RESEARCH REPORT ON CLIMATE RESILIENT LOCAL SEED BUSINESSES

July, 2015

Integrated Seed Sector Development Programme Uganda

ISSD Uganda

Research report on climate resilient local seed businesses

Integrated Seed Sector Development Programme in Uganda

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Photo on cover page by ISSD Uganda Mbarara ZARDI Experts:

An on-farm demo field planted in 2013B season by Turibamwe Mixed Farmers' Rural Producer Organisation in Kamwenge district, Uganda. Field demonstrates how use of inorganic fertiliser at early stages of plant growth as required on an improved rice variety (NARIC 3) makes plants robust enough to survive the effects of dry weather conditions later on. (field on right side is fertilized and that on left side is not)

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- Contributors to concept, methodology and participatory tools development, and report review – Astrid Mastenbroek and Abishkar Subedi,. Your contribution is acknowledged

List of abbreviations and acronyms

AGRA	Alliance for a Green Revolution in Africa
CDI	Centre for Development Innovation, Wageningen UR
DANIDA	Danish International Development Agency
DUS	Distinctness, Uniformity and Stability
EAAPP	East Africa Agricultural Productivity Programme
GOU	Government of Uganda
HH	Household
ISSD	Integrated Seed Sector Development
LSB	Local Seed business
NAADS	National Agricultural Advisory Development Services
NARO	National Agricultural Research Organisation
NGO	Non-Governmental Organisation
PAR	Participatory Action Research
PRA	Participatory Rural Appraisal
UNDP	United Nations Development Programme
Wageningen UR	Wageningen University & Research centre
ZARDI	Zonal Agricultural Research and Development Institute

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Summary

Given the challenges agriculture faces as a result of climate change, building resilience is a priority. Crop adaptation has been suggested by a number of studies as an effective strategy for adapting to climate change. Crop adaptation requires farmers to make decisions on which crops to grow that are suited to their environments. Seed systems play a crucial role as a basis for crop selection, and subsequently adaptation to climate change. This study used participatory research approaches to assess the extent of climate variability as perceived by communities, its effect on crop and seed systems and identification of varieties that hold potential as climate resilient varieties for integration into local seed business. The participating groups of farmers ranged from 24 to 48 members.

In the wider context of gaining deeper insight of how climate change influences the seed sector in Uganda, this research aimed at understanding how local farming communities are responding and adapting to observed changes in relation to the climatic conditions and what diversity and innovations are tailoring to those changes. The study was conducted in two different stages (July and December) in 2014. The first study stage focussed on identifying major local climatic factors affecting crop production and major crops affected by different hazards of local climate change and the second one on developing an inventory of varieties of major food security crops grown by farmers, identify which varieties are most affected by various factors governing to local climate change. Organized as such, this research documented farmers' perception of climate change, identified seemingly adaptable crops and options for counteracting the detrimental effects of the climate hazards in relation to seed production.
The study was conducted in West Nile zone and three local seed businesses were sampled purposively to represent the general West Nile agro-ecology viz. Vuura sub-county of Arua district, Warr sub-county of Zombo district and Wadelai sub county of Nebbi district.

In all communities, farmers reported that climate change has inevitably affected their crop production cycles and food availability and security. An unpredictable rainfall pattern was identified as the main driving factor for all challenges in their agro-ecosystems across all three research sites.
In Vuura sub-county, farmers considered droughts, pests and diseases and soil infertility to be most important climate factors in the area. Similarly, in Warr sub-county, drought, pests and diseases and rainfall patterns (delayed and heavy rains) were identified as the most important climate hazards affecting crop and seed production. In Wadelai sub-county on the other hand, farmers identified drought, pest and diseases and floods as the most important climatic hazards affecting yield and quality of crop production. These changes mainly affect production and quality of seed and the sources where farmers get the seed from (informal, intermediate, formal). Concerning farmer saved seed and Local Seed Business (LSB) seed the major effects occur during production. In response to the perceived climate changes, farmers in the three study sites indicated to have employed some measures to cope with or adapt to these changes. These measures were generally related to adjustments in crop and land management practices. In Vuura sub-county farmers adapted by using seed of improved varieties and employing improved technologies for farming such as use of ox-ploughs and tractors to improve the soil properties. In Warr sub-county the measures include selecting crops that are resilient against the observed hazards (in this case drought), integrating plants with a shorter maturity period and incorporating additional agricultural activities in their farming systems such as poultry or fish farming. In Wadelai sub-county farmers adopted agricultural practices like row planting, started using high yielding crop varieties and employing crop rotation to be able to manage pest and disease pressure and incorporated elements of conservation / organic agriculture into the farming systems. Additionally, shifting to off-farm work was noted as a strategy to cope with the consequences of climate change.

