Research on Humanities and Social Sciences www.iiste.org
ISSN (Paper)2224-5766 ISSN (Online)2225-0484 (Online)
Vol.6, No.14, 2016

Farm-Level Adaptive Capacity to Climate Variability in Rice Production, Northern Uganda

G. O. Akongo[1, 2] W. Gombya-Ssembajjwe[1] M. Buyinza[1] and A. Bua[2]
1. School of Agricultural Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda
2. National Agricultural Research Organization, NARO, P.O Box 295, Entebbe, Uganda
Correspondence: Graceline O. Akongo, National Agricultural Research Organization, NARO, P.O Box 295, Entebbe

Abstract
Rice is Uganda's second major cereal crop however; its productivity has been considerably low and stagnant between 1.3 to 2.4 tons per hectare over the last 15 years. One of the underlying factors of low productivity is the current growing conditions which are not optimal for production due to climate variability. Adaptation is therefore pivotal in countering climatic challenges in production. Empirical evidence however, point to limited adaptive ability of farmers. This paper assessed farm-level adaptive capacity and its contribution to rice yield enhancement in Northern Uganda. The study was conducted on a sample of 240 rice producers in northern Uganda during 2010 - 2014 growing seasons. Adaptation capacity was measured quantitatively using indicator of access, use, knowledge and consultation levels. The study results revealed that the average farm-level adaptive capacity was 0.64 which falls in the range of moderate adapters. The study drew the following conclusions: adaptive capacity regarding use of local coping strategies was high contrary to the conventional strategies such as improved variety and herbicide. The moderate to high adaptive capacity was due farmer's ability to access and use coping strategies than knowledge and consultation on the strategies. There was a considerable difference in yield between the low and high adapters. In order to improved farmer adaptive capacity, there is need for: early weather information sharing on specific crops and locality, research on rice production technologies, validating, strengthening and out-scaling of relevant local coping strategies, improving adoption of conventional coping strategies and access to quality seeds.
Keywords: Coping strategies, Adaptive capacity, Climate variability, Rice.

1. Introduction

Since 1990s, rice production has increased significantly in Uganda as a result of the introduction of upland varieties and the deterioration of some traditional cash crops such as cotton. Rice is the country's second major cereal crop after maize and has contributed significantly to agricultural Gross Domestic Product (GDP), (Republic of Uganda, 2009; Republic of Uganda, 2010; UBOS, 2015). Despite being a major cereal crop, rice productivity has been considerably low and stagnant between 1.3 to 2.4 tons per hectare over the last 15 years (Odogola, 2006; Oonyu, 2011; Kijima *et al*., 2011; Kijima, 2012; UBOS, 2002; UBOS, 2015; NEWEST, 2012; Miyamoto *et al.*, 2012; Akongo *et al.*, 2016).

One of the underlying factors of low productivity is the current growing conditions in Uganda which are not optimal for rice production because of high rainfall variability (Republic of Uganda, 2010; USAID, 2013; EPRC (2016); Akongo *et al*, 2016). Although Uganda lies within a relatively humid and equatorial climate zone, geographic features such as topography, prevailing winds and water bodies cause location specific difference in rainfall and temperature patterns. Variation include: seasonal total rainfall, the onset, cessation and the length of each rainy season (Figure1). The typical rain falls during two seasons in the south of the country which merges into one rainy season as one moves north and eastward. However, the current and past trends indicate that the timing of rainfall can vary considerably. According to USAID (2013), onset of rainy seasons can shift by 15 to 30 days (earlier or later), while the length of the rainy season can change by 20 to 40 days from year to year. As such, rice is considered second after coffee as the most vulnerable crops to seasonal climate variability (USAID, 2013).The major rice disease such as blast and bacterial leaf blight have significantly aggravated by adverse weather conditions that affect temperature, air humidity, and soil moisture status.

Production of highland rice is affected by the significant water stress due to intermittent short-term dry periods. According to Namazzi *et al*., (2010), drought is one of the main constraints in rice production with an annual loss of 18m^3/ha in Uganda. Reoccurrence of drought in Africa besides nitrogen deficiency have been cited as the leading constraints in production affecting nearly 80% of the potential 20 million hectares of rain-fed rice (NEWEST, 2012). IFPRI (2007) forecasts rice yield losses between 10 and 15% by 2050 as a result of climate change. While the rain-fed lowland rice on one hand is subjected to unseasonal frequent flooding of wetland (Odogola, 2006). However, the country lacks irrigation systems; only 2% of the total rice land is irrigated lowland, while 53% is rain-fed lowland and 45% is upland (USAID, 2013).

