Citrus fruit farmers' adaptation capacities to climate variability in Ngora district, Eastern Uganda

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KURJ
ISSN 2790-1394

pp. 86 - 98
Vol 1. Issue 3.
July 2022

ABSTRACT

Over the past three decades the government of Uganda prioritized fruits growing in Teso sub-region as a means to promote socioeconomic development. However, climate variability threatens the realization of this initiative and yet inadequate research has been done to address this gap. This study assessed citrus fruit farmers' adaptation capacities to climate variability in Ngora district, eastern Uganda. Longitudinal and cross-sectional research designs were adopted in which 135 randomly selected farmers were interviewed. Findings indicated that 82% of the respondents attested that rainfall amounts and temperature patterns had changed with the highest rainfall of 1686 mm received in 1991, and the lowest amount of 785mm received in 2009. Average annual temperatures in the same period varied between 23.8ºC and 25.7ºC. These variations contributed to a drop in orange fruit yields from 90% in 2015 to below 54% in 2016. Overall, 94.8% of citrus farmers were aware of the term climate variability and they associated it to variation in rainfall amounts and distribution, rise in surface temperature and occurrence of droughts; 73.3% of the farmers had positive attitude towards climate variability adaptation especially in instances where it directly affected their livelihoods. Only 21% of the farmers did something to adapt to climate variability through irrigating young orange trees. Conclusively, citrus growing provided an option to poverty eradication, however climate variability threatens farmer's efforts. In a short-run farmers may be encouraged to work in groups. Overall capital investment on irrigation technology by government and or other stakeholders will offer lasting solutions.

Keywords: Citrus fruits - climatic factors, Climatic changes, Agriculture - environmental aspects , Ngora district, Uganda

Background

Climate change which usually manifests itself inform of unreliable rainfall and high temperatures is among the greatest challenges that human race has faced in the 21st century and if not well managed; its impacts are likely to stall or reverse international efforts to propel development and reduce poverty (Trumper *et al.*, 2008). The capacity of humans to adapt to and cope with the effects of climate variability such as unreliable rainfall and prolonged droughts are progressing slowly (Juana *et al.*, 2013; Okonya *et al.*, 2013).

As such adaptation to climate variability may require farmers to first appreciate that the climate has changed and then identify useful mechanisms to cope with the ongoing changing conditions (Gbetibouo, 2009). In scenarios where farmers are unable to adopt to climate change effects, the consequences are dire and usually result to social, economic and ecological loses (Juana *et al.*, 2013).

Uganda like many developing countries in the world that depend on rain fed agriculture is very prone to the negative impacts of climate variability; this is worsened by the fact that the livelihood of the local people and the country's economy is agro-based. Thus any change in rainfall pattern and distribution usually results into worst conditions in food security, soil erosion and land degradation among others (Shikuku *et al.*, 2017).

Over the past four decades the amount and distribution pattern of rainfall has not been uniform, for instance; between 1991 and 2000, Uganda experienced seven droughts episodes and these had serious negative impacts on water resources, hydropower production, agriculture and the overall economy (Lane & McNaught, 2009). In the same period excess rainfall was noted during the ElNino of 1997/98 which also had its damaging impacts. For example; it caused outbreak of diseases, loss of crops and destruction of some infrastructure like roads and bridges. The worst occurrence of ElNino was in 1998 when excess rainfall caused deaths of over 100 people and displacement of more than 150,000 people. In March 2010, the occurrence of landslides for example in Bududa district left over 100 people dead and destroyed lots of food crops. In the downstream areas, over 6,000 people were affected by flush floods directly or indirectly especially in Butaleja district.

Similar to the above, analysis of pre-analysed rainfall and temperature data for Ngora district also showed that between 1983 –2013, the amount and distribution of rainfall and temperature had varied. Variations and shifts in rainfall patterns affects crops yielding and farmers livelihoods (Belarmain & Sanchez, 2015; Kotir, 2011). Meteorologists and economists of Uganda for example note that; the persistence of poverty among the rural farmers in Uganda is partially due to poor crop yields exacerbated by inadequate and erratic rainfall. This is further illustrated by the decline in economic growth from about 1.3% (6.6% in 2004/05 to 5.3% in 2005/06 due to inadequate rainfall received in that time (Osbahr *et al.*, 2011).