Generally, farmers were well aware of the fact that crops have different levels of response to climate change hazards and qualitatively prioritized specific crop resources in relation to specific hazards.

Detailed information of over 165 different varieties belonging to 15 different major food and cash crops from three different study sites was analysed to identify the varieties that are resilient to different climate hazards. In Vuura sub-county, Arua district, a total of 55 varieties of 10 different varieties were analysed. The studied crops included beans, cowpea, groundnuts, banana, Irish potato, sweet potato, sorghum, finger millet and rice. The majority (38) of the varieties are local ones and according to the farmers 91% of the seed of those varieties comes from informal seed systems which included own stock, neighbours and the local market. The remaining 9% are sourced from intermediary (LSB, NGOs) and formal seed systems (NAADS, NARO, seed companies). In Warr sub-county, Zombo district, a total of 77 varieties of 11 different varieties were analysed. The studied crops included beans, cowpea, groundnuts, cassava, banana, sweet potato, Irish potato, yam, sorghum, finger millet, rice, and onion. Majority (59) of the varieties are local ones and according to the farmers 74% of the seed of those varieties comes from informal seed systems which included own stock, neighbours and local market. The remaining 26% are sourced from intermediary (LSB) and formal seed systems (NAADS, NARO, seed companies). In Wadelai sub-county, Nebbi district, a total of 38 varieties of 10 different crops were analysed. The studies crops included beans, groundnuts, cowpea, sesame, cassava, sweet potato, sorghum, finger millet, rice and pumpkin. Majority (24) of the varieties are local ones and according to the farmers 68% of the seed of those varieties is sourced from informal seed systems which included own stock, neighbours and local market. The remaining 32% are acquired from intermediary (LSB) and formal seed systems (NAADS, NARO, seed companies).
Generally, varieties that showed climate resilient features were mainly (75%) local varieties acquired from informal sources. 25% were sourced from intermediary and formal seed systems. Crop resources with promising levels of resilience were bananas, sorghum and finger millet for West Nile. Sorghum and finger millet were perceived as important adaptation crops against droughts, and pests and diseases. Sorghum and finger millet however were considered as inferior by the farmers or did in their eyes appear not to carry any business potential. This caused reluctance to take them up as LSB crops. Therefore, for seed of climate resilient varieties to be integrated in the LSBs' production range, analysis of their market potential is necessary.

In order to utilize the full potential that LSBs carry to produce and market seed of climate resilient varieties their capacities have to be further strengthened. Areas for capacity building include: i) knowledge enhancement of varieties and adapted agricultural practices to employ such as different crop rotation patterns ; ii) introduction of innovations in the area of land management and crop varieties; iii) technological improvements such as labour saving technologies, irrigation and weather forecast; and iv) support for farmers' access to credit.

Key words: Seed systems, Climate variability, Resilience, Local Seed Businesses

Chapter 1: Introduction

1.1 Background of the study

Agriculture is the backbone of the Uganda's economy and the livelihood of many people. However, agriculture is often characterized by high variability of production outcomes, that is, by production risk. Unlike most other entrepreneurs, agricultural producers cannot predict with certainty the amount of output their production process will yield, due to external factors such as weather, pests, and diseases. Rainfall variability influenced by large scale inter-seasonal and inter-annual variability resulting in frequent extreme weather events is among the major risk factors affecting agricultural production and food security in Uganda. With only 0.1% of land irrigated, changes in rainfall greatly impact the rain-fed agricultural sector as well as the ability to achieve broader development objectives in Uganda and MDGs (GOU, 2009; James, 2010). The increased uncertainty of climate effects represents an additional problem to farmers that translates into production risks associated with crop yields.

