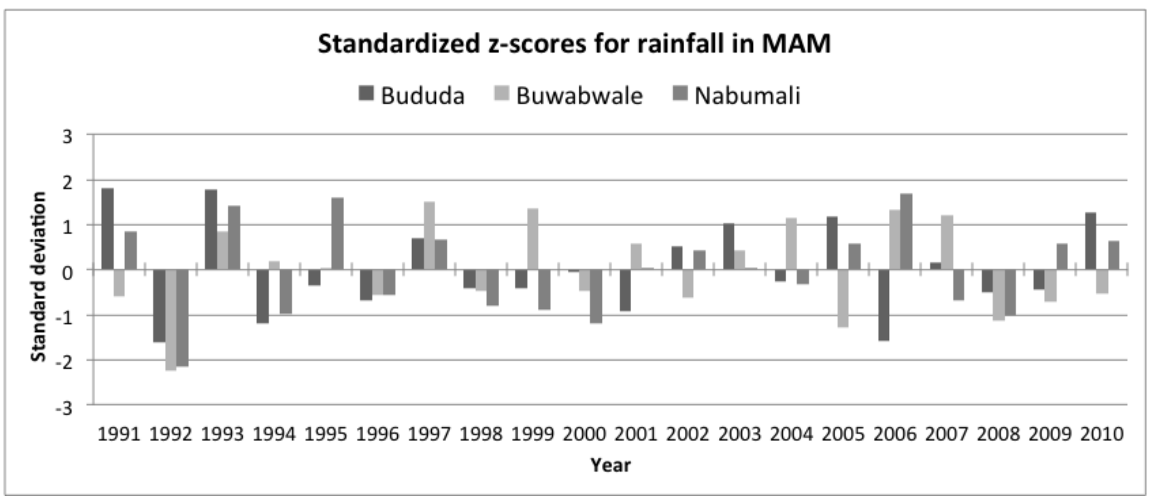


Figure 13 Graph showing tendencies in wetter/drier climate during the months of MAM relative to the mean rainfall in MAM from 1991 to 2010. The graph is classified after the three climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

In Figure 14 z-scores for JJA are given. In the graph some extreme outlines can be seen for Bududa in 1995 and for Buwabwele and Nabumali in 1999. These are all statistical significant scores indicating that the weather is wetter than normal.

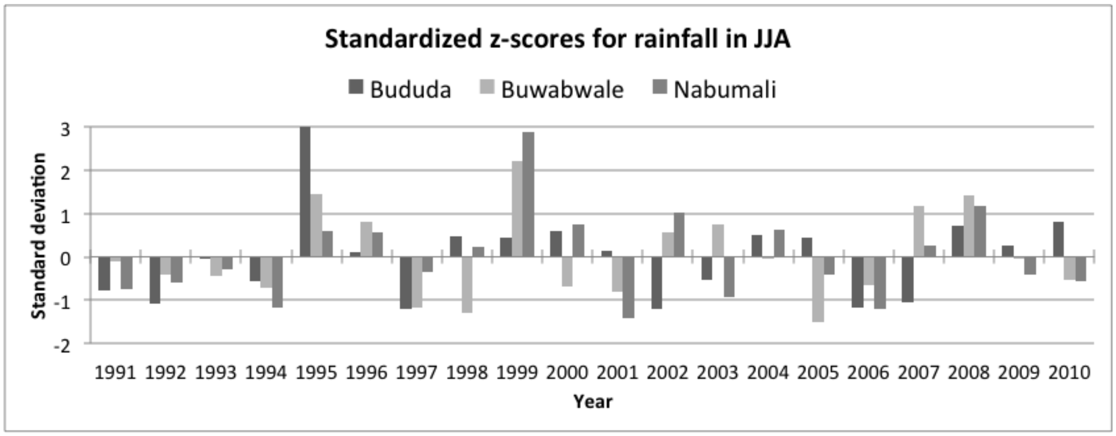


Figure 14 Graph showing tendencies in wetter/drier climate during the months of JJA relative to the mean rainfall in JJA from 1991 to 2010. The graph is classified after the three climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

Figure 15 shows the graph with z-score for the months SON. The graph show statistical significant extreme dry scores for Nabumali in 1992 and extreme wet scores for Buwabwale in 2005.