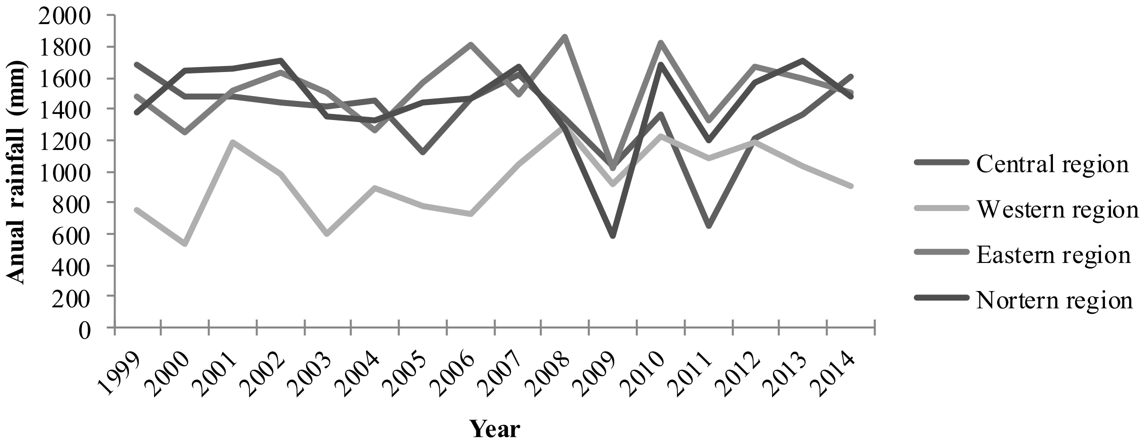

Figure 1: rainfall (mm) trend from selected centres by region.

Adaptation is therefore pivotal in translating climatic challenges and agricultural response into positive changes in production (UNEP, 1998). The Ministry of Water and Environment has moved a step forward by establishing a Climate Change Unit department (Republic of Uganda, 2011). This has provided institutional flat form through which stakeholders can address climate and adaptation issues. Adaptation is resilience of a country, community or household to absorb shock and build defenses against subsequent climate stressors (Mabe *et al.,* 2012). However, capacity to adopt coping strategies (such as improved technologies and crop management practices) is site, community and farmer specific as dictated by resources, economic activities and social factors (Akong'a *et al*., 1988; ACTS, 2005; Odogola, 2006; Mary & Majule, 2009; Mabe *et al*., 2012; USAID 2013).

To date, climate related studies in Uganda have focused primarily on impact projections, vulnerability and adaption options at national level (Wasige, 2009). Specifically northern Uganda is more vulnerable due to its agro-ecological characteristic and socio-economic settings but empirical evidence that point to adaptive capacities of rice farmers is limited. Some of the available literatures on adaptation studies include: effects of risk and uncurtaining from climate change actors along rice chain (EPRC 2016). Odogola (2006) investigated status of rice production where he found 67% of rice farmers were drought prone and did not have any coping strategies to drought. USAID (2013), conducted climate change vulnerability assessment and the study ranked rice second after coffee as the most affected crops to climate change and variability with northern Uganda being more vulnerable due to the two decades of northern.

This paper bridges the current literature gap by exploring farm-level adaptive capacity in rice production. The objectives are twofold: first, it was to determine farm-level adaptive capacity of rice producers and second, to assess contribution of farm-level adaptive capacity to rice yield enhancement.

2. Method

2.1 Survey design

The study was conducted in northern Uganda which comprised of Acholi and Lango sub-regions (Wortmann & Eledu, 1999; Wasige, 2009). It covered rice growing seasons of 2010 to 2014 (Akongo *et al*., 2016). Rice is not grown equally throughout the zone and this called for multiple sampling stages and techniques. In the first stage, two districts were selected from each sub-region based on prevalence of rice production. In Acholi sub-region, Amuru and Lamwo districts were selected while Lira and Otuke districts were picked for Lango sub-region. The four districts selected were purposively represented by the following sub-counties: Okwang (Otuke), Barr (Lira), Agoro (Lamwo) and Pabor (Amuru). Subsequently, selection of a total of 240 rice growing households which constituted the study sample was done on the basis of availability of a household head or spouse for interview on the first field visit in 2013 (Akongo *et al*., 2016). Two subsequent field visits were made in 2014 and 2015. The list of rice growing households was provided by the sub-country production department.

2.2 Data

All rice farming households within the study geographical area are equally exposed to climate stressor, but the levels of adaptive capacity vary from one farmer to another. To capture individual variation, a semi-structure household questionnaire was used to quantitatively classify and capture indicators of adaptive capacity (accessibility, utilization, knowledge and consultation levels of each copping strategy). These indicators as applied to coping strategies defined the nature of farmer adaptive capacity.

At the same time, a qualitative inquiry was conducted to determine farmer perceptions on the current seasonal climate which provided in-depth insights into the locally perceived climate patterns. Information on perceptions was elicited based on farmers perceive variability related to excessive rains, untimely rains, longer dry periods. All these indicators can interrupt the normal growth cycles of rice production, resulting in low yields or total crop losses. Additional checklist was used to capture climate and rice data from Uganda National Bureau of Statistics (UBOS) and Uganda National Meteorology Authority (UNMA), Akongo *et al*. (2016). All the data captured fell within seasonal growing calendar for rice in the region (April to October).

2.3 Analytical procedures

Farmers are rational and as such they adapt to climate variability in order to reduce its consequences (Ellis, 1988). The act of developing adaptation measure is based upon prior expectation and perception by the farmer about a current climatic condition and how it affects crop production. As such, this study defines farm-level adaptive capacity as the ability of rice farmers cope with climate stressor (cession, duration and extreme events like drought and floods) by adopting a set of coping. However, capacity to adapt a set of coping strategies varies from farmer to farmer based on certain factors that are peculiar to each person (Nakuja *et al*., 2012). Farm-level adaptive capacity in this study was determined quantitatively by focusing on key indicators of adaptive capacity and its implication on rice yield.