Despite the predicted bad conditions, the capacity and readiness of local farmers in most parts of Sub Saharan Africa and Uganda in particular, to adapt to such conditions is still very low (Kotir, 2011; Okonya *et al.*, 2013). There is also very scanty information to explain the relationship between farmers perceptions and adaptations to changing rainfall and temperature patterns (Belarmain & Sanchez, 2015; Okonya *et al.*, 2013; Osbahr *et al.*, 2011). It was therefore very important to conduct this study as it would provide useful information to address the current challenges faced by citrus farmers and may also act as a reference source for decision making in matters of adaptation to the negative impacts of climate change. The main objective of the study was to assess the perception and adaptation capacities of citrus farmers to the impacts of water stresses and shortages (climate variability) in Ngora district. Specifically the study intended to: 1) Assess temporal variations in rainfall and temperature in Ngora district over a period of 30 years 1983 to 2013. 2) Establish the relationship between Farmers' socioeconomic factors and Knowledge, Attitude and Practices (KAP) towards adaptation to climate variability

Materials and Methods

Study site

This study was carried in Kees and Kumel parishes both located in Mukura Sub County in Ngora district (figure 1). Ngora district is located in Eastern Uganda. These parishes have many citrus fruit farmers, at the same time they are usually faced with harsh weather conditions especially higher temperatures, drought and irregular rainfall (Ngora District Development Plan, 2015 - 2020). The study examined pre-calculated rainfall and temperature data covering a period of 30 years (1983 to 2013), this period was considered due to availability of complete datasets for both rainfall and temperature which was extracted from online data sources. While data on farmer adaptations was collected over a period of 20 years that is since the technology of citrus fruit growing was introduced in Teso sub-region where Ngora district is located.

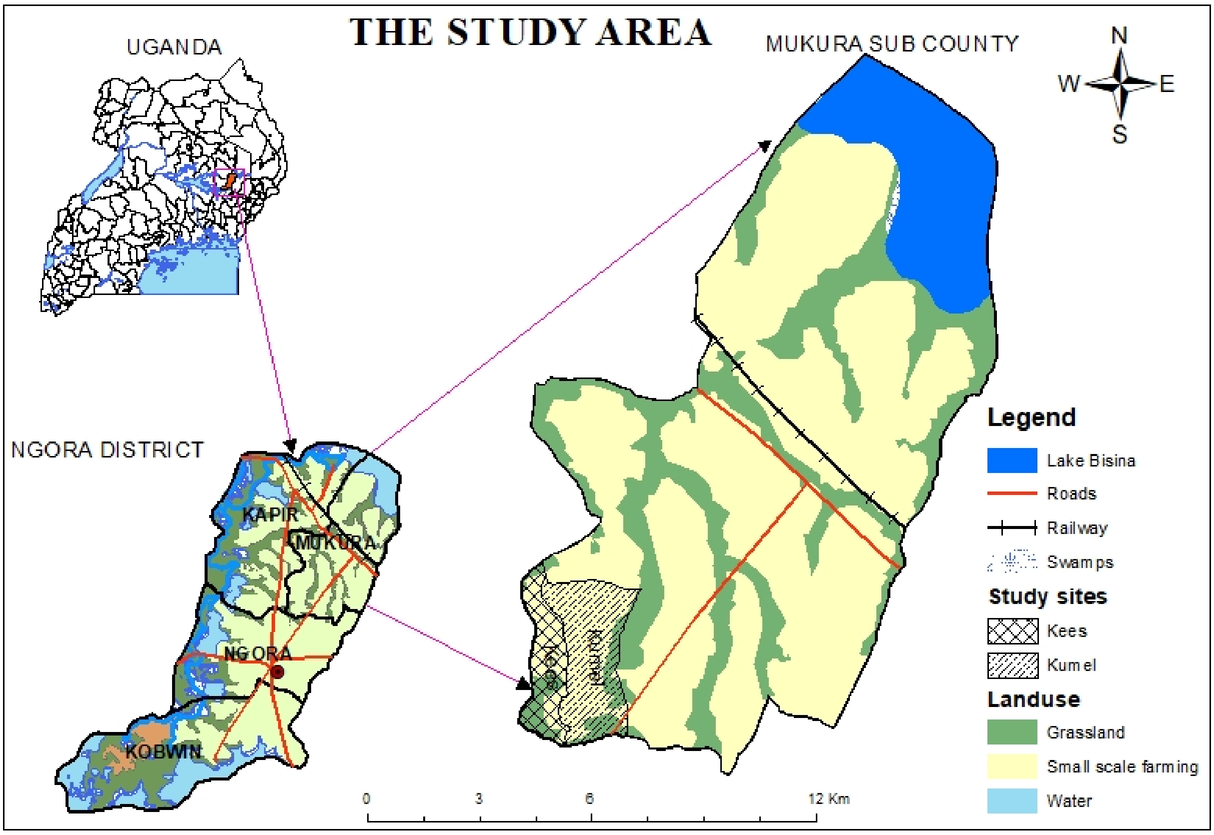

Figure1: Location of study site in Ngora district

Study design and population

This study adopted both longitudinal and cross-sectional study designs, this was because some (weather) data had been collected overtime and the other was directly collected from the citrus fruit farmers. The study population constituted of the local citrus fruits farmers as primary population, and the other category included Key Informants Interviews (KIIs) including district agricultural officer, assistant agricultural officers, wetlands officer, environment officer, forestry officer and the in-charge Operation Wealth Creation (OWC). There were about 204 households with more than 50 citrus trees on their farms that is in Kees (108) and Kumel (96) parishes respectively (District Development Plan 2015 - 2020).