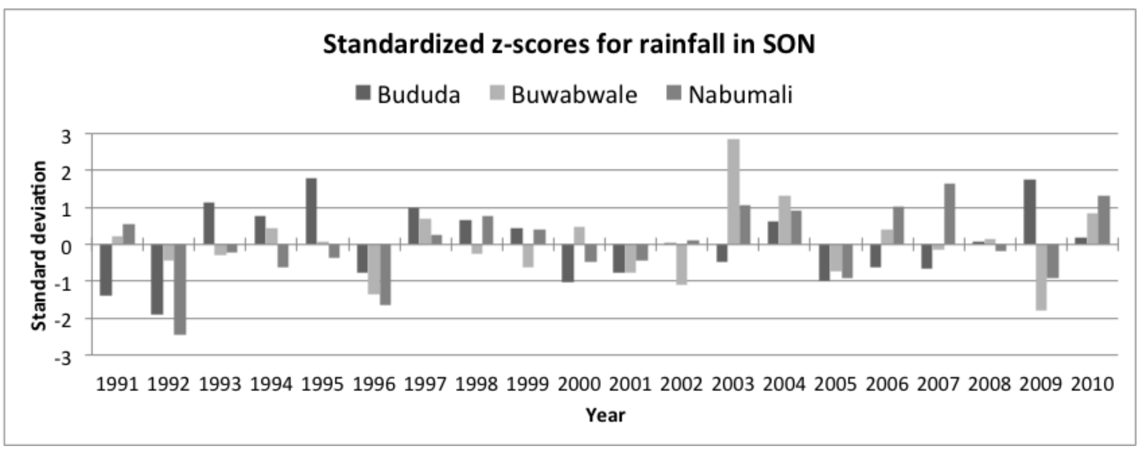


Figure 15 Graph showing tendencies in wetter/drier climate during the months of SON relative to the mean rainfall in SON from 1991 to 2010. The graph is classified after the three climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

In Figure 16 z-scores for yearly mean is given. In 1992 there are significant dryer scores for the climate stations Bududa and Nabumali, and the same for Nabumali in 1994. Bududa have significant wetter scores in 1995 and so have also Nabumali in 1999 and Buwabwale in 2003.

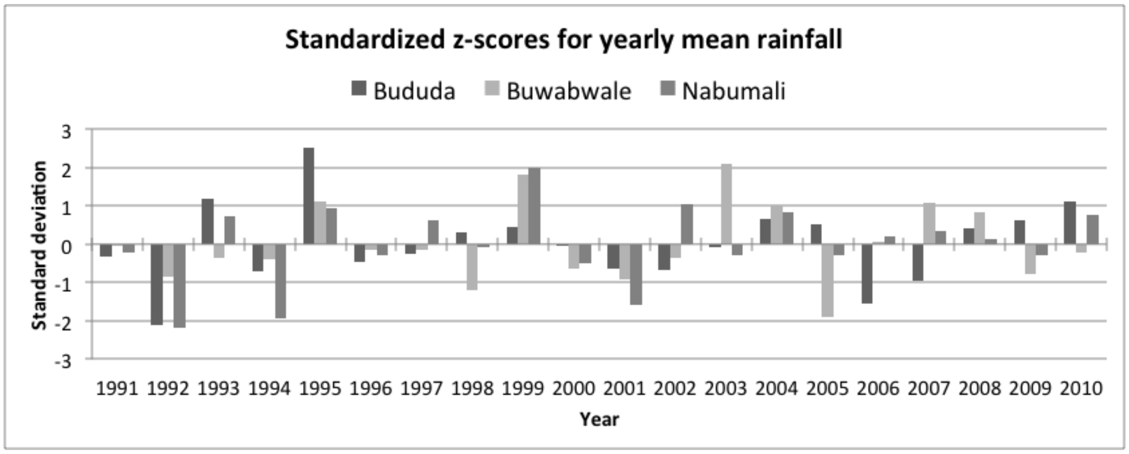


Figure 16 The graph show tendencies in wetter/drier climate yearly for mean relative to the mean rainfall from 1991 to 2010. The graph is classified after the three climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

The pie charts in figure 17 show the SPI classified deviation for the rainfall for DJF, MAM, JJA, SON in the period from 1991 to 2010. The value in percentage represents the summed distribution of a SPI class for all the three climate stations. As there can be seen in all the charts the rainfall amount of rainfall in the respective season was over 60 percent near to normal.

