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Original article

Watershed management and climate change adaptation mechanisms used by people living in dryland areas of Lokere catchment in Karamoja, Uganda

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ABSTRACT

The effects of climate change in Uganda are manifested by severe and sometimes extreme weather events such as droughts and landslides. An Integrated Watershed Management (IWM) plan was initiated in the Karamoja region, aimed at generating information that could be used to reduce climate vulnerabilities among the rural poor. The study aimed at determining the local community's perception of the effects of climate change on their livelihoods; and, to examine the effectiveness of the Integrated Watershed Management practices (IWMPs) on agricultural production within the area. Three hundred and ninety-seven households were randomly chosen and included in the survey. Interviews with local government officials who held high posts were conducted. Direct observations were also used for data collection. Findings showed that droughts and increases in pests and diseases; were some of the impacts caused by climate change events. Despite the initiation of IWMPs, climate change events moderately increased food insecurity (γ = 0.556; P=0.000) and also moderately affected community assets like roads and valley dams (γ = 0.426; P=0.000). In addition, household income insecurity was moderately and positively related to climate change effects (γ = 0.556; P=0.000). A weak positive relationship was found between the application of IWMPs and agricultural production (γ = 0.273; P=0.000). The Uganda Government should emphasize and intensify the implementation of IWMPs among the farmers living in agricultural watersheds as a means of continuously improving agricultural production and building the farmers' resilience to climate change events.

KEY WORDS: agricultural production; climate variability; food security; Integrated Watershed Management Iinitiative; livelihood components

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1. Introduction

The history of the study of climate change in environmental science can be traced back to the 19th century when the concept of the "Ice Age" and the "Greenhouse Effect" were proposed (IPCC, 2001, 2020). The early 1980s saw a sharp increment in worldwide temperatures and numerous specialists point to 1988 as the basic turning point for when watershed occurrences put global warming within the spotlight (HANSEN, 1988). In the United States for example, the summer of 1988 was the most scorching and saw a broad dry spell and rapidly spreading fires within the United States for example (HANSEN, 1988). Researchers like CHIJIOKE ET AL. (2011) and MIKOVA ET AL. (2015) predicted floods and droughts together with more powerful heatwaves as global warming increased. Consequently, it was stated that global warming would lead to unprecedented and highly damaging impacts like desertification and reduced agricultural food production (IPCC, 2001; ONOJA ET AL., 2011).

SALINGER (2005) and NYENJE & BATELAAN (2009) found that the major climate patterns of the 21st century included rapid temperature increases in high latitudes of the Northern Hemisphere, which caused more dryness in the Mediterranean regions and also led to erratic and unpredictable weather

changes. This adversely affected the day-to-day livelihoods of human beings (BAGAMBA ET AL., 2012). This is because according to KHANAL (2009), NELSON ET AL. (2009) and TUBIELLO (2012), agriculture, rural livelihoods and food security are inseparably connected with climate change. Hence, according to GROOTAERT & VAN BASTELAR (2002) and FAO (2005), climate change impacts can adversely affect access to livelihood components for community members by jeopardizing livelihood outcomes. The outcomes include reduced income, reduced vulnerability to climate change effects, and increased food insecurity (KRANTZ, 2001; SERRAT, 2017). The livelihood components according to ASHLEY & CARNEY (1999), KRANTZ (2001), FAO (2005) and SERRAT (2017) include human, social, natural, physical and financial aspects. This study mainly focused on the human, natural, physical and financial components. This is because, the components may be used as indicators in the study area that enable the farmers to recover from stress and shocks brought about by climate change effects (ASHLEY & CARNEY, 1999; SERRAT, 2017). The components may also be used as a measure of an individual's well-being (GOLLNICK & CHINN, 2013). Disruptions to livelihood components caused by climate change impacts are therefore more likely to affect the outcomes of a farmer's livelihood (SERRAT, 2017).

When considering the livelihood components, some studies (IPCC, 2001, 2020; OLSSON ET AL., 2019) show that the impacts of climate change are likely to be more severe for people in developing countries than for people in developed countries and are more likely to have undesirable effects on poor households in particular (BUCHS ET AL., 2011). In addition, KAISER (2006) posited that the impact of climate change on agriculture in developing countries is enormous since these countries tend to strongly depend on climatic conditions. CHIJIOKE ET AL. (2011) and IPCC (2020) add that increases in climatic variability bring about increases in extreme weather events which translates to low food production and availability especially in sub-Saharan Africa. Integrated Watershed Management (IWM), a modern method of land rehabilitation and climate adaptation (HADUSH, 2015), was introduced and used to counteract some of the impacts caused by climate change, especially in developing countries (GEBREGZIABHER ET AL., 2016). This is because, watershed ecosystems are reported to be highly vulnerable to climate extremes due to the nature of most of their landscapes, which are characterized by hilly terrain with both gentle and steep slopes that are subject to intense erosion (GEBREGZIABHER ET AL., 2016; NBI, 2017).