Determination of the Sample size

Given that the total population targeted by this study was 204, the sample size n of 135 was determined from Slovin's Formula

$$n = \frac{N}{1 + Ne^2}$$

where e = 5% or 0.05, at 95% confidence level, N = 204

Therefore the study targeted information from a sample of 135 respondents: 71 from Kees and 64 from Kumel. Farmers to be interviewed were then selected randomly.

Data collection and analysis methods

A cross sectional survey using a self-administered questionnaire and face to face interviews were held to collect data from the local citrus fruit farmers. In addition, focused group discussions comprising of 12 citrus fruit farmers were held to supplement and triangulate the interviews responses. Data were analyzed using the Statistical Package for Social Scientists (SPSS) version 20. Time series trend analysis was used to present rainfall and temperature patterns over the 30 year period.

Results

Temporal variation in rainfall and surface temperature in Ngora District over a period of 30 Years

Field findings indicated that annual rainfall totals in Ngora district ranged between 785mm and 1686mm The highest amounts of rainfall of 1686mm was received in 1991, 1639mm received in 2001 and 1626mm received in 1996 respectively while the lowest rainfall amount of 785mm was experienced in 2009 (Figure 2). The rest of the years recorded moderate rainfall amounts ranging between 1490mm and 1000mm per annum. It is visible that the amount of rainfall received was still adequate to support crop farming, the only challenge was its distribution which was erratic in nature.

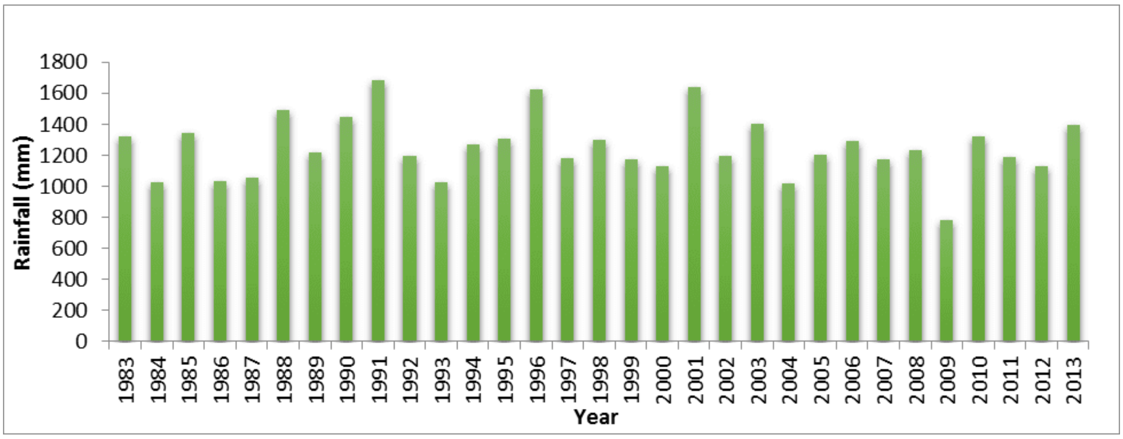

Figure 2. Temporal variation in annual rainfall in Ngora District from 1983 to 2013

In terms of monthly rainfall distribution, the months with high average rainfall amounts (above 100mm) over the study period were April and May (for the first season) and August, September, October and November (for the second season). Looking at the dry conditions, the lowest average rainfall amounts of below 60mm was experienced in January, February and December (figure3).

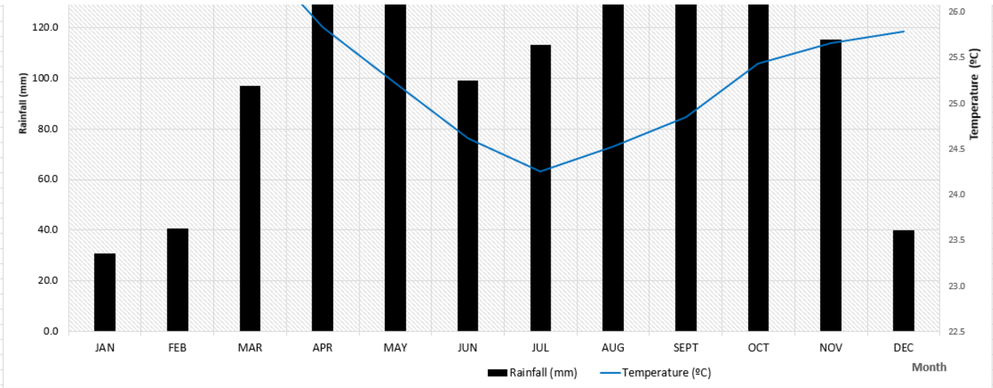

Figure 3. Temporal variation in rainfall and temperature in Ngora District over a period of 30 Years.