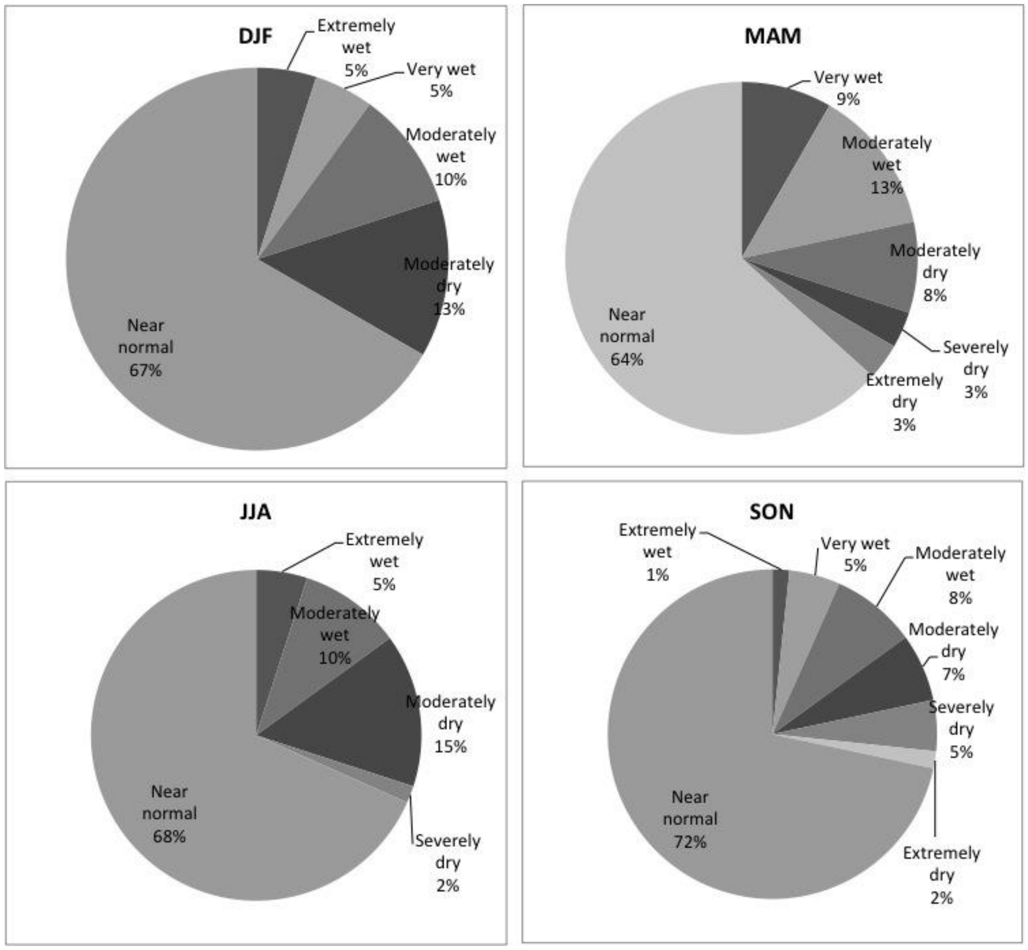


Figure 17 Distribution of seasonal rainfall after SPI classification. The each chart is the summed rainfall values for all station in the monthly season. (N=60)

5.2.2 Temperature

In figure 18 the z-scores for temperature in the months DJF are shown. None of the scores are statistically different from the long time mean temperature in the studied time period.