1.1. Theoretical framework

The study was anchored on the Theory of Change (ToC) model of climatic change adaptation as put forward by BOURS ET AL. (2014). This is because, the theory emphasizes well-coordinated long-term interventions to climate change adaptation and ecosystem services as is the case with the IWM (STEIN & VALTERS, 2012; SERRAT, 2013; ROGERS, 2014). BOURS ET AL. (2014) argued that the ToC model is well suited for climate change adaptation and evaluation because, although, the ultimate goal and time frame may extend far beyond the reach of the IWM initiative at hand, the model would be used to evaluate the outcomes of the project in the near term. ROGERS (2014) also postulates that the ToC explains how strategies put forward by the IWM may be adapted and responded to, as a result of the emerging issues for a particular outcome. It is also believed that the ToC articulates how the IWM interventions can be used as a precondition to achieve long term outcomes that may include food security and sustained livelihoods among community members (REINHOLZ & ANDREWS, 2020). The Integrated Watershed Management Practices (IWMPs) introduced as a way to adapting to the effects of climate change were aimed at promoting social changes among community members and hence the ToC was regarded as a perfect theory upon which the study hinged (CHETTY, 2018). Therefore, the ToC model follows a planning hierarchy of ecosystems which are sustainably managed for long term visions and is able to support the implementation of the ecosystems services' development strategies, with the view of alleviating poverty and sustaining people's livelihoods as outputs (BOURS ET AL., 2014).

1.2. Conceptual background

The term climate change is defined as the changes in climatic conditions that can be identified by climate's variability characteristics and that persists over long periods of time (IPCC, 2012, 2020). The NATIONAL RESEARCH COUNCIL (2010) argued that climate change is the statistical distribution of long-lasting weather patterns spanning decades to millions of years. LANDMAN (2010) define climate change as a change in the statistical properties (mean and spread) of the climate system, caused directly or indirectly by man, when considered over long periods of time. Hence, this study views climate change as the state of the climate system that has been naturally or anthropogenically caused and persists for an extended period of time.

IWM is defined according to some scholars such as GEBREGZIABHER ET AL. (2016), WANG ET AL. (2016), HADUSH (2015), KARPUZCU & DELIPINARI (2011), and FORCH (2009), as an adaptive, integrated, and multi-disciplinary systems approach to management that aims to maintain the productivity and integrity of ecosystems in terms of water, soil, plants and animals within watersheds, thereby protecting ecosystem services for environmental and economic benefit and restoration. The authors further view IWM as the process of organizing the use of land and other resources within a watershed to provide the services people want in a sustainable manner without impacting soil and water resources. Rain-fed agriculture contributes about 58% of the world's food basket (RAJU, 2008) and it is viewed as a focus of poverty, malnutrition, food insecurity, vulnerability to severe land degradation, water insecurity and poor social and institutional infrastructure (ROCKSTROM ET AL. 2007). A watershed development programme is, therefore, seen as an effective tool to address many of these issues and these are recognized as potential drivers of agricultural growth and development in vulnerable rain-fed areas (WANI ET AL., 2006). Watershed development projects according to GEBREMEDHIN (2006), have been designed to address several issues with the aim of promoting appropriate technologies for soil protection, land productivity enhancement, and the efficient and sustainable use of natural resources and agricultural productivity. Watershed management is reported to be at the centre of rural development and focuses on improving the livelihoods of local communities and households by promoting sustainable farming systems (DESTA ET AL., 2005; GEBREGZIABHER ET AL., 2016).

IWM practices according to FORCH (2009), SANDEEP (2015), JAMALI & RAEESI (2015) and GEBREGZIABHER ET AL. (2016) improve resilience towards climate change effects especially in arid areas by making water available in order to increase food productivity and to protect the agro-ecosystem thus raising peoples' socioeconomic conditions based on food security, health and education. Reports show that climate hazards such as floods, droughts, frosts, soil erosion and landslides are reducing in areas where IWMPs have been implemented (YACOB ET AL., 2008; GEBREGZIABHER ET AL., 2016). For GURJAR ET AL. (2011) and KERSE (2017), IWM programmes are initiated in dryland areas for the collective use of agricultural lands, water and vegetation to lessen the shortcomings brought about by climate change and they aim to improve people's livelihoods. KERR (2002), ROCKSTROM ET AL. (2007) and NBI (2014) add that the management of natural resources at the watershed scale aims to promote the conservation of soil, water and natural vegetation by using soil and water conservation practices such as terracing, mulching, and planting basins that may lead to a higher productivity of crops and livestock and thus improving peoples' livelihoods and protecting the environment from the effects of climate change. Hence, an IWM approach aims at balancing human and environmental needs, while guarding ecosystem services and biodiversity (BAKKER, 2012; WANG ET AL.,2016).