Over the three decades 1983 to 2013, the annual average temperatures ranged between 24.3ºC and 27ºC; it was only in the three years (1985, 1989 and 1994) where the lowest (around 24ºC) mean annual temperature was recorded. On the other hand, the three years of 2003, 2002 and 2009 recorded the highest mean annual temperature of above 25.5ºC; the rest of the years recorded temperature of between 24ºC and 26ºC (figure 3).

In terms of monthly temperature variations; the months of June, July and August recorded the lowest mean monthly temperatures below 24ºC whereas January, February and March recorded the highest mean monthly temperatures above 25.5ºC (figure 4).

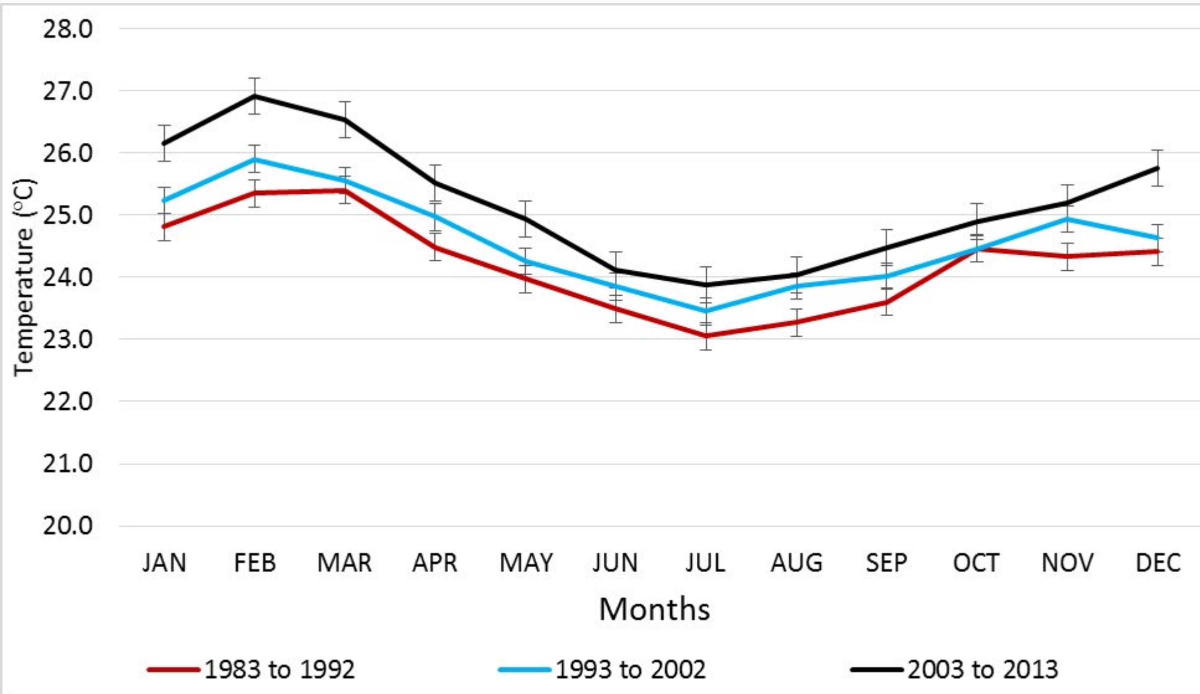

Figure 4: The average surface temperature variations for the decades of 1983 to 2013 in Ngora District

Farmers' perception on rainfall distribution and temperature over the past 10 years

Study findings show that 82% of the respondents testified that the rainfall and temperature patterns had become irregular (figure 5). Farmers stated that in the past it was easy to master the farming calendar; they knew for example that first planting commences in late February or March. "In February the first rains would start falling and go on until late June where a short dry season would follow in the months of July and August.

By September, the second rains would then start falling and continue through to mid-December when the long dry season would commence and go on till late February or March. However, in the recent past the reverse is true, 'the rains never come on time, and even whenever they did, the amounts were very small with various breaks (dry spells) in between the wet season", stated one of the orchard farmers during a focused group discussion in Kees Parish. Timely return of rains would enable farmers to plan on what crops to grow (especially annual crops), depending on rainfall amounts expected in that specific season.