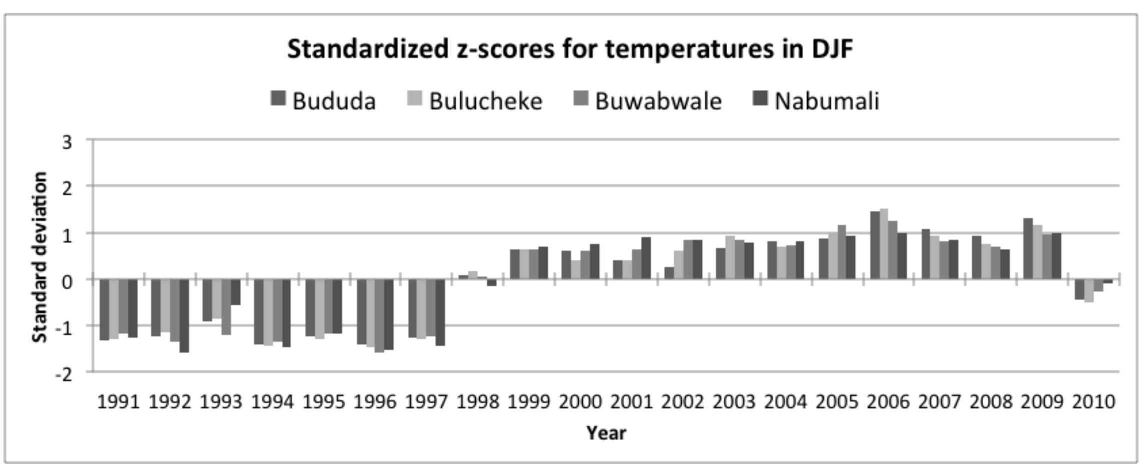


Figure 18 The graph show tendencies in colder/warmer climate during the months DJF relative to

the mean temperature in DJF from 1991 to 2010. The graph is classified after the four climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

In Figure 19 z-scores for temperatures in the months MAM are given. For all stations 1997 is an outlining year with scores being extreme warmer than normal. For the climate stations Bududa, Bulucheke and Buwabwale the scores are statistical significant.

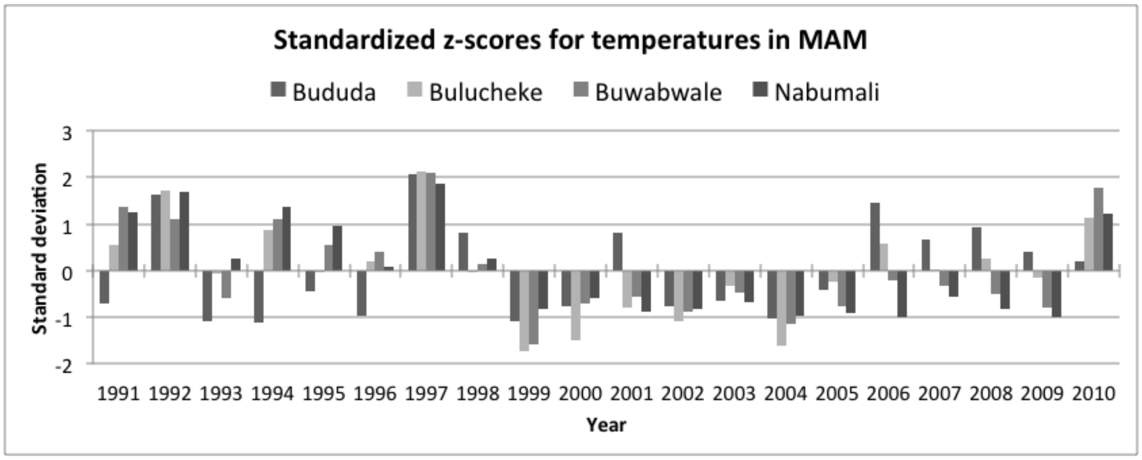


Figure 19 The graph show tendencies in colder/warmer climate during the months MAM relative to the mean temperature in MAM from 1991 to 2010. The graph is classified after the four climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

In Figure 20 are z-scores for the months JJA shown. In the graph there are two years, 1996 and 1997, peaking out being warmer than normal. In 1994 the score is statistically significant for all climate stations while in 1997 the stations Bududa, Buwabwale and Nabumali.