In this way, IWMPs are believed to enhance food security and alleviates poverty among members of the local community who live in watershed areas (NBI, 2014; HADUSH, 2015; GEBREGZIABHER ET AL. 2016). GEBREGZIABHER ET AL. (2016) further state that IWMPs are able to restore vegetation in previously eroded places and thus enhance the productivity of watershed areas.

1.3. Contextual background

In Uganda, climate change is being felt in all parts of the country, particularly manifested in unpredictable, violent and sometimes extreme weather events such as droughts, floods and landslides (HEPWORTH, 2008; FAO, 2017). The scale, frequency and severity of these disasters, especially droughts, have increased in recent decades (FAO, 2017). Specifically, in the region of Karamoja, evidence of climate change comes in the form of intolerable heat waves, droughts and extreme rainfall, resulting in undermining development gains and the lack of basic needs (CHAPLIN ET AL., 2017). The region is highly vulnerable to climate variability and change while suffering dramatic environmental degradation and deforestation which is a result of charcoal production, bush fires, deforestation and landscape change due to mineral extraction (MWE, 2017). Recurring droughts and flooding in Karamoja cause overwhelming food and income insecurity (NYENJE & BATELAAN, 2009; MWE, 2017) among the Karimojong and specifically within the Lokere catchment. Similarly, the prolonged droughts have led to complete crop failures with far-reaching effects on food security and the vulnerability of communities to hunger; less water and pasture for cattle; disease outbreaks; loss of biodiversity and increased conflict over resource use (TAYLOR ET AL., 2014; MWE, 2017). To address these impacts of climate change, particularly in Karamoja, the Government of Uganda, through the Ministry of Water and Environment in the 2003 Water Resources Reform, aimed to improve the resilience of watershed communities and agricultural systems by starting an integrated

watershed management programme to mitigate the impacts, by linking the management of water resources with the management of land, ecosystems and socio-economic systems. Most of the watershed inhabitants in developing countries like Uganda practice agriculture for a livelihood (SHENG, 1994). Given that the catchment is highly volatile and highly vulnerable to climate change shocks, it was realistic to assume that IWMPs have the potential to address climate change-related issues in the Lokere catchment (MWE, 2017). The main focus was to maintain agricultural productivity, as the distribution of rainfall is highly uneven and easily constrained by the effects of climate change, which adversely affect people's livelihoods (GEORGIS ET AL., 2010). Agricultural activities and smallholder farming in the Lokere catchment have been used as engines to retain the natural resource base of the drylands in order to contribute to the adaptation and mitigation of climate change. However, little information is known and documented about the initiative's successes and failures, if any, since the initiative was launched. This study therefore focuses on the Lokere catchment, in the Karamoja region of Uganda, to explore the effectiveness of the initiated IWMP in building adaptive capacity and ultimately mitigating the impacts of climate change (MWE, 2017). The primary focus was to generate the information needed by the local community members to appreciate the effects of climate change impacts in watersheds and to make informed decisions about their mitigation and adaptation. This would enable members of the local community to implement appropriate interventions that will enhance their resilience towards climate change impacts. Specifically, the objectives that guided the study were to determine the local people's perception of the effects of climate change on their livelihoods; and to examine the effectiveness of the IWMPs on agricultural production in the Lokere catchment.

2. Methodology

2.1. Study area

The current study was undertaken in the Lokere catchment located in the Karamoja region (Fig. 1) where the Integrated Watershed Management was initiated. The survey was conducted from the month of January to September, 2019. The catchment covers the districts of Kaabong, Moroto, Napak, Nakapiripirit and Kotido. The Lokere catchment covers a total area of 8,156 km^2, and has a population of 420,000 people from 51,299 households (MWE, 2017). The River Lokere Basin is strongly influenced by the River Lokere and its tributaries, and the Lower Lokere wetland complex. The catchment area is located on a large inland plateau, 400 m above sea level. 3,083 m above sea level. Mount Moroto which is 3,083 m above sea level, is the catchment's most noticeable landmark, while Mt. Napak located on the southern boundary of the catchment is about 3,000 m above sea level.