Mabe *et al*. (2012) measured adaptive capacity by considering five indicators (knowledge level, utilization, availability, accessibility and consultations on a coping strategy). With reference to Nakuja *et al*., (2012) and to Mabe *et al*. (2012), farmers were asked to indicate their degree of attainment of each indicator (knowledge, utilization, accessibility and consultation levels of a coping strategy) as a measurement of their relative adaptation. This study considered coping strategies used by the farmers to include: tillage practice, seedbed leveling, high seeding rate, weeding, use of herbicides, switching rice varieties, training and lowland cultivation. Adaptive capacity was then quantified according to indicator levels on a coping strategy. The level of indicators with respect to a coping strategy therefore determines whether a farmer has low, moderate or high adaptive capacity. The highest degree of attainment of each indicator is given a score of 1.0, moderate is given 0.5, whereas the lowest is scored 0.25. The score level for a farmer with highest attainment of each indicator on a coping strategy should be above 0.75 and it is summed as adaptive capacity. Table 1 summarizes how each indicator is measured. Table 2 provides description of indicators and levels of adaptation based on coping strategy.

Table 1: score levels of farmers' achievement of indicators according to a coping strategy.

Indicators	High	Moderate	Low
Knowledge	Very well	Well	Not well
Utilization	Several times	Twice	Once/Never
Accessibility	Easily accessible	Accessible	Not easily accessible
Consultation	Several times	Twice	Once/Never
Scores	1.00	0.50	0.25

The adaptive capacity of a rice farmer is calculated as shown in equation (1) below:

$$AdapCap = \sum_{k=9} \frac{Accessibility(k) + Utilization(k) + Knowledge(k) + Consultation(k)}{number\ of\ indicators} \qquad (Eqs. 1)$$

Where: k is the coping strategy (switching to lowland, small plot size, tillage practice, leveling seedbed, high seed rate, switching rice varieties, weeding, herbicide use, and water control).

Lastly, the score level attained in equation 1 is summed for the entire sample to get average adaptive capacity in equation (2) below as follows:

$$Average\ AdapCap = \sum \frac{Adaptive\ capacities}{observations} \qquad (Eqs. 2)$$

Table 2: Description of variables

Variable	Variable description	Ranges of indices
Indicators of a strategy		
Accessibility	Access to a coping strategy	0.25 ≤Adaptive capacity≤ 1.00
Utilization	Utilization of coping strategy	0.25 ≤Adaptive capacity≤ 1.00
Knowledge	Knowledge on a coping strategy	0.25 ≤Adaptive capacity≤ 1.00
Consultation	Consultation on a coping strategy	0.25 ≤Adaptive capacity≤ 1.00
Adaptive capacity		
Low	Low degree	0.25≤Adaptive capacity≤ 0.49
Moderate	Moderate degree	0.50≤Adaptive capacity≤ 0.74
High	High degree of	0.75≤Adaptive capacity≤ 1.00

3. Results and discussion

3.1 Description of coping strategies used by rice

Table 3 provides descriptive statistics of coping strategies. The region has two types of rice cropping system; lowland and upland. Lowland cultivation is done by 86% of the sampled fields but Lango sub-region constitute majority of lowland cultivators. Most farmers prefer lowland to guard against risk of low moisture availability in a situation of less rainfall. Odogola (2006) also reported that 0.5% of farmers shifted their rice fields to the lowlands to take advantage of better moisture regimes in the valleys. The strategy of reducing plot size to only 0.4 hectares to minimize a foreseen risk of variability in climate was among 67%of the farmers. Average plot size under rice cultivation is 0.49 hectares which concurs with findings in Kijima (2012). While the average rice yield is 2 tons per hectare. Tillage practice using oxen or tractor to prepare rice field was applied by 66% of the sampled farmers. Leveling seedbed by ploughing two to three times before planting is applied by 93% of the sampled farmers. The practice is more prevalence in Lango sub-region where Odogola (2006) also found that farmers ploughed their field a number of times before planting. According to the sample, 82% of farmers use higher seed rate above 60 kg per hectare to compensate for those that may not germinate. About 59% of the farmers switch from one variety to another (Supa, Kaiso, Sindano and Nerica) as required. Regulating water in rice field was done by 68% of the farmers, higher than in Odogola (2006) and Kijima (2012) who reported less than 30% of the farmers. Farmers start weeding their rice before 2 weeks after germination and the study found 71% of the farmers were able to weed their rice field twice and above. Although herbicide an important labour saving technologies, its application in weed control is limited as reported by only 25% of the farmers.