An extensive literature has been developed on the impacts of climate change and variability on agriculture, with the earliest focusing primarily on the vulnerability of the sector (for example Kurukulasuriya and Mendelsohn, 2006). The general message is that the degree of vulnerability of the agricultural sector to climate variability and change is contingent on a wide range of local environmental and management factors: biological conditions, type of crop, extent of knowledge and awareness of expected changes in climate, the extent of support from government and other agencies, and the ability of key stakeholders to undertake the necessary remedial steps to address climate concerns. A number of options for managing climate-induced risk in agriculture have been cited in literature. Diversifying agriculture with crops and varieties that can perform better under various climatic stresses is among the most cited strategies for adapting agriculture to climate variability and change (Di Falco et al.,2006; Kurukulasuriya and Mendelsohn, 2006; Nzuma et al., 2010).

Crop adaptation requires farmers to make decisions on which crops to grow that are suited to their environments. Seed systems play a crucial role as a basis for crop selection, and subsequently adaptation to climate change. Existing seed systems in Uganda are farmer saved seed, community-based, seed entrepreneurship (local seed business or individual farmer entrepreneur), private companies (national, regional and multi-national) and cash crop value chains (ISSD Africa, 2012). Farmers obtain about 80-85% of seed from their own sources, by saving part of their harvest as seed for the next planting season or exchange seed among neighbours and relatives, or buying grain at local markets for use as seed. About 20% of farmers' seed is thus obtained from the formal system. Intermediate seed system is new and the focus of the Integrated Seed Sector Development (ISSD)[1] programme, where farmers in organized groups produce quality seed of superior varieties and make it available to the local community. This intermediate system compliments the formal system, particularly focusing on crops that are of limited interest to formal sector. The intermediate seed system is based on seed entrepreneurship principles. Climate change is likely to affect seed entrepreneurship, since seed production is also generally rain-fed.

Developing climate resilient seed systems will serve the key basis to minimise the associated production risks and provide opportunities for development of sustainable seed businesses, as well as supporting access to seed by farmers. However, how climate change is impacting to seed sector in Uganda is not well understood. In this context, Integrated Seed Sector Development (ISSD) Uganda program conducted a Participatory Action Research (PAR) to understand the

[1] The Integrated Seed Sector Development in Uganda aims to contribute to the development of a vibrant, pluralistic and market oriented seed sector, providing more than 100,000 smallholder farmers access to affordable quality seed of superior varieties. This is achieved through two major outputs – developing sustainable local seed businesses, and supporting an effective public sector supporting seed sector) and seed policy regulation. The programme currently works with 30 LSBs in three zones (10 in each) – West Nile, Northern and South Western.

perceived changes, impact and vulnerability of the seed sector resulting from climate change in West Nile program sites. Key scope of study was to emphasize on local agricultural production, local crops and varieties and different seed systems. The study appraised how local communities are responding / adapting to observed changes and what diversity and innovations are tailoring to these changes.

1.2 Research questions

More specifically the study sought to answer the following questions:

1. What are the perceived common drivers of climate change at local level such as drought, rainfall, disease-pest incidences and other resulted social, economic pressures?
2. How are these above factors impacting to local crop production and seed systems?
3. Which are the crops and varieties that are most affected by various factors governing to climate change?
4. Which areas/communities/production landscape of the project sites are most affected by severe impact of climate change?
5. What are the existing crops and varieties (both local and improved) that have climate resilient characters to adapt with changes as perceived by farmers?
6. In which seed system do these varieties best fit?
7. How such climate resilient crops/varieties could be part of LSB to market unique/superior products for their customers?
8. What types of support and capacity building programme is needed for LSB to fully internalize climate smart/resilient LSB's new seed business strategies?
9. What type of support and capacity building is needed for other seed systems?

1.3 Research outputs

The research will develop three key outputs:

1. Farmers perception, crop diversity and current local innovations documentation
2. Climate resilient varieties (local or improved) for LSB identified through a participatory varietal selection process and
3. Tailor made capacity building programmes for LSBs and project partners implemented and lessons documented.

1.4 Justification

Key result of the analysis provide strategic inputs for; 1) Recommendations on how to strengthen the roles of different seed systems and 2) Recommendations for LSBs to be more resilient and climate smart in doing their business which can serve right varieties and seed to their customers in times of change.

1.5 Scope of the study

The study was conducted in West Nile, one of the ISSD operational zones. Other than the participatory rural appraisal, the study will also involve collection of data from households using survey methodology as well as interviews with value chain actors to ensure that adequate information is obtained to address the research questions, but also for data triangulation and validation. This report therefore focuses on presenting results and discussion from participatory rural appraisal with three communities in West Nile.

Chapter 2: Methodology

2.1 Research design

This research used descriptive study design. Qualitative data was collected about using participatory rural appraisal (PRA) tools. All data was collected during July 2014.

2.2 Target population

The study was conducted in West Nile agricultural production zone[2]. The zone comprises 8 districts – Adjumani, Arua, Koboko, Maracha, Moyo, Nebbi, Yumbe, and Zombo. The zone is endowed with high rainfall (average 1,340mm) and has good to moderate rated soils. Most of the agricultural production in the zone occurs in a single rainy season that begins in April and ends in mid-November. Mixed cropping is common with a wide variety of crops. The system is in the sub-humid zone where the vegetation community is moist *Butyrospermum* / *Combetrum* / *Terminalia* grassland. Livestock activities are limited by the presence of tsetse fly. Tobacco and cotton are major cash crops. Major food crops comprise of beans, ground nuts, millet, sorghum and cassava. Other crops like rice, maize, sesame and potato are also grown in specific districts both for cash and food.

FEWSNET (Famine Early Warnings Systems Network) further divides West Nile into four major livelihood zones: 1) West Nile Arabica Coffee and Banana Zone, 2) West Nile Tobacco, Cassava and Sorghum Zone, 3) North Kitgum-Gulu-Amuru Simsim, Sorghum, and Livestock Zone, and 4) Albertine-West Nile Lowland Cattle Zone. Table 1 shows the different livelihood zones, their characteristics and sample districts for this study.

2.3 Sampling procedure

Based on the characteristics of the region and distribution of districts to various livelihood zones, the study followed a stratified sampling method where the livelihood zones formed the strata (see Table 1). We selected three districts were selected to represent the different livelihood zones as shown in Table 1. The districts included in the study were – Arua, Nebbi and Zombo. For ease of presenting the study results, the research team has categorized these areas into three sub agro-ecologies, based on their main differentiating characteristics i.e. Highland agro-ecology (Zombo), West Nile grassland agro-ecology (Arua) and Nile belt agro-ecology (Nebbi).
From each of the districts, one sub county was purposively selected. The sub-counties selected were those where Local Seed Businesses (LSBs) existed supported by the Integrated Seed Sector Development (ISSD) Uganda programme. Local seed businesses are groups of small-scale market-oriented farmers organized for and employed in seed production and marketing, having access to research, extension, quality assurance, finance and a market. In each of these districts and sub-counties, ISSD is supporting at least one LSB to produce quality seed of various crops that are locally demanded, adaptable to local conditions and have market potential.

Table 1
Study area and biophysical characteristics

[2] Government of Uganda's zoning exercise divided the country into 10 production zones. According to the PMA and MFPED (2004), an "a*gricultural production zone"* is an area with similar socio-economic characteristics and where ecological conditions, farming systems and practices are fairly homogeneous. It is assumed that a unique agricultural production zone has common crops and livestock types.

Livelihood zone	Districts	Characteristics	Sample district (sub-county)
West Nile Arabica Coffee and Banana Zone	Zombo, parts of Arua	• High land area with bimodal rains delivering 1400- 1600 mm of annual rainfall • Major crops are coffee, bananas, vegetables, cassava, beans	Zombo (Warr)
West Nile Tobacco, Cassava and Sorghum Zone	Arua, Koboko and Yumbe	• Denser population in the southern areas but thins out towards the border with Sudan. • Single rainy season that begins in April and ends in mid-November • Main crops - cassava, millet, sorghum, tobacco and ground nuts	Arua (Vuura)
North Kitgum-Gulu-Amuru Simsim, Sorghum, and Livestock Zone	Nebbi, Gulu, Amuru and Kitgum	• Bimodal, with rains between April and June and between July and November providing an average of 800-1000mm of precipitation annually. • Major crops produced for consumption are sorghum, cassava, simsim, pigeon pea, and maize.	Nebbi (Wadelai)
Albertine-West Nile Lowland Cattle Zone	Nebbi	• Low land livelihood zone, stretching from L. Albert and the Nile belt • Cattle keeping and fishing are the major source of food and income	Nebbi (Wadelai)