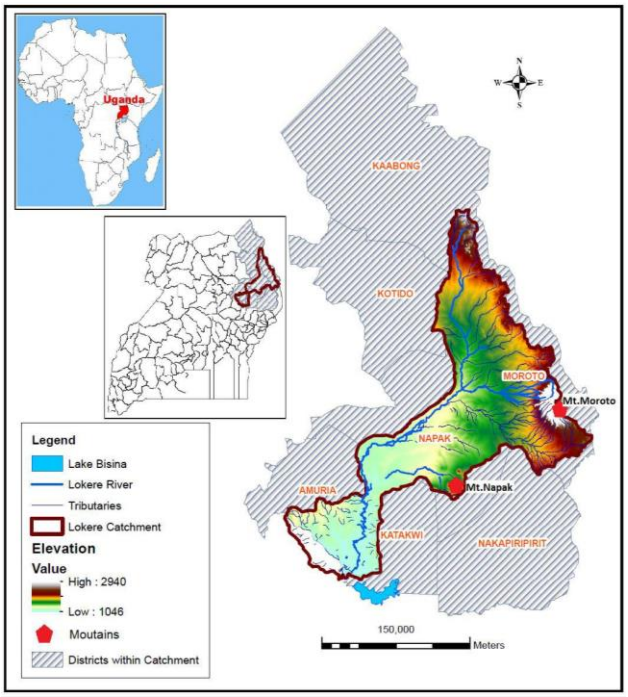


Fig. 1. Location of Lokere catchment, Karamoja Region

The River Lokere rises in the mountains of Moroto and Napak and the rugged mountains of the Kenyan border. The river flows to the southwest, via a network of seasonal rivers and extensive wetlands which eventually merges with the Awoja catchment located on the eastern part of Lake Bisina. From there, the water flows west through the Awoja wetlands to Lake Kyoga. The Lokere catchment includes five sub-catchments: Kapir, Omanimani, Akokorio, Lockoman and Nangaloapolon (MWE, 2017).

2.2. Techniques and instrumentations

This study included a descriptive cross-sectional survey using both quantitative and qualitative data structures. The descriptive cross-sectional survey design provided information about the study variables of the Integrated Watershed Management and how it affected climate change adaptation at some point in time (HALL, 2008). Qualitative data helped to confirm and enrich the quantitative information obtained from the study (LINDLOF & TYLOR, 2011; SARANTAKOS, 2005). A number of complementary strategies were used to collect the

vast amount of information. These strategies had the advantage of improving our ability to decipher the information collected as suggested by HOGGART ET AL. (2002).

Key primary data for respondents in the study area were collected by means of a questionnaire (appended). The questionnaire was used to gather information from community members and was pre-tested in another area. Pre-testing allowed interviewers to familiarize themselves with the questionnaire and provided the opportunity to use and audit the survey instruments. The reliability statistics for the items found in the questionnaire were determined and the Cronbach's alpha statistic, $\alpha = 0.879$, was obtained. The Cronbach's alpha statistic exceeded $\alpha = 0.70$ which indicated that there was good reliability and internal-consistency of the research instrument (AMIN, 2005). Pre-testing the questionnaire also helped us assess how respondents comprehended the questions and to determine if they had any problems responding. The questionnaire focused on respondents' understanding of watershed management and adaptations to climate change in the arid region of the Lokere catchment found in Karamoja. The respondents were asked for their perceptions and opinions on the effectiveness of the IWM interventions for agricultural production. This was done for both farmers who do, or do not, employ the Integrated Watershed Management interventions on their farmland within the Lokere catchment.

In addition, an interview guide was used to gather data from key informants who held the highest positions within the local government of the departments of Agriculture, Veterinary, Natural Resources and Forestry from the districts. Also, direct field observations were made concerning the methods members of the local community employed to counter the effects of climate change and also to observe what was happening to some physical assets. Digital photographs were used to represent the information directly observed in the field and these were used to confirm the reliability of information provided by the study participants during the survey.

2.3. Sample size and sample selection

The households used in the study were part of the 51,299 total households found in the whole of the Lokere catchment within the Karamoja region (MWE, 2017). Slovin's formula, $n = N/1+Ne^2$, was used to calculate the required sample size. (n=sample size, N=Total number of households, e=Significant level, 5%). Therefore, the sample size, n, was 397 households, which was regarded as representative for the entire population. As suggested by KOTHARI (2004), at a significance level of 5%, the results represent the true condition of the population and the use of the large sample size ensured a minimal sampling error. The households used in the study were randomly selected. One grown-up individual, aged 18 or over, was chosen from each selected household, and informed that the reason for the study was academic, and the respondent's secrecy and anonymity was guaranteed. The questionnaire was administered to the respondent in the form of an interview and in the common local dialect, since the larger part of the respondents (70%) had no formal education and were thought to have a low understanding of the survey instrument.