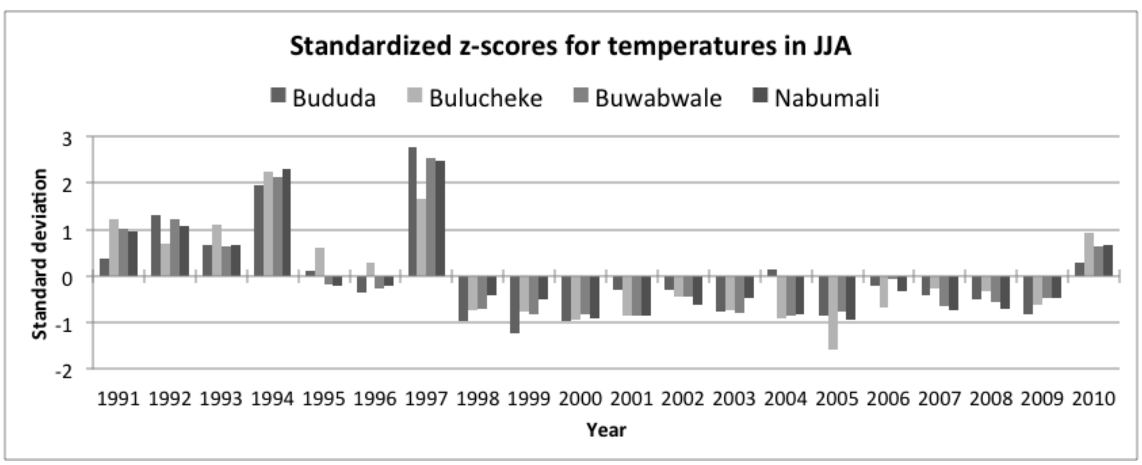


Figure 20 The graph show tendencies in colder/warmer climate during the months JJA relative to the mean temperature in JJA from 1991 to 2010. The graph is classified after the four climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

In Figure 21the z-scores for temperatures in the months SON are given. There are some variations in tendencies in the graph. However, statistically different from the mean is Bulucheke in 1998 and 1999 being extreme colder than normal.

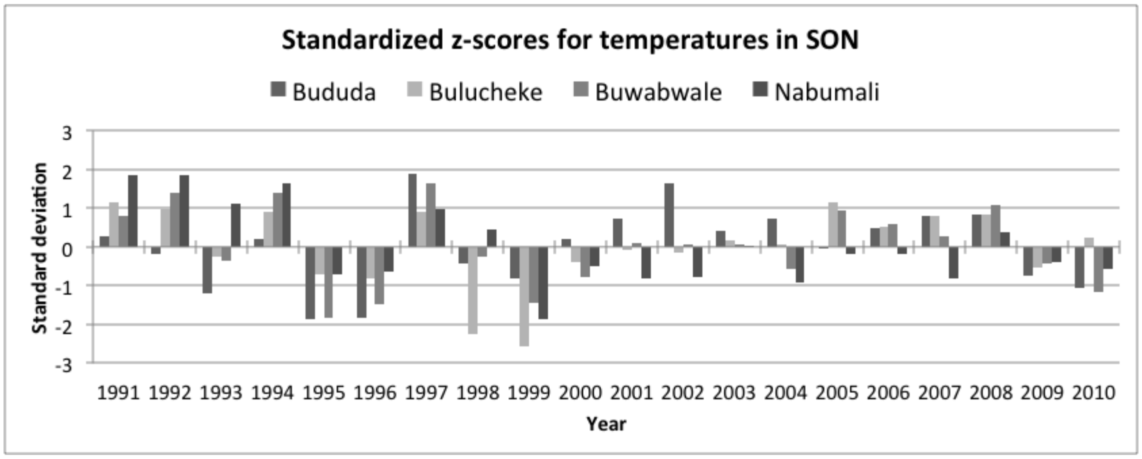


Figure 21 The graph show tendencies in colder/warmer climate during the months SON relative to the mean temperature for SON from 1991 to 2010. The graph is classified after the four climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96.

In Figure 22 are the z-scores for yearly mean temperatures. The years 1995 and 1996 seem to be extreme cold years with statistically different scores for all the stations. While 1997 seem to be an extreme warm year with statistically different scores for Buwabwale and Nabumali. Very different from the rest of the climate stations is Bududa in 2009 with extreme warm scores.