Table 3: Farmers using coping strategies

Adaptive Strategies	Mean	Std. Dev.	Min	Max
Switching to lowland	0.86	0.35	0	1
Reducing plot size (0.4 ha)	0.67	0.47	0	1
Tillage practice (use oxen or tractor)	0.66	0.47	0	1
Leveling seedbed (twice or more)	0.93	0.25	0	1
Seed rate (more than 60kg ha^{-1})	0.82	0.39	0	1
Switching rice variety	0.59	0.49	0	1
Weeding (twice or more)	0.71	0.45	0	1
Herbicide use	0.25	0.43	0	1
Water control	0.68	0.47	0	1

3.2 perception of climate trend

Local perceptions by farmers with respect to seasonal variability in temperature and rainfall (Table 4) are closed related to empirical analysis of rainfall and temperature trends using the data obtained from meteorological station (Figure 1), UBOS (2015). Generally in the past, rainfall use to begin in March but with a short dry spell in June before resuming in July. However, farmers noted variation in rainfall amounts and patterns as indicated by either early or late onset of rainfall. A particular area might be receiving the same amounts of rainfall in a season but there are changes in distribution and therefore leading to floods and/or droughts.

About 18% of the farmers observed delayed onset of rainfall at the start of rice growing season thus causing delays in cropping activities. The delayed onset of rainfall during 2010, 2013 and 2014 affected mainly farmers who sow their seeds between March and April. However, farmers who sow their seeds in July experienced delays in start of the season during 2010, 2011, and 2012. While only 2% said onset of seasonal rainfall was earlier than usual. However, 3% contrasted the first three category of farmers and said that onset of rain was at the usual time in accordance with their rice cropping activities.

In regards to amount of rainfall, 13% of the samples confirmed that rainfall during their various rice production activities was too short and inadequate to support healthy plant growth. According to Tsuboi (2011), a 5 day mean rainfall above 20mm in a month from planting date is adequate for rice productivity. Less rain below 20 mm was received in April (2010, 2011 and 2014), June (2013 and 2014) and July (2012 and 2014) but the amount varied between the years. April is the sowing month for those who plant early (especially varieties with longer maturity period). While shorter maturing varieties like Nerica is planted in July. However, 47% reported that rainfall amount was adequate while 15% noted that rainfall was too much and affected normal cropping activities. As depicted in figure 1, rainfall was generally low throughout the growing season of 2014. The same applies to the rest of the years where rainfall was low between April and July with September to October which are harvesting months having more rains.

For farmers, this implies increased risk of crop failure, due to poor seed germination, washing away of seeds and crops, stunted growth, drying of crops caused by changes in rainfall pattern and amount. Sometimes this leads to re-ploughing and replanting thereby increasing production costs or reducing plot size and increasing seed rate application, while some move cultivation to lowland area. Increased pest infestation like in Otuke district where unknown invasive weed can causes up to 100% yield loss due to flooding. However, fields which are not subjected to flooding experience none or minimal incidence of this parasitic weed. FAO (2007) reported that changing temperatures and rainfall in drought-prone areas are likely to shift populations of insect pests and other vectors and change the incidence of existing vector-borne diseases in both humans and crops.

Other studies have also reported similar observations of intra-seasonal factors, such as timing of onset of first rains, distribution and length of period of rain during the growing season affect crop-planting regimes (Rowhani *et al*., 2011; Nagabhatla &Yurova 2012). IPCC (2007) reported that changes in rain-fall amount and patterns also affect soil erosion rates and soil moisture, both of which are important for crop yields.

Table 4: farmer perception about climate pattern during rice production activities.

Perceived pattern	Percentage
onset of the rain delayed and it was dry	18
Onset was earlier than usual	2
Onset of rain was at the usual time	3
Rain span was too short and inadequate	13
Rain was enough	47
Rain was too much	15

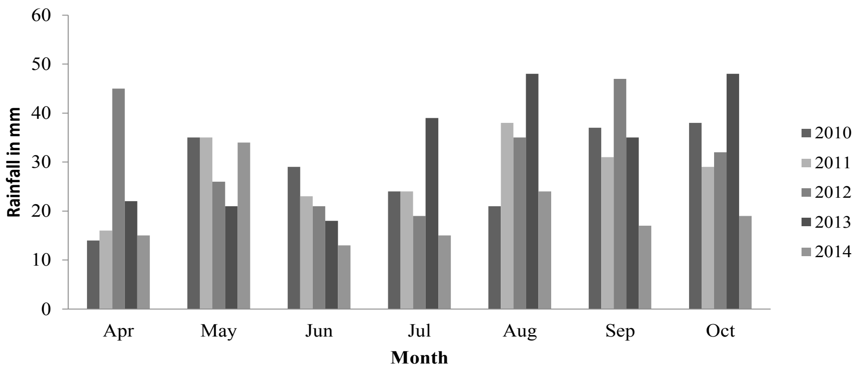

Figure 2: rainfall average (mm) of 5 days in a month

3.3 Degree of adaptive capacity

The degree of adaptive capacities of rice farmers to the various coping strategies is presented in table 5. Farmers are generally moderate adaptive capacity to coping strategies to minimize effects of climate variability on rice production. On average, farmers have high adaptive capacity only on weeding rice field twice and above which was registered on average at 0.75. However, farmers in Lango sub-region have moderate adaptive capacity in weeding compared to their counterparts in Acholi sub-region. Weeding rice field more than once boost plant growth.