The key informants were purposively selected in order to acquire an expert's opinion about the topic of study. Their answers about the variables were compared in order to determine the effectiveness of IWM interventions in creating the adaptive capacities of the communities and to mitigate climate change impacts in the dryland areas of Karamoja. Also, purposive sampling of the respondents provided the study with a rich background of information on the topic under study (KOMBO, 2006).

2.4. Statistical `analysis

The data gathered using the questionnaire were analyzed using version 20.0 of IBM-SPSS for Windows. This provided descriptive and inferential statistics concerning the IWM and climate change adaptation in the dryland areas of the Lokere catchment in Karamoja. Descriptive statistics like the measure of frequency and mean were used to provide information on the respondent's household characteristics and their knowledge concerning the IWM practices based on the 5-point Likert scale. The association of the attributes within the study were tested using the Chi-square test. In addition, correlation analysis was employed to determine the possible associations between some variables under study such as the result brought about by the effects of the occurrence of climate change on food security in the study area. An ANOVA test was performed to understand whether the differences that exist in the application of the various IWMPs were as a result of the level of education of members of the local community. Inferential statistics allowed us to generalize the data while reporting on specific points in the study. Generalization enabled the research findings to be extrapolated in order to reflect the characteristics of the entire population as stated by BRYMAN (2004) and SARANTAKOS (2005). Data from key informants were thematically

categorized based on specific interests as stated by SARANTAKOS (2005).

3. Results

3.1. Household characteristics

The majority (68%) of the respondents were female and some 31% of the respondents formed a bigger proportion aged 48 years and above. This was closely followed by a quarter of the respondents (25%) whose age group was 28–37 years. The biggest proportion (70%) of the respondents never obtained formal education and only 21% were primary (elementary) school graduates (Table 1). This was an indication that almost the entire population (91%) at $\chi^2 = 685.7$ (P = 0.05) living in the Lokere catchment whose education was not beyond elementary level had few skills and little knowledge (less human capital) to qualify them to seek formal employment for their improved socio-economic status. Hence, they mostly depended on the surrounding natural resources for agricultural activities for their livelihoods. Such members of the community were likely to be adversely affected by climate change occurrences.

Table 1. Household characteristics of the respondents (Researcher's Questionnaire Survey, 2019)

Variable	Frequency	Chi-square
Gender		
Male	126	$\chi^2 = 52.3$; P = 0.05
Female	271	
Age group (years)		
18 – 27	90	$\chi^2 = 9.2$; P = 0.05
28 – 37	101	
38 - 47	83	
48 and above	123	
Education level		
None	279	$\chi^2 = 685.7$; P = 0.05
Primary (elementary)	85	
Secondary	30	
Diploma	1	
Degree	2	

3.2. Effects of climate change on the livelihoods of people living in Lokere catchment in Karamoja region

The watershed communities were asked for their perceptions and opinions about the occurrences of the effects of climate change on their livelihoods, despite the IWM interventions in the area. The livelihood components that were covered in this study include human components, natural components, physical components and financial components.

Climate change effects brought many problems in the Lokere catchment. These effects include droughts on natural assets as reported by 99% of the respondents, followed by the prevalence of pests and diseases (91%) on human assets and then wildfires (86%). Some other respondents (49%) experienced floods affecting natural assets as a result of climate change.

Climate change effects negatively affected the food security of the people of the Karamoja region where the two variables were found to have a moderate and significant relationship ($\gamma = 0.556$; P = 0.000) as shown in Table 2. This depicted that whereas there was an initiation of IWMPs in the study area, an increase in climate change events tended to increase food insecurity and hence negatively affect the financial assets of community members.

In addition, a significant and moderately positive relationship ($\gamma = 0.426$; P = 0.000) was obtained when climate change occurrence and community assets were correlated as shown in Table 3. The community assets (physical components) that were under study in the Karamoja region include roads, markets, valley tanks and dams. Therefore, irrespective of the implementation of IWMPs in the study area, an increase in climate change occurrences moderately affected community assets as well.

The information was supported by some field observations during a transect walk in the area of study. It was observed that most boreholes (water points) were spoilt as a result of heavy rains and floods which dug out the underneath of the boreholes' apron that made them collapse. The few functional boreholes seemed to be following suit since it was even observed that floods (Fig. 2) still linger around them.