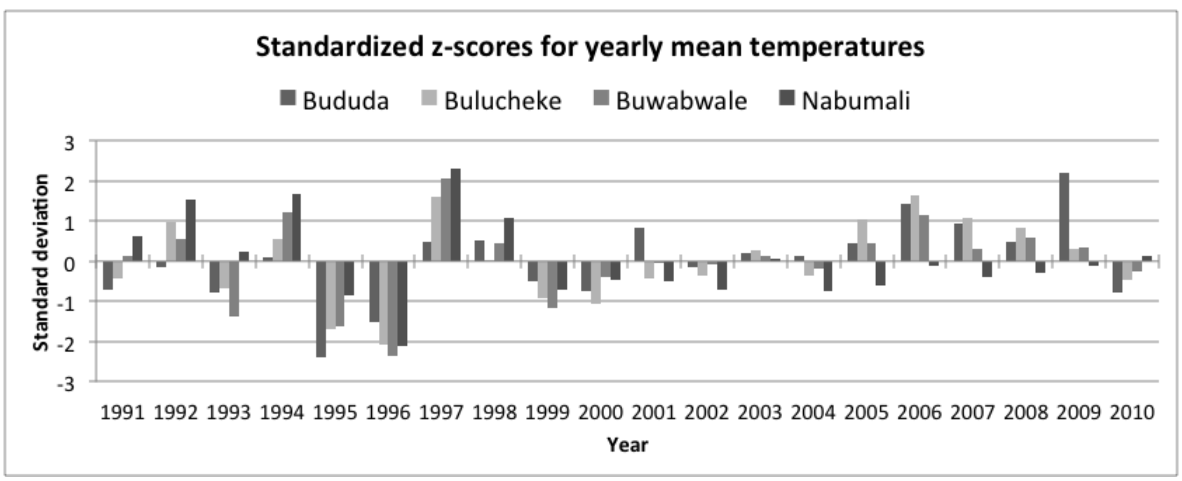


Figure 22 The graph show tendencies in colder/warmer climate for yearly mean relative to the mean temperature from 1991 to 2010. The graph is classified after the four climate stations within the study area. The z-scores are significant at a standard deviation of +-1.96

6 Discussion

6.1 The farmers perspective

From the theories presented in this report it can be concluded that the land problems and climate variations noticed by the farmers on Mount Elgon are similar to what the rest of Uganda is experiencing. A total of 87 percent of the farmers have an experience of climate change. The type of climate change that was mentioned most times by the farmers were drought, storms, floods, change in rainfall season, destroyed cropping and shorter rain season. Many of these are connected and have influence on another, such as drought, destroyed cropping and shorter rain season. How the farmers choose to express themselves by using words like drought and famine (expressed in the interviews), which are terms often used for conditions more extreme than those that can be found in the study area. However, this does not mean that the problems the farmers have are less real. As there can be concluded from the interviews 81 percent of the respondents are dependent on agriculture as their major source of income, further it could be seen that farming is a highly unstable source of income ranging between 8000 – 60,000 Ugandan shillings (UGX) per month. Converted to US dollars 8000 UGX ≈ 3 USD and 60,000 UGX ≈ 24 USD. Based on this income the farmer can be classified to be in extreme poverty living on under 1,25 dollar (FN sambandet 2013) per day.

The land is without doubt very important for the farmers on Mount Elgon. Their status of living depends greatly on what the land produces, as a source of income. When the respondents were asked if they had experienced any problems with their land, 89 percent answered yes. The major types of problems specified by the respondents were soil infertility, drought, soil erosion, flooding and pest and deceases. The connection between the experienced climate extremes and problems with land can be concluded from the literature. Strong rainfall, especially on uncovered soil, is very like to erode making the soil loose its fertility and also the connection between drought and change in rainfall is clear. In the perspective of hazards, larger variations from the normal tend to bring stress for the humans, and from what the respondents have answered many of them tend to live under stressed conditions. The farmers are vulnerable for changes. In a greater view this have an influence of the farmer interest and perspectives at a regional and national level, as people at risk generally are less provided with rights and protections, and are also found more politically vulnerable (Hewitt 1997). Giving the farmer knowledge of how they can manage their land more sustainable is said to be one of the best ways to protect the local environment and make the farmers less vulnerable for future climate changes (Ulsrud et al. 2008). It can therefore be found problematic that only 43 percent of the respondents answered yes to the question if they had been in contact with authorities or NGOs. The impression the farmers made during the interviews when asked this question was frustration and anger. Those who had been contacted by authorities or NGOs could tell they were only given seeds of bad quality or the help that has been promised never came.