A smaller percentage of 15% of the fruit farmers agreed that the rainfall and temperature patterns were regular and had not changed very much compared to the past decades. Despite this, they also acknowledged that the amounts of rainfall had reduced while the temperatures had continuously increased. To this category of respondents, the distribution of rainfall remained bimodal. Only five respondents were not sure whether the rainfall pattern was regular or irregular. Accordingly, they stated that sometimes rains come a little earlier that is in late February or early March and other times the rains delayed for example start in April. However, like others, they also appreciated that the conditions in 2016 were a little unique and distorted as very little rainfall and very high temperatures for both the first and second season were experienced.

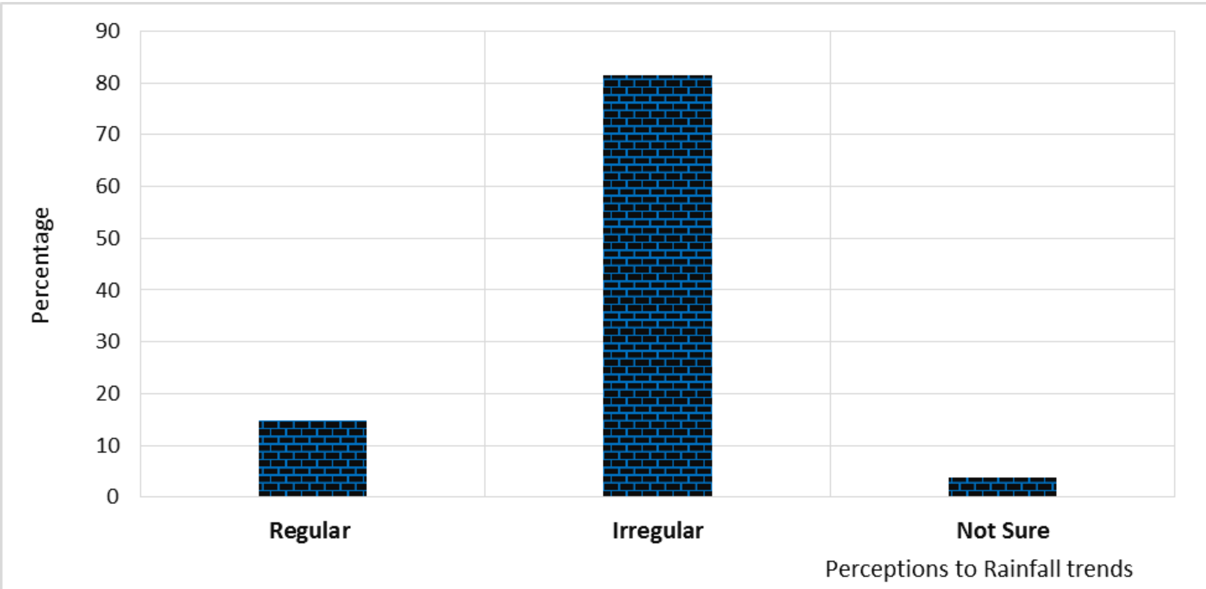

Figure 5. Farmers' perception on rainfall distribution and temperature over the past 10 years

Farmers' Knowledge, Attitude and Practices (KAP) towards climate variability

Results show that 94.8% of the citrus famers had heard of the term climate change. The farmers associated climate variability to changes in rainfall distribution and amounts, increase in temperature and other weather parameters like strong winds especially during the dry season and storms in the wet season. However, about five percent of the respondents claimed not to be aware of the meaning of climate change, although they were experiencing variations in rainfall distribution, amounts and temperature.

During focused group discussion, citrus farmers noted that the worst harvest over the past decade occurred in 2016 where a prolonged dry spell led to death of young orange fruits, affecting orange fruiting (plate 1). This was further confirmed by the district agricultural officer who noted that there was a significant drop in the yield from about 90% in the previous years to less than 54% in 2016. Drought severely affected orange fruit yields….. "*Usually when we have adequate rainfall I harvest about 55 bags of oranges from my 110 trees (orchard), however due to the long dry spell this year, I have got only 27 bags*" reported one orange farmer in Kumel Parish. Reduced yields worried most farmers as it directly affected their earning.

Although climate variability manifested in many ways, the dry spell and rise in temperature were noted to have affected farmers most as all the farmers irrespective of their location while flooding was ranked least because it affected fewer farmers especially those in low lying areas.

About 98% of the farmers stated that human activities like vegetation clearance and degradation of wetlands have contributed to changes in rainfall and temperature conditions. Such human activities are known to increase drought conditions by reducing the amount of rainfall received. Trees and wetlands through evaporation and evapotranspiration processes recharge the hydrological cycle which in turn influence the prevailing weather conditions of any place. However, once vegetation is lost, the recharging aspect and carbon sequestration are equally lost, noted a forest ranger. Despite high awareness about climate change variability, some farmers believed that the current weather variations were natural and cyclic in nature and man had little or no control over it.