While moderate adaptive capacities were recorded on cultivating lowland, water control, reducing plot size, tillage practice and high seeding rate. Switching to lowland cultivation was 0.69 although higher adaptive capacities (0.84) were found among farmers in Lango sub-region. Lowland area usually retain considerable amount of moisture even during dry spell which improved crop performance. Odogola (2006) found only 5% of the farmers had the capacity to shift their rice fields to the lowlands to take advantage of better moisture regimes in the valleys. Capacity to regulate and control water is 0.50 but farmers in Acholi sub-region were lower adapters (0.47). Poor drainage management can cause flooding in some instance and limited water availability situation. In the case of Acholi sub-region (Agoro irrigation scheme), construction of irrigation scheme between 2012 and 2013 affected water supply to the field. Some fields were flooded as water level increased while others lacked access to adequate water due to poor elevation and drainage.

This result agrees with findings in Odogola (2006) where fewer farmers (24.7 percent) could regulate water in their fields. The practice of reducing plot size contrary planed size to minimize risks when farmers expect extreme climatic event was moderately adapted (0.52). Smaller plot size has the advantage of reduction in the magnitude of damage and costs but also compels the farmer to complete specific cropping activities within time. Moderate degree of adaptive capacity was observed in tillage practice (0.67) but farmers in Lango sub-region have high adaptive capacity (0.70). One of the reasons advanced by the farmers for using oxen or tractor is that it brings fertile soil to the surface, shutters the soils thus allowing for water infiltration as well as reducing the burden of weeds. This could explain why farmers in Lango weed their rice fields only once or twice. Higher seeding rate registered moderate degree of adaptive capacity among rice farmers (0.69) but farmers in Lango sub region have high degree of adaptation capacity (0.77).

The recommended seeding rate is 50 kg per hectare, but farmers are using between 62-130 kg per hectare as risk minimizing strategy to compensate for those which may not germinate or die. The finding in this study is similar to previous studies where seeding rate was 90 kg per hectare (Haneishi *et al*., 2011; Miyamoto *et al*., 2012). Farmers attributed risks of poor germination and low plant population to poor seed quality and climatic condition such as drought or floods which affects seed germination. Miyamoto *et al*. (2012) recommended the need to re-examine whether the recommended seeding rate of 50 kg per hectare is appropriate. Akongo *et al*. (2016) agrees to this recommendation but site specific factors and seed quality that characterize small holder farmers should be considered. However, low adaptive capacity was registered on strategies like switching rice variety, leveling seedbed, and herbicide application.

Switching rice variety as required by prevailing climatic condition was low at 0.44. This is because farmers have limited options of drought tolerant and early maturing rice varieties at their disposal to choose from. The current drought tolerant variety (Nerica, also known as New Rice for Africa) is not highly suitable for the agro-climatic condition of northern Uganda. Capacity for leveling seedbed was only 0.47.Leveling has advantage of ensuring uniform plant growth, distribution of water in the field as well as proper moisture infiltration. Capacity for herbicide application was also low (0.34).

Table 5: Adaptive Capacities of Farmers by strategies

	Northern region		Lango sub-region		Acholi sub-region	
	Mean	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Cultivating lowland	0.69**	0.25	0.84***	0.09	0.55**	0.27
Water control	0.50**	0.19	0.54**	0.16	0.47*	0.21
Switching rice variety	0.44*	0.15	0.44*	0.13	0.44*	0.17
Reducing plot size	0.52**	0.17	0.53**	0.16	0.52**	0.17
Leveling seedbed	0.47*	0.21	0.58**	0.22	0.37*	0.13
Tillage practice	0.67**	0.17	0.70**	0.15	0.64**	0.17
High seed rate	0.69**	0.27	0.77***	0.26	0.61**	0.25
Weeding two to three times	0.75**	0.24	0.65**	0.29	0.84***	0.12
Herbicide application	0.34*	0.14	0.39*	0.16	0.29*	0.09
Obs	211		101		110	

***High adaptive capacity, **Moderate adaptive capacity, and *Low adaptive capacity.

In terms of percentage distribution of indicators of adaptation by degree of adaptive capacity among farmers, moderately adapting farmers were inclined to accessibility (74%), utilization (65%) and knowledge (57%) of coping strategies than the two categories of low and high adapters. While farmers who were more inclined to consultation constituted low adapters. Consultation usually prevails under farmer group organizations and association where farmers learn from one another as well as access of trainings from extension workers within their group settings. It is possible that low adapters are limited by access and use of potential coping strategies much as they consult and get knowledge from fellow farmers within the associations and extension workers. Limitation in accessibility and utilization of coping strategies is not surprising given the fact that households in the region are yet to regain their livelihood assets owing to the two decades of conflict. Input requirements such as suitable land, quality seeds and capital are a constraint to the already resource poor farmers. Displacement resulted in loss of production assets and disrupted access to agricultural production resources (Republic of Uganda, 2003; Omach, 2002; Ahikire *et al*., 2012; ACCS, 2013).Large numbers of high adapting farmers subscribed more to utilization (35%) and accessibility (22%) but again are constraint in knowledge and consultation. Generally, knowledge and consultation ability of farmers on coping strategies is weak (Figure 3).