6.2 The climate perspective

At a whole there cannot be detected any clear tendencies of wetter/dryer or colder/warmer climate but there are occasions with extreme climate events happening in the studied period. Not unexpected there can be seen more geographical variation between the different climate stations on the rainfall data, than in the there can be read in the temperature data. This is can be because the variation in topography within the study area making the precipitation fall more uneven and showers to be more local.

Since El Nino southern oscillation is believed to have a strong impact on climate extremes such as drought and more rain it would have been interesting to compare this with the z-score anomalies to look for similar patterns in wetter/dryer or colder/warmer years.

6.3 Whose responsibility?

The environmental degradation can also be results of deforestation and inappropriate farming practices and deforestation. The invariably of cultivation, misuse of practices and use of simple tools will in long terms lead to land degradation. When continuously farming on the soil without replenishment nutrients the fertility of the soil become lower (Nema 2010). In the slopes of Mount Elgon there is no longer good and fertilize soil available so people have to move uphill towards less productive soil, where forest is removed to be used as agricultural land. The same area has also been identified to one of the hot spots for land degradation such as soil erosion and soil infertility (Nema 2010, Bamutaze 2010). So why is this land still in use? The answer to this is because of the growing population the demand of land for settlement and agriculture is high (Nema 2010).

It has been easy to find information about signs of climate change happening in Uganda, there are much literature written about the topic and all the reports from the government, NGOs and scientific articles conclude the same; there are climate change happening in Uganda and it is the farmers in rural areas who are the most vulnerable to these changes. But there seems to be a huge gap between what is said and concluded at national and regional level and the action happening in the local communities. Alone the farmers do not have the resources to adapt to climate change and they lack the knowledge to protect the land with better conservations practices, therefore the help most come from outside. Than the question is who are responsible of providing that help?

6.4 Uncertainties and limitations to knowledge

Climate is complex. And to be able to give realistic description of the climate more parameters than the two used in this study should be included. A discussion on how representable these climate stations are for the whole study area should have been done. A huge dilemma in this report has been validating how accurate the climate data is. Since the data has not been given to the writer directly from the primeary source but instead have been adapted from earlier studies in the same area it is difficult to validate. It could have been possible to look for new and better data, because of the frame of this project it has not been possible to contact primary sources and ask for new data. Nevertheless this is recommend for continued studies in the area. For this project, there have instead been put trust on earlier scientists that have used the same data.

There are always uncertainties in trusting how good peoples memory is and this should have been taken into greater consideration in the interviews by asking more question and having the respondents define better what they expressed. The data from interviews therefore have to be interpreted at a more general level with again give more impreciseness to the report.

7 Conclusion

A total of 87 percent of the farmer respondents claims in the interviews that they are experiencing climate change in events such as drought, storms and flooding. Drought is mentioned as one of the major problems farmers are experiencing on their land together with soil erosion and soil infertility. Based on a statistical analysis of rainfall and temperature data from 1991-2010 there cannot be concluded any tendencies of a changing climate, but there are events of extreme climate that potentially can be hazardous.

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Appendix 1

Interview questions

1. Name
2. Age
3. Gender
4. How many people live in your household?
5. Main occupation
6. Source of income
7. How many years did you go to school?
9. A) How long have you been living in this village?
   B) How far and why did you move?
10. Name of village
11. Population of the village
12. A) Have people moved to or from the village in the last five years?
    B) How many?
13. How much land do you use/cultivate?
14. A) What do you experience is the biggest problem with your land use?
    B) Have you done anything to improve your land?
15. Have you experienced any climate change in recent years, such as an increase or decrease in rainfall, temperature, drought, flooding, landslides?
16. Who owns the land?
17. Where is the land situated?
18. What is your major land use/crop?
19. Do you irrigate?
20. How is the work in the field organized?
21. Have you had any contact with local government or NGO:s been here talking about land degradation?

Institutionen för naturgeografi och ekosystemvetenskap, Lunds Universitet.

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