Plate 1. The effect of prolonged drought on citrus fruits in Kumel village (October, 2016)

Attitudes and Concerns about Climate Variability

In examining the attitudes of citrus fruit farmers' towards climate variability, questions were asked regarding the extent to which they were concerned about climate change effects. Results of these are presented in figure 6.

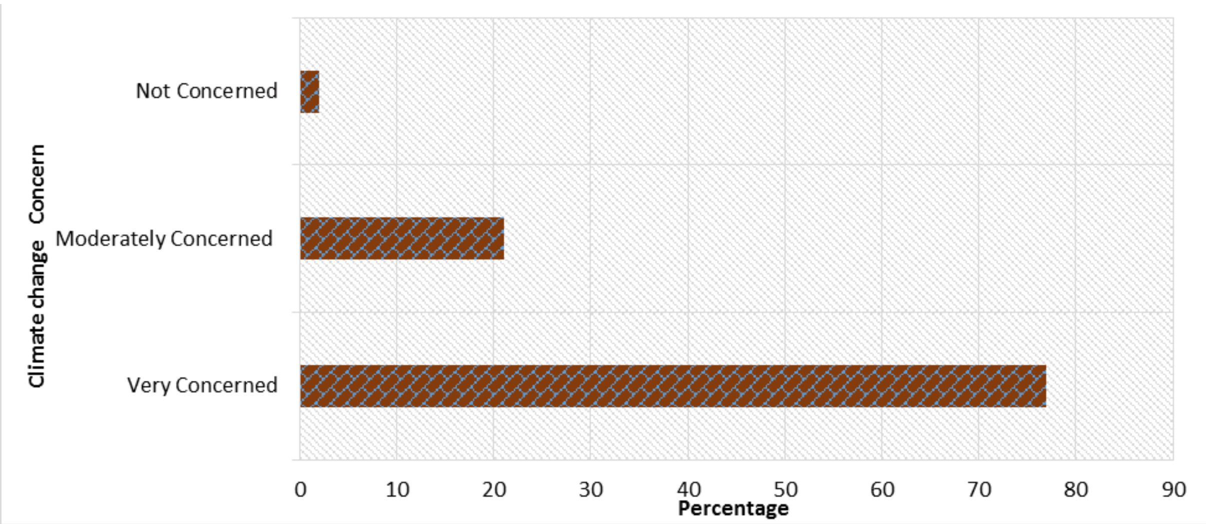

Figure 6. Farmers concerns about Climate Change

About 77% of citrus farmers were very concerned about the negative effects of climate variability especially on their orchard establishments. They noted that droughts and high temperatures contribute to reduced orange fruit yielding and this in turn led to increased poverty levels. Some of testified that they were not able to pay school fees for their children because of poor yields realized and they requested government to support them during dry seasons. "*….we call government or any other nongovernmental organizations to support us to access irrigation facilities to avoid total losses in times of inadequate rainfall. We ask for this because irrigation technologies are very expensive and therefore many farmers cannot afford*". In the meantime farmers were willing to do anything possible to adapt to climate variability effects. This was through irrigating the young orange trees using old perforated plastic bottles filled with water and tied directly on the stem of an orange tree or supported with a stick (plate 2). The water in the bottle then trickles down slowly and improves on the moisture content of the soil.

During group discussions and through field observations, drip irrigation technologies were mostly applied on younger orange trees and in small gardens (plate 2). The older trees could not be irrigated using perforated plastic bottles because they required much water which a small plastic bottle couldnot hold. Most old orange trees therefore dried or suffered water stress whenever drought or high temperatures occurred.

Although faced with the harsh weather conditions, about 21% of fruit farmers were moderately concerned about climate variability, this applied mostly to those farmers who did not have strategies for managing the weather extremes. They believed that, the actual causes and origin of climate change were not known thus single actions by a few individuals could not cause much change in combating climate change. "*committing ourselves alone without engaging other persons in the world can never yield any positive results in managing extreme droughts and flooding, there is need for everyone to be engaged especially people from the developed world who contribute much to pollution and climate change*" stated one farmer in Kees village.

It is worth noting that many farmers were less educated and relatively poor, for that reason, they could not afford any alternative means to mitigate climate extremes. To others, climate variability in terms of excessive rainfall was seen as a relief especially during the second planting season which in the past associated with the challenges of inadequate rainfall, they could therefore engage in the growing of other crops for subsistence and other benefits. Furthermore, about 2% of the farmers were not concerned about the negative effects of climate variability on their fruit trees. They believe these are works of nature that are not permanent, because in due time, the situation would normalize and farmers would be able to earn normally from their orchards. Generally, increased awareness among farmers on how to cope-up with the negative impacts of climate variability greatly influenced their behavior and willingness to mitigate climate variability.