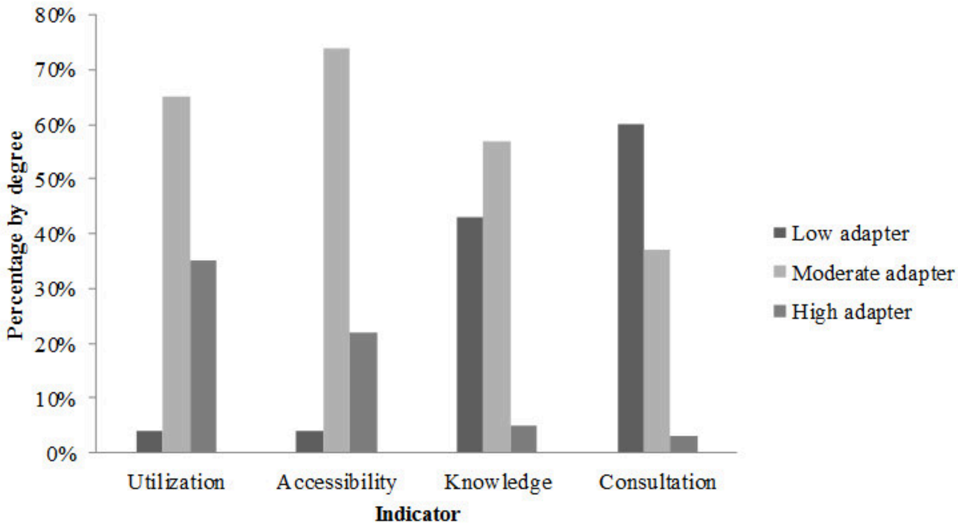

Figure 3: percentage distribution of indicators by degree of adaptive capacity.

The overall average adaptive capacity of farmers to effects climate variability in rice production is 0.64 which falls in the range of moderate degree of adaptive capacity (Table 6). USAID (2013) also found that 10% and 22% of rice growing households in Lira and Gulu respectively were most vulnerable to climate variability. The result in this study agrees with Mabe *et al.*, 2012 who also found that rice farmers in Tanzania were moderate adapters at 0.55. This implies that farmers in east African region are moderate adapters to climate change and variability. High degree of adaptive capacity was 0.75 which constituted 8% of the sampled farmers in Northern region, 14% in Lango sub-region and 3% in Acholi sub-region. Moderate degree of adaptive capacity was 0.59, constituting 69% of farmers but Lango sub-region contained larger percentage of the farmers (78%). Farmers falling in the range of low adaptive capacity constituted remaining 9% of the samples. Low adapters could be those whose agricultural livelihood was greatly affected by conflicts (Ahikire *et al.*, 2012; ACCS, 2013). Odogola (2006) also found 69% of rice farmers did not have coping strategy to drought and were drought prone.

Table 6: distribution of degree of adaptive capacity

	Northern region		Lango sub-region		Acholi sub-region	
	Mean	**percent**	**Mean**	**percent**	**Mean**	**percent**
High adapters	0.81 (0.05)	18	0.82 (0.05)	30	0.76 (0.02)	7
Moderate adapters	0.62 (0.06)	73	0.63 (0.06)	62	0.60 (0.06)	82
Low adapters	0.46 (0.02)	9	0.44 (0.01)	8	0.46 (0.02)	11
Average Adaptive capacity	0.64 (0.11)		0.67 (0.12)		0.60 (0.09)	

Figure in parenthesis are standard deviation

3.4Adaptive capacities and yield performance

The average yield per hectare across sampled fields in the region is about 2 tones but vary by the degree of adaptive capacity of the farmer (Table 7). Farmers with high adaptive capacities obtained 2.4 tons per hectare of paddy rice constituting yield growth increase of 25% above the regional yield average. Lango sub-region recorded more percentage yield growth of 31% compared to Acholi sub-region which was only 2% per hectare among high adapters. A substantial decline in yield below the average was registered at 3% in the entire region and further drop of 15% below average in Lango sub-region among moderate adapters. On the contrary, moderate adapters in Acholi sub-region experienced yield enhancement by 3%. Farmers with low adaptive capacity got lower yield of only 1.4 tons per hectare which is 29% decline relative to the regional yield average per hectare. Yield among low adapters in Acholi and Lango sub-regions dropped by 25 and 38% respectively.

The findings in this study agree with USAID (2013) who found rice income constituted half of all crop income and contributed between 24 to 33% of the total household income among rice households with low adaptive capacity (the most vulnerable rice households) in Gulu and Lira districts. This implies that rice households with low adaptive capacity do not diversify income source as opposed to their counterparts.

Table 7: yield performance by degree of adaptive capacities.

	Northern region		Lango sub region		Acholi sub region	
	Yield	**growth**	**Yield**	**growth**	**Yield**	**growth**
High adapters	2.4 (1.0)	25	2.5 (1.0)	31	2 (0.8)	2
Moderate adapters	1.9 (0.9)	-3	1.7 (0.8)	-15	2.1 (0.9)	3
Low adapters	1.4 (0.6)	-29	1.2 (0.6)	-38	1.5 (0.5)	-25
Average yield	1.9 (0.9)		1.9 (1.0)		2 (0.8)	

Figure in parenthesis are standard deviation. Yield is given in tons per hectare. Growth is in percentage

4. Conclusions and recommendations

4.1 Conclusions

The objectives of this paper were to determine farm-level adaptive capacity of rice producers and second, to assess contribution of farm-level adaptive capacity to rice yield enhancement. Local perceptions by farmers with respect to seasonal variability in temperature and rainfall are closed to information on rainfall and temperature patterns from meteorological station. Local perception of onset, duration and amount of rainfall differ by location and among farmers depending on sowing calendar. Prior knowledge of climatic condition of a growing season is of paramount importance in planning with greater confidence to minimize the negative consequences and exploit the benefit and opportunities which comes with variability. Unknown invasive rice weed has in Otuke district is linked to excessive rainfall and flooding of rice field. Farmers are moderate adapters to locally generated farm-level coping strategies but low adapters to conventional coping strategies. Adaptive capacity is influenced level of accessibility, utilization, knowledge and consultation on adaptive strategies. There is a considerable difference in yield between the low and high adapters.

4.2 Recommendations

The study gave consideration to the following specific recommendations:

i. A well-developed early warning system including weather information sharing on specific crops and locality is an invaluable asset in any plan to adapt crop production systems to a variable climate.
ii. Climate adaptation research and development progammes should be directed at developing rice production technologies and practices such as soil moisture conservation, suitable drought tolerant and high yielding rice variety for agro-ecological requirement of northern Uganda, herbicides and other forms of weed management technologies.
iii. Selection, testing, strengthening and out scaling of relevant locally generated coping strategies for their effectiveness to the rest of rice farming communities.
iv. Improve adoption of conventional coping strategies such as improved varieties, quality seeds, herbicides and fertilizers through on-farm technology dissemination and promotional activities.
v. Research should be done on optimal seed rate requirement for rice farmers in marginal agro-ecological areas.

Acknowledgement

The authors are grateful to the National Agricultural Research Organisation (NARO) for providing the financial resources which facilitated this study.

References

ACCS. (2013). Northern Uganda Conflict Analysis. Advisory Consortium on Conflict Sensitivity (ACCS), September 2013.

ACTS.(2005).Mainstreaming adaptation to climate change in the development process in Uganda. African Centre for Technology Studies (ACTS). Ecopolicy Series no. 15.

Ahikire, J., Madanda, A., & Ampaire, C. (2012). Post-war economic opportunities in northern Uganda: Implications for women's empowerment and political participation .International Alert, July 2012

Akong'a, Downing, Konijn, Mungai, Muturi, & Potter (1988). The effects of climatic variations on agriculture in central and eastern Kenya. In *the Impact of Climatic Variations on Agriculture, Volume 2.Assessments in Semi-Arid Regions.* The Netherlands, pp. 121–27.

Akongo, G. O., Gombya-Ssembajjwe, W., Buyinza, M., & Bua, A. (2016). Effects of Climate and Conflict on Technical Efficiency of Rice Farmers in Northern Uganda. Journal of Economics and Sustainable Development. Vol.7, No.11, 2016. ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online). Available on: www.iiste.org.

Ellis, F. (1988). Peasant economics, farm households and agrarian development Chapter 2 and 4. WYE studies in agricultural and rural development.

EPRC .(2016).Risks and Uncertainty from Climate Change affect Actors along the entire Rice Value Chain.How can domestic private sector investments support climate risk management along agricultural value chains in Uganda? Eonomic Policy Research Centre. Available online at: http://eprcuganda.blogspot.ug/search? Updated-min=2016-01-01T00:00:00-08:00&updated-max=2017-01-01T00:00:00-08:00&max-results=2.

FAO. (2007). Climate variability and change: adaptation to drought in Bangladesh. A resource book and training guide. Asian disaster preparedness center food and agriculture organization of the United Nations.

Haneishi, Y., Maruyama, A., Asea, G., Okello, S. E., Tsuboi, T., Takagaki, M., &Kikuchi., M. (2011). Exploration of rainfed rice farming in Uganda based on a nationwide survey: Regionality, varieties and yield. *An internal report of NaCRRI-JICA NERICA Project*. Namulonge, Uganda.

IFPRI. (2007). The International Food Policy Research Institute (IFPRI) report Climate Change: Impact on Agriculture and Costs of Adaptation.

IPPC. (2007). Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC (978 0521 88010-7 Hardback; 978 0521 70597-4 Paperback).

Kijima, Y. (2012). An Empirical Analysis of Expanding Rice Production in Sub-Sahara Africa Expansion of Lowland Rice Production and Constraints on a Rice Green Revolution: Evidence from Uganda. Working paper No. 49 December 2012. JICA Research Institute.

Kijima, Y., Otsuka, K., &Sserunkuuma, D. (2011). An inquiry into constraints on a Green Revolution in sub-Saharan Africa: The case of NERICA rice in Uganda. *World Development, 39*, 77-86. National Crops Resources Research Institute (NaCRRI). (Undated).Rice cultivation handbook. NERICA Promotion Project, National Crops Resources Research Institute, Namulonge, Uganda.

Mabe, F.N., Sarpong, D.B., & Osei-Asare, Y. (2012). Adaptive Capacities of Farmers To Climate Change Adaptation Strategies And Their Effects On Rice Production In The Northern Region Of Ghana. Russian Journal of Agricultural and Socio-Economic Sciences, No. 11 (11) /2012.

Mabe, F.N., Sarpong, D.B., Osei-Asare,Y. (2012). Adaptive Capacities of Farmers to Climate Change Adaptation Strategies and Their Effects on Rice Production in the Northern Region of Ghana. Russian Journal of Agricultural and Socio-Economic Sciences, No. 11 (11) / 2012

Mary, A. L., &Majule, A. E. (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. African Journal of Environmental Science and Technology Vol. 3 (8), pp. 206-218, August, 2009. ISSN 1991-637X © 2009 Academic Journals. Available online at http://www.academicjournals.org/AJEST.

Miyamoto, K., Maruyama, A., Haneishi, Y., Matsumoto, S., Tsuboi, T., Asea, G., Okello, S., Takagaki, M., & Kikuchi, M. (2012).Nerica Cultivation and its Yield Determinants: The Case of Upland Rice Farmers in Namulonge, Central Uganda. Journal of Agricultural Science; Vol. 4, No. 6; 2012. ISSN 1916-9752 E-ISSN 1916-9760. www.ccsenet.org/jas Journal of Agricultural Science.

Nagabhatla, N., &Yurova, A. (2012).Rice and Climate Variability: A Point Of Interest from The Context Of *Food Security.* APEC Climate Symposium 2012 8th October 2012, St Petersburg-Russia.

Nakuja, T., Sarpong, D.B., Kuwornu, J.K.M. &Ashante, F.A. (2012).Water storage for dry season vegetable farming as an adaptation to climate change in the upper east region of Ghana. African Journal of Agricultural Research, Vol. 7(2), pp. 298-306.

Namazzi, B.S., Okori, P., Baguma, Y. & Lamo, J. (2010). Analysis of drought tolerance in selected upland rice genotypes in Uganda.Second RUFORUM Biennial Meeting 20 - 24 September 2010, Entebbe, Uganda.

NEWEST (2012). Nitrogen and water efficiency salt tolerant rice: Annual progress report.

Odogola, R. W. (2006). Final Survey Report On The Status Of Rice Production, Processing And Marketing In Uganda. Submitted To the Embassy of Japan in Uganda through JICA and Sasakawa Africa Association-Uganda.

Omach, P. (2002). Civil War and Internal Displacement in Northern Uganda: 1986-1998. Working Paper. Published by NURRU Publications. December 2002.

Oonyu, J. (2011). Upland rice growing: A potential solution to declining crop yields and the degradation of the Doho wetlands, Butaleja district-Uganda. African Journal of Agricultural Research Vol. 6(12), pp. 2774-2783, 18 June, 2011. Available online at http://www.academicjournals.org/AJAR ISSN 1991-637X ©2011 Academic Journals.

Republic of Uganda. (2003). Post-conflict Reconstruction: The Case of Northern Uganda. Discussion Paper 7, April 2003, Ministry of Finance, Planning and Economic Development Office of the Prime Minister Office of the President.

Republic of Uganda. (2009). The Uganda National Rice Development strategy (NRDS) lays out Uganda's strategy for promotion of rice production between 2009/10 - 2017/18. Ministry of Agriculture, Animal Industry and Fisheries. Available on: www.agriculturego.ug.

Republic of Uganda. (2010). Agriculture Sector Development Strategy and Investment Plan: 2010/11-2014/15. Ministry of Agriculture, Animal Industry and Fisheries. Available on: www.agriculturego.ug.

Republic of Uganda.(2011). Ministry of Water and Environment. Climate Change Adaptation Strategy for the Water Sector.

Rowhani, Lobell, Linderman & Ramankutty. (2011). Climate variability and crop production in Tanzania. Agricultural and Forest Meteorology. Agricultural and Forest Meteorology 151 (2011) 449–460. Journal homepage: www.elsevier.com/locate/agrformet.

Tsuboi, T. (2011).Rice cultivation handbook. National Agricultural Research Organisation.

UBOS. (2002). Statistical abstract. Available on: http://www.ubos.org/publications/statistical-abstract/.

UBOS. (2003). Statistical abstract. Available on: http://www.ubos.org/publications/statistical-abstract/.

UBOS. (2015). Statistical abstract. Available on: http://www.ubos.org/publications/statistical-abstract/.

UNDP. (2013). Climate Risk Management for Sustainable Crop Production in Uganda: Rakai and Kapchorwa Districts. Prepared by the International Institute for Sustainable Development (IISD).Copyright © UNDP 2013.

UNEP. (1998). Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies.

USAID. (2013). Uganda climate change Vulnerability assessment report. USAID African and Latin American Resilience to Climate Change (ARCC), August, 2013.

Wasige, J. E. (2009). Assessment of impact of climate change and climate variability on crop production in Uganda. End of technical report submitted to START (Global change System for Analysis Research and Training – US national science foundation.

Wortmann, C.S. & Eledu, CA. (1999).Uganda's Agroecological Zones: A guide for planners and policy makers. Kampala, Uganda: Centro International de Agriculture Tropical.