Fig. 2. Floods around a borehole in the study area (Ndungo, 2019)

Household income, as one of the financial assets for the people living in the Lokere catchment was found to be moderately related to the occurrence of the climate change effects (γ = 0.556; P = 0.000) as shown in Table 4. Initiation of IWMPs in the study area were expected to positively impact on household income for the members of the local community. However, it was realized that an increase in climate change occurrences in the study area led to a moderate increase in the insecurity of household incomes.

Table 2. Correlation analysis between climate change events and food insecurity in Lokere catchment (Researcher's Questionnaire Survey, 2019)

Variables	Climate change occurrence	Food insecurity
Correlation coefficient	1.000	0.556**
Climate change occurrence Sig. (2-tailed)		0.000
Spearman's rho N	397	394
Correlation coefficient	0.556**	1.000
Food insecurity Sig. (2-tailed)	0.000	
N	394	394

**Correlation is significant at the 0.01 level (2-tailed)

Table 3. Correlation analysis between climate change occurrence and community assets in Lokere catchment (Researcher's Questionnaire Survey, 2019)

Variables	Climate change occurrence	Community assets
Correlation coefficient	1.000	0.426**
Climate change occurrence Sig. (2-tailed)		0.000
Spearman's rho N	397	395
Correlation coefficient	0.426**	1.000
Community assets Sig. (2-tailed)	0.000	
N	395	395

**Correlation is significant at the 0.01 level (2-tailed)

Table 4. Correlation analysis between climate change occurrence and household income insecurity in Lokere catchment (Researcher's Questionnaire Survey, 2019)

Variables	Climate change events	Income insecurity
Correlation coefficient	1.000	0.556**
Climate change occurrence Sig. (2-tailed)		0.000
Spearman's rho N	397	394
Correlation coefficient	0.556**	1.000
Household income insecurity Sig. (2-tailed)	0.000	
N	394	394

**Correlation is significant at the 0.01 level (2-tailed)

3.3. Effectiveness of Integrated Watershed Management on agricultural production in the Lokere catchment

The respondents' knowledge, perception and application of various Integrated Watershed Management practices in the Lokere catchment were considered to examine the effectiveness of the initiative on agricultural production in the catchment. An average number of three hundred and twenty-four (324) respondents, corresponding to 81.8% of the cohort applied different Integrated Watershed Management Practices in the catchment. The respondents who used micro-basins (Zai pits) were n=267, trenches (n=335), terraces (n=347), afforestation (n=379), composting (n=251), and mulching (n=367).

The respondents' level of knowledge of Integrated Watershed Management practices on agricultural production were determined by focusing on finding out whether members of the local community have adequate knowledge of using micro-basins (Zai pits), trenches, contour bands or terraces, afforestation, compost making and mulching, as a means used to improve agricultural outputs. The study revealed that the respondents had

adequate knowledge and used Integrated Watershed Management practices aimed at improving agricultural outputs with a mean of 4.0 which was measured using a 5-point Likert scale that assumed the optimal mean of 2.5.

The respondents' perception of the effectiveness of IWMPs on agricultural production was studied bearing in mind the notion that most rural communities have mixed feelings concerning new initiatives introduced in the area. The information obtained from some key informants revealed that members of the community were skeptical about the usefulness of the initiative, with some stating that the initiative was a gimmick for promoting some academic concepts. However, the results obtained from the study (Table 5) indicated a mean value of 4.0 based on the 5-point Likert scale that positively deviates from the optimal mean of 2.5 which signifies that the IWMPs including use of micro-basins, trenches, contour bands, tree planting and others, improves agricultural production in the study area. In line with some other information obtained from key informants, someone stated that:

"The members of the local community who managed to practice some IWMPs, realized some improvement on their crop yields, and this is likely to promote their well-being and hence be able to popularize the use of the introduced Integrated Watershed Management Practices".

Table 5. Responses on farmers' knowledge on use of Integrated Watershed Management Practices, based on a 5-point Likert scale (Researcher's Questionnaire Survey, 2019)

Item	Level of response	Frequency	Percentage	Mean
I have adequate knowledge on use of micro-basins (Zai pits)	Strongly disagree	15	4	
	Disagree	106	27	
	Not sure	0	0	3.7
	Agree	120	32	
	Strongly agree	147	37	
I have adequate knowledge on use of trenches	Strongly disagree	6	2	
	Disagree	56	14	
	Not sure	0	0	3.9
	Agree	216	54	
	Strongly agree	119	30	
I have adequate knowledge on use of terraces	Strongly disagree	7	2	
	Disagree	43	11	
	Not sure	0	0	4.1
	Agree	184	46	
	Strongly agree	163	41	
I have adequate knowledge on use of afforestation	Strongly disagree	2	1	
	Disagree	16	4	
	Not sure	0	0	4.5
	Agree	156	39	
	Strongly agree	223	56	
I have adequate knowledge on use of compost	Strongly disagree	11	3	
	Disagree	135	34	
	Not sure	0	0	3.6
	Agree	98	25	
	Strongly agree	153	39	
I have adequate knowledge on use of mulching	Strongly disagree	1	0	
	Disagree	29	7	
	Not sure	0	0	4.4
	Agree	137	35	
	Strongly agree	230	58	
Average				4.0

A Chi-square test (Table 6) was performed to ascertain whether perception of the effectiveness of IWMPs on agricultural production was associated with the level of education of respondents in the study area. The study found out there was no association between the respondents' perception of the effectiveness of IWMPs on agricultural production and education level of respondents, since the P-value generated (P=0.312) was greater than α=0.05. Therefore, despite the fact that some elite persons were skeptical of the effectiveness of the initiative in the Lokere catchment, the

majority of the members of the local community, though not educated (70%) perceived that the Integrated Watershed Management practices in the Lokere catchment were very effective for agricultural production.

A one-way ANOVA test was performed to understand whether application of various Integrated Watershed Management practices by the local community members of the Lokere catchment was based on their level of education. The study revealed that there was no mean difference between the application of various Integrated Watershed Management practices in the Lokere catchment and the level of education of the respondents (F=1.285; P=0.275) as shown in Table 7. Therefore, the application of IWM interventions is independent of the level of education of the members of the local community in the Lokere catchment. A correlation coefficient test was performed to find out whether application of IWMPs in the study area resulted in increased agricultural production. The study revealed a weak positive relationship between application of Integrated Watershed Management practices and agricultural production ($\gamma = 0.273$; P=0.000). This probably meant that some other factors such as local people's attitudes towards implementation of Integrated Watershed Management practices, soil type of the area and seed-specific studies, among others, in addition to the applied Integrated Watershed Management practices contributed to the improvement of agricultural production in the Lokere catchment.

Table 6. Chi-square test between educational level and perception of farmers on the effectiveness of Integrated Watershed Management practices on agricultural production (Researcher's Questionnaire Survey, 2019)

Variables	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	77.362[a]	72	.312
Likelihood ratio	64.748	72	.716
Linear-by-linear association	.282	1	.596
N of valid cases	397		

a.76 cells (80.0%) have expected count less than 5. The minimum expected count is .00

Table 7. One-way ANOVA between educational level of farmers and application of Integrated Watershed Management Practices (Researcher's Questionnaire Survey, 2019)

Variables	Sum of squares	df	Mean square	F	Sig.
Between groups	109.479	4	27.370	1.285	.275
Within groups	8346.445	392	21.292		
Total	8455.924	396			

Thus, it can be concluded that despite implementation of integrated watershed management practices in the Karamoja region, continued increase in occurrences of the effects of climate change to some extent negatively affected the local community livelihoods, exhibited by food insecurity, household income insecurity, lower human assets and destruction of physical assets. However, a wave of relief was experienced by the participants when the effects of climate change occurrences were countered as a result of the initiation of watershed management practices, like the use of micro-basins, terraces, mulching and afforestation which resulted in some improvements in the agricultural production.

4. Discussion

Climate change occurrences continued to cause significant negative effects to people living in the Karamoja region despite the implementation of integrated watershed management practices. It caused droughts (99%), which led to pests and diseases flourishing (91%), and floods (49%). In addition, climate change events significantly affected community assets, and to some extent contributed to food insecurity and household income insecurity. The results tend to agree with the studies conducted by BASIIMA (2018), who stated that floods hindered food production in the Kasese district, Uganda, that led to increased food prices. FUNK (2005), BROUWER (2015) and OLUWOLE ET AL. (2017) documented that heavy rains and prolonged dry spells brought about by the climate change enhanced crop failure in Uganda and in some other sub-Saharan countries. A study conducted in Zimbabwe by DZVIMBO (2017) and OKONYA ET AL. (2013) posited that climate change effects impacted on agriculture negatively through extensive and prolonged periods of drought, unpredictable rainfall patterns and floods, yet agriculture was known to be the backbone of food security in the

country and more especially for the rural low-income farmers. TUBIELLO (2012) and MIKOVA ET AL. (2015) intimate that agricultural systems are the most vulnerable due to the presence of droughts and floods which in turn affected crop production. GEORGIS ET AL. (2010) reported that agricultural production was always constrained by high climate variability and long dry spells which resulted in poor crop yields. WREFORD ET AL. (2010), TUBIELLO (2012) and MIKOVA ET AL. (2015) stated that increased climatic extremes promoted plant diseases and pest outbreaks. KERSE (2017) adds that climate change effects encouraged pests and diseases and allowed them to flourish which constrained crop production even when IWM initiatives were implemented. IPCC (2020) reported that climate change negatively affected crop yields especially in drylands and low-latitude regions including those in sub-Saharan Africa. In addition, HADUSH (2015) and IPCC (2020) wrote that droughts due to longer dry spells encouraged the spread of alien weed species and crop pests which led to a reduction in the yields of crops which was more pronounced in Africa.

The Integrated Watershed Management practices which were introduced by the initiative aimed at countering climate change effects culminated in a positive and significant benefit to agricultural production in the area of study. Results from the Pearson correlation coefficient revealed a slight positive relationship between the application of Integrated Watershed Management Practices and agricultural production. Findings of some scholars like JOSHI (2005) and WANI ET AL. (2008), were in agreement with the results where they reported that watershed development programmes were considered to be an effective tool for agricultural growth especially in fragile and rainfed ecosystems. ROCKSTROM ET AL. (2007) posits that management of natural resources at the watershed scale produced a number of benefits including increased food production and environmental protection. VANCAMPENHOUT ET AL. (2006) and RAES ET AL. (2007) in their investigations reported that the use of soil bunds as one of the IWM practices led to enhanced yields in crops which were grown in Tigray-Ethiopia and Tanzania respectively. SANDEEP (2015) reported that water harvesting structures like terraces enhanced water sustainability and hence led to an improvement in crop yields. MEKURIA ET AL. (2007), GIRMAY ET AL. (2008) and KERSE (2017) stated that the use of soil and water conservation measures in watershed areas promoted infiltration, which eventually led to availability of water that resulted in increased crop yields. SHENG (1994) and NBI (2014) documented that IWM practices aimed at conservation of soil, water and other natural resources which eventually promoted agricultural productivity and improved the livelihoods of local communities.

Scholars like GEBREGZIABHER ET AL. (2016) reported that integrated watershed management practices formed a central point for rural development and were a means of poverty alleviation among rural communities. Similary, KARPUZCU & DELIPINARI (2011) and HADUSH (2015) affirmed that IWM practices enabled positive economic growth by increasing the incomes of communities who lived in the watersheds. GURJAR ET AL. (2011) stated that some of the purposes of implementing IWM programmes, like planting vegetation, were to reduce drought impacts and moderation of floods. KERR (2002), ALEMU & KIDANE (2014) and KEBEDE (2015) state that crop production and Integrated Watershed Management objectives promote conservation of soil, water and natural vegetation, which in turn lead to high productivity of crops that improve people's livelihoods. In addition, Integrated Watershed Management practices undertaken in the Kenya Highlands resulted in increased yields as affirmed by OKOBA & DE GRAAFF (2005).

Furthermore, KATO ET AL. (2011) mentioned that the use of stone bunds and grass strips as some form of terracing, resulted in robust and positive outputs especially on crops which were grown in low rainfall areas. Other authors such as HERWEG & LUDI (1999), TENGE (2005) and TESHOME (2013) also noted that the application of more than one Integrated Watershed practice, like the use of composting, bunds, and planting basins increased soil moisture content and reduced soil erosion, which in turn increased crop yields.

5. Conclusions

A host of effects have been documented to have affected the livelihoods of people living in the Lokere catchment, in the Karamoja region as a result of climate change. The study found that intermittent droughts, prevalence of pests and diseases, wildfires and floods resulted in food insecurity and household income insecurity among the households in the Lokere catchment.

Climate change effects also resulted in the destruction of some physical assets like roads, markets, and water points, which were perceived to have negatively affected the livelihoods of community members living in watershed areas.

Government should emphasize and intensify implementation of the watershed management practices including, among others, micro basins,

contour bands, and mulching by members of the local community living in watershed areas to counter and mitigate climate change effects since each practice is perceived to function differently, and also that the IWMPs use seems to have positively impacted the lives of the respondents. This may enhance the production of agricultural outputs which in turn may improve the livelihoods of community members.

The continuous awareness of community members about the use and implementation of different integrated watershed management practices should be promoted and aimed at enabling the community members to change their attitudes and embrace these practices for a better livelihood.

Soil type-seed specific studies should be conducted in areas for crop production, aimed at determining which seeds are most suitable for planting in particular areas for improvement in crop yields and at the same time enhancing resilience of the farmers against adverse climate change effects.

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