Adaptation practices applied by citrus farmers to minimise climate variability

Fruit farmers used various strategies and practices to adapt to the variability of climatic conditions especially in times of drought and high temperatures. About 21% of the citrus fruit farmers did something to adapt to climate variability while 79% could not afford alternative adaptation strategies to minimize climate variability. Farmers used water retention technologies like mulching and drip irrigation as to adapt to water stress (Plate 2).

Plate 2: A farmer demonstrating the use of perforated plastic bottle for drip irrigation

Generally, the most common practices used by some farmers to minimize negative effects of water shortages included; diversification of agriculture, swamp/wetlands restoration (conservation), afforestation and reforestation, soil conservation, rainwater management and growing of fast maturing crops among others (figure 7).

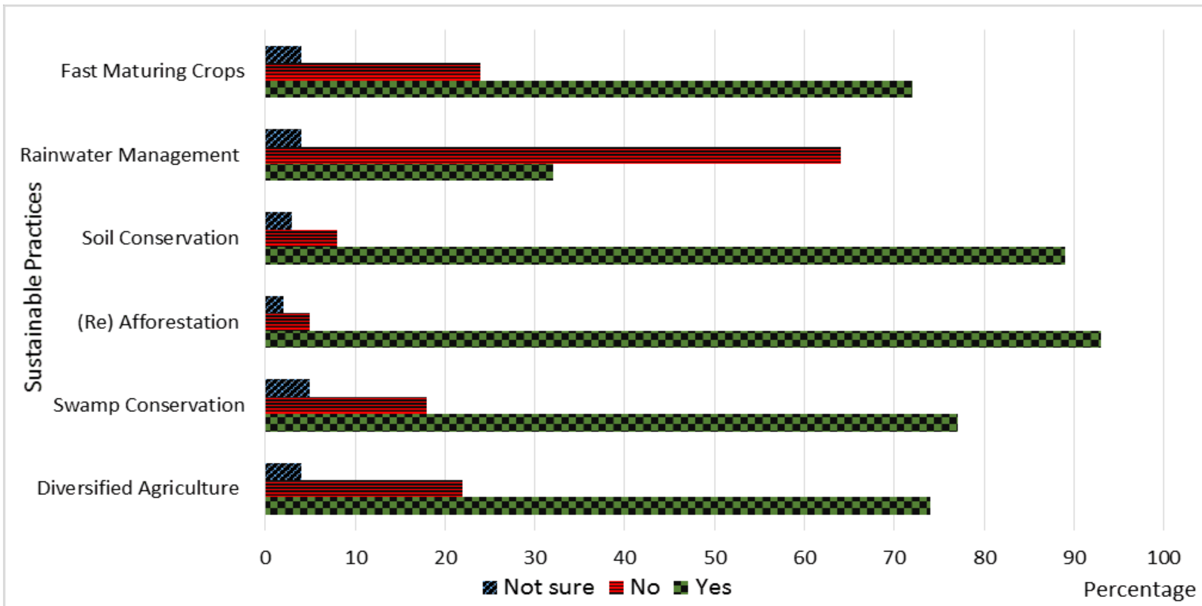

Figure 7. Adaptation practices and strategies applied by citrus farmers to minimise climate variability

Discussion

Demographics

Male farmers were more engaged in citrus fruit growing as compared to female farmers; this may be attributed to the cultural practices of land inheritance where land is passed-on from one generation to another following patrilineal male lineage. The boys who get land inheritance rights therefore may easily involve themselves in fruit tree growing as compared to their female counterparts.

Similarly, the young were less involved in fruit tree growing probably due to cultural limitations as well in that decisions on the use of family land is mostly determined by parents, thus even if youth and females had interest in growing orange trees they could not due to the above reasons. A bigger proportion of farmers earned less than 500 dollars in a year, therefore they could not invest in technologies that were capital intensive to address the challenges of climate variability. Results of the focused group discussions indicated that besides engaging in formal employment, most households headed by educated persons were engaged in commercial and some intensive farming because they had some money to invest in technologies and strategies to adapt to climate variability. It is therefore possible that the low annual incomes among many farmers is as a result of low education levels since such farmers could not benefit from formal employment and also take long to internalize and or adapt to any new changes..