2.4 Data collection and analytical procedures

The study was conducted in two different stages in the year 2014. The first stage was carried out in July 2014 and the second stage in December 2014. Data collection was organised through use of various Participatory Rural Appraisal (PRA) tools. The participating groups of farmers ranged in size from 24 to 48 members (Table 2 and Table 3). Participants of the PRA exercise were both LSB members and non-LSB members (i.e. seed users). The study did not do purposive selection to ensure equal representation by gender and socio-economic categories. However, it was realized that the groups had mixed gender and age categories which added value to the discussion to understand perceptions of different categories with regard to the research questions.

The first study stage focussed on identifying major local climatic factors affecting crop production and major crops affected by different hazards of local climate change. Four major PRA tools were used to enlist responses about the research questions from the groups. These were resource mapping, time line creation, seasonal calendar and matrix ranking. The resource map aimed to identify main areas in the community affected by different climatic hazards and to assess their risk, as well as documenting adaptation strategies used by farmers. The timeline was useful in understanding the trend and variability in climate and how this has conditioned or not conditioned people's farming practices over 30 years. The seasonal calendar aimed to document community perceptions on occurrence and changes in climate or climate induced factors in the last 30 years or before at the study/project site. Matrix ranking was used to organize the key climate hazards, key crops of importance in response to the perceived climate hazards. In that way, prioritization of crops to integrate into the LSB portfolio is reached. A compendium of tools used is included as an annex 1 to this report.

Table 2 Study respondents and their distribution by district and gender in July 2014 (first stage of study)

Sample district	Target LSB	PRA participants		
		Male	Female	Total
Arua	Nyio Ajia LSB	25	7	32
Nebbi	Farson LSB	14	10	24
Zombo	Agiermarch LSB	17	12	29

The second stage of this study was carried out at the same sites as the first stage and specifically focused on developing an inventory of varieties of major food security crops grown by farmers. Within this range of varieties those ones which are affected most by various factors governing to local climate change can be identified. Further, different crop varieties (both local and improved) that are perceived by the farmers to be climate resilient are grouped according to the seed system (informal, intermediate, formal) they fit best.

Table 3 Study respondents and their distribution by district and gender in December 2014 (second stage of study)

Sample district	Target LSB	PRA participants		
		Male	Female	Total
Arua	Nyio Ajia LSB	15	20	35
Zombo	Agiermarch LSB	25	23	48
Nebbi	Farson LSB	21	25	46

The study employed different PRA tools viz. four cell analysis, special matrix and matrix ranking to facilitate the discussion and systematic documentation of information from farmers. After each group exercise results were shared in plenary discussion with other farmers to validate information and agree upon a common conclusion.

Four Cell Analysis: This tool was used for rapid asessment of farmers knowledge on local production status of crops or varieties by using the two key variables: production area and HHs growing the crop or varieties. These variables are organized into four different cells viz. a) crop or varieties grown by many households in large production area b) crop or varieties grown by many households in small production area c) crop or varieties grown by few households in large production area d) crop or varieties grown by few households in small production area. Farmers were first asked to group their food and cash crops into the four different cells. Immediately after the analyzis farmers were asked wha the reasons are for a 'specific' crop being grown by many HHs in a large area. Same questions repeated for all crops which are distributed by farmers in different four cells. This helped to identify priority crops for different reasons. These prioty crops were selected to analyse variety level information. The process for variety level analysis was the same as for the crops analysis.

S*pecial matrix:* This tool was designed to document detailed information at varietal level. This included information about name of crop, name of varieties per crop, types of varieties (local/recycled local or improved), varietal characteristics, major source of seed and seed sufficiency status. First the farmers were asked for their major source of seed as an open question than responses were grouped into two major clusters of seed systems viz. informal seed systems where farmer mentioned as own stock, neighbours, and local informal market. Another cluster of seed system on Local seed business (LSB) and formal seed systems where farmers responded seed sources from NAADS, NARO, private seed companies. Seed-sufficiency status was analysed for each variety at community level not at households level. Three proxy variables were developed to analyse the seed sufficiency status. 'Sufficient' implies to a variety of which seed demand in volume was fulfilled at 100% within the last crop production season, 'medium' implies seed demand in volume was fulfilled to more than 50% but less than 100% in the last crop production season and 'insufficient' means seed demand in volume was fulfilled to less than 50% for last crop production season.

Matrix ranking: This tool was used to compare the farmers' perception and rank the varieties per crop according to the various aspects of crop specific climate resilient characteristics e.g. drought tolerant, disease-pest resistance and so on. These crop specific climate resilient characteristics were identified at each site during the first stage of the study in July 2014. The same characteristics were used to analyse the variety level information to maintain the consistency in data collection. Cumulative highest score is considered as resilient variety based on farmers perception of the study sites.

2.5 Ethical considerations

The purpose of the study was well explained to the participants (i.e. LSB and non-LSB farmers) who all agreed to contribute information to this research. Unless otherwise indicated, permissions were sought to include photos of specific individuals and farming areas in the report.

Chapter 3: Results

3.1 Perceived common drivers of climate change at local level

3.1.1 Perceived historical trends and variability in climate

At all three study locations, farming communities identified changes in climate variability over a period of 30 years plus, as well as changes in the farming systems as a result of perceived climate changes. The communities also identified other occurrences of importance within their community that could have affected crop production with in the 30 year time period (Figure 1 a, b, and c).

In Vuura Sub-county, community members noted that unprecedented rainfall patterns were first observed in 1980 and to have escalated up-to-date (Figure 1a). Droughts are a major occurrence stretching from January to June leading to the area having only one planting season, with erratic rainfall within the season that results into floods experienced at least once in every year from November to December. Some interventions were performed by NAADS and other NGOs particularly focusing on tree planting for environmental protection and early land preparation to time the start of the rains.

In Warr Sub-county, farmers noted that their crop and seed production systems were affected by climatic hazard as far as 1975. Their farming system has since been characterized by food shortages on a yearly basis. Details of the occurrences of the climatic events and their impact on local crop production systems are presented in Figure 1b. Pests and diseases have been recurrent for most of the crops but most especially cassava, millet and bananas. Too much sunshine and droughts have been noted majorly from early 2000, alternating with too much rain and flash floods. It was also interesting to note that farmers observed that river Ora floods every decade, damaging a number of crops in the community. This was attributed to natural process of river bed de-silting, which would normally take about 10 years to re-occur.

In Wadelai Sub-county farmers assessed the occurrence of the climatic events in time and observed an increased frequency and level of damage of the climatic hazards to their crop and seed production systems. The events are presented in Fig. 1c. There was a general consensus among farmers on the frequency and intensity of the climatic hazards. Community members observed detrimental changes in the precipitation patterns and intensity of droughts affecting yield and crop quality. Droughts were noted to occur yearly mostly during the months of January, February, June and December as seen in Plate 6. Floods were also reported to have increased in intensity and they were occurring in the months of September, October and November affecting mostly Ocayo lower, Ocayo Upper and Parabi area.

a)

Year	Occurrence/Major Events	Year	Occurrence/Major Events
Past years to 1980	▪ Good rainfall Patterns	2013	▪ Intervention by ISSD ▪ Bean seed supplied to farmers by ISSD ▪ Nyio Ajia entered into partnership with ISSD, NARO and sub-county to produce and market quality seed in Arua District ▪ Nyio Ajia bought Foundation seed from NARO, Equator Seed and Makerere University being linked by ISSD
1993	▪ Long drought from Jan to June		
1994	▪ Drought between Jan-April and then June-Mid July ▪ Floods between Aug-Oct hence Famine	2013 to date	▪ A number of capacity building done to Nyio Ajia through ISSD e.g. quality seed and good production practices
1995-2014	▪ Serious changes in rainfall patterns		
2009	▪ NAADS started educating community to plant trees, preparing land early and ways of cultivating in wet lands	2014	▪ Rice, soybeans, beans, Groundnuts and Cassava cuttings were given out by ISSD ▪ Good quality seeds solid by Nyio Ajia Group
2010	▪ Educating community in Agriculture by NGOs (e.g. CEFORD)		

b)

Year	Occurrence/Major Events	Year	Occurrence/Major Events
1975	▪ Diseases of Cassava (Mbiki): e.g. Cassava mosaic and Cassava root rot	1975-2001	▪ Bad roads and so people in the rural areas suffer the consequences
1980	▪ Diseases of Millet (Ujimini/worms): ▪ Flooding of R. Ora: Many people lost animals (Cows, goats) and crops (e.g. sugarcanes	2010	▪ Drought thereby leading to famine
1998-2011	▪ Diseases of Bananas (Kitule)	2011	▪ Too much rain, floods and famine
2000	▪ Too much Sunshine thus famine	2012	▪ Too much rain that spoilt Cassava and beans
2004	▪ Too much Sunshine thus drought: No seeds for beans	2012-2014	▪ Good weather and high crop yields
2005 to date	▪ Worked with NARO ▪ Working with ISSD ▪ Produced and sold quality seed	2014	▪ Improved road network
Generally: Shortage of food yearly since 1975 but al teast there was a slight improvement in the last two years			

c)

Year	Occurrence/Major Events	Year	Occurrence/Major Events
Before 1962	▪ People settled along R. Nile valley	2008	▪ Lack of food due to too much sunshine
1962	▪ 1st river flood which led to people's migration out of the valley	2009	▪ Community road upgraded to FIDDER road (Ojigo-Pakwiny)
1980	▪ Oyaro (famine) due to war	2010-2011	▪ Lack of rain and Cassava mosaic prevalence
1991	▪ Famine due to drought	2011	▪ Change in rain pattern from March-June and July-Nov to April-May and July-Dec
2000	▪ Sometimes no rain during 1st Season ▪ Almost all fishes in R. Nile died	2012	▪ Worst R. Oraa flood that destroyed crops
2007	▪ Formation of FARSON group for crop production and animal rearing	2013-2014	▪ FARSON got involved in local seed business, dealing in rice and simsim ▪ FARSON sold seed to NAADs

Figure 1: Time line for Vuura sub-county, Arua District (a), Warr sub-county, Zombo district (b) and Wadelai sub-county, Nebbi district (c), as developed by communities focusing on events of importance to them.

3.1.2 Perceived seasonal changes and variability in climate

Using a seasonal calendar, communities explored the changes and variability in climate within the year, comparing the situation of 15-30 years back and now. Farmers discussed questions like what has been the change in key climate variables. Climate variables explored included temperature, rainfall, drought, pests and diseases, floods and soil fertility. Farmers used their own signs to represent no change, slight increase, strong increase, strong decrease or slight decrease (for example Figure 2 a, b and c).

In Vuura Sub-county farmers noted an increase in temperature between March and May and then July. Normally these months used to be fairly cool since they also coincided with the first rainy season. It was noted that rainfall in March has reduced drastically, thus reducing the first growing season to just two months – April and May. Moreover, rainfall in these months has also reduced compared to 15 years ago. The occurrence of in-season droughts was also noted, especially in first season. Similarly, the occurrence of pests and diseases has increased at the first season. Generally, farmers agreed that the first season is no longer good for farming thus leaving them with the second season only which stretches from July to November. In the second season, farmers agreed that the climate variables have not changed much, so they can still plan on growing their crops in this season. Decline in soil fertility though not a climate variable, was of high importance to the community and they indicated that fertility of their soil has gradually reduced greatly affecting crop production.

Similarly, in Warr Sub County the seasonal calendar developed by the community indicated high variability within the seasons. The first season has shifted from a start in early March to mid or late March, with a variation of more than two weeks for the start of the season. In-season droughts have also been observed especially for season one occurring around May and June. Interestingly, farmers noted that from 2012 to 2014, the weather has been good and crop yields as well. This may partially explain why direct climate variables (droughts and heavy rain) were ranked less serious in comparison to pests and diseases.

In Wadelai Sub County, farmers noted an increase in temperatures especially in the months of December, February and March, and within the growing season (May-June). December to February is normally a dry season with high temperatures, but farmers felt that it's generally hotter than it used to be more than 15 years ago. Decrease in rainfall was noted for the first season, while a general increase in rainfall was noted for the second season. In-season droughts are generally observed in the first season, together with high increase in pests and disease incidences. The second season though seemed to have increased amounts of rainfall, it was also considered highly variable in terms of rainfall distribution and intensity. There is an increase in flush floods in second season due to high intensity rainfall.

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