Variation in rainfall and surface temperature in Ngora District over a period of 30 Years

The study affirmed that surface temperature and rainfall distribution and amount had varied in Ngora District during the three decades of this study. This was furthers supported by the district agriculture and production report which indicated that the variability of weather had contributed to a drop in the yield of orange fruits from about 90% in the in 2015 to below 54% in 2016. Similarly a study in Ethiopia also indicated that 58% of farmers had observed changes in climate over the past 20 years. This had led to loses in terms of decreased yields, it was also regarded as the major cause of increasing poverty (Habtemariam *et al.*, 2016; Tessema, Aweke, & Endris, 2013). It is thus worth commenting that climate variability is one of the leading causes of poverty among the people of Ngora district and Uganda at. This because most of the local farmers depend on farming which is rain-fed in nature and cannot withstand extreme weather conditions.

Farmers' Knowledge, Attitude and Practices (KAP) towards climate variability

More than 90% of the farmers were aware of the meaning climate variability, this finding coincides with what most scholars discovered that most people world over were aware of what climate change means (Muller & Shackleton, 2013; Sacchettini & Calliera, 2017). Despite the higher levels of awareness, some farmers still believe that the current weather variations were natural and cyclic in nature and they had little or no control over it. It is important to note that such respondents were from born again Christian (Pentecostal) households who believed that, the droughts or floods experienced could have resulted from God's anger emanating from unrepentant behavior of human beings (Mike Hulme, 2009; Takyi & Addai, 2002). They believed that farmers could overcome the current weather challenges through praying to God for forgiveness. Such farmers stated that the current humans had sinned against God in many ways and the current climate change and other disasters were warnings were fruits of sins committed by the fore-fathers and the current humans, they were also sign of the end times.

Adaptation practices and strategies applied by citrus farmers to minimise climate variability

The response of farmers to the challenges of climate variability is manifested by the myriad of adaptation practices such as: diversification of agriculture through growing of fast maturing crops, restoration and conservation of wetland resources, afforestation and reforestation, soil conservation and rainwater management among others as the major adaptation practices. Such practices have also been adopted by farmers in other parts of the world (Habtemariam *et al.*, 2016; Tessema *et al.*, 2013, Bryan *et al.*, 2013). Although there is an elaborate range of such practices, planting short season varieties, crop diversification were considered as very useful short term adaptation strategies (Biazin & Sterk, 2013; Tambo, 2016); and growing of draught resistant crop varieties were highly recommended (Li *et al.*, 2015; Okonya *et al.*, 2013) .This is because some of the coping strategies are not very feasible and practicable because they require high investment costs (Bamutaze and Mutenyo, 2011; Elum *et al.*, 2017). Most of the farmers could not afford better adaptation strategies since they are at the base of the economic pyramid (Mapfumo *et al.*, 2013; Muller & Shackleton, 2013). It is advisable that the local governments and other development partners consider such expensive ventures in order to support citrus fruit growing in Ngora district as a means of alleviating poverty and promoting socioeconomic development among farmers.

Conclusions and Recommendations

This study confirmed that climate variability had taken place in Ngora district and mainly manifested itself in form of variations rainfall distribution and amounts. The highest rainfall 1686 mm was received in 1991 and the lowest rainfall amounts of 785mm was experienced in 2009. The annual average surface temperatures ranged between 23.8°C and 25.7°C. However, a lover surface temperature of 24°C was experienced in 1989, 1985 and 1994 respectively.

Some citrus farmers had adapted to climate variability through application of drip irrigation especially for younger orange trees, others harvested rain water and grew fast maturing and drought tolerant crops. Farmers requested governments and other development partners to support them through establishment of irrigation facilities and ensuring that flowing water reaches out to all the farmers in the landscape, this would minimize loses and ensure bumper harvests which would lead to socioeconomic emancipation.

The study recommends that, as a short term measure, citrus farmers should be mobilized to work in groups to harvest rain water through digging of trenches and holes to collect water during the rainy season this water would be used to irrigate orchards during the dry season. Working in groups a tradition practice in the study area it is therefore easy to mobilise farmers and help them in a short run to cope up with the challenges of climate change. To mitigate the increasing rate of erratic rainfall patterns and droughts, Ngora district local government in partnership with line government ministries and other development partners should invest on modern irrigation technologies to harvest water and benefit citrus farmers so that they are able to produce even in times of extreme weather conditions as exacerbated by climate variability. In the mid and long term, there is need to strengthen the climate early warning systems to regularly and on a timely basis provide farmers with relevant information on current weather to support farming.

Acknowledgements

The authors express their sincere thanks to all the respondents' reviewers for their valuable inputs and opinions that supported the writing of this report. Specifically we thank the farmers of Kumel and Kees parishes, the Ngora district local Government leader's especially the Heads of Department for Environment and Natural Resources and Production and Marketing for providing information during data collection and most importantly the technocrats of Uganda National Meteorological Authority for providing pre-calculated climate data.

Funding

The study was privately sponsored and is part of a Masters study for ASP.

Availability of data and materials

All data generated and analysed during this study are included in this published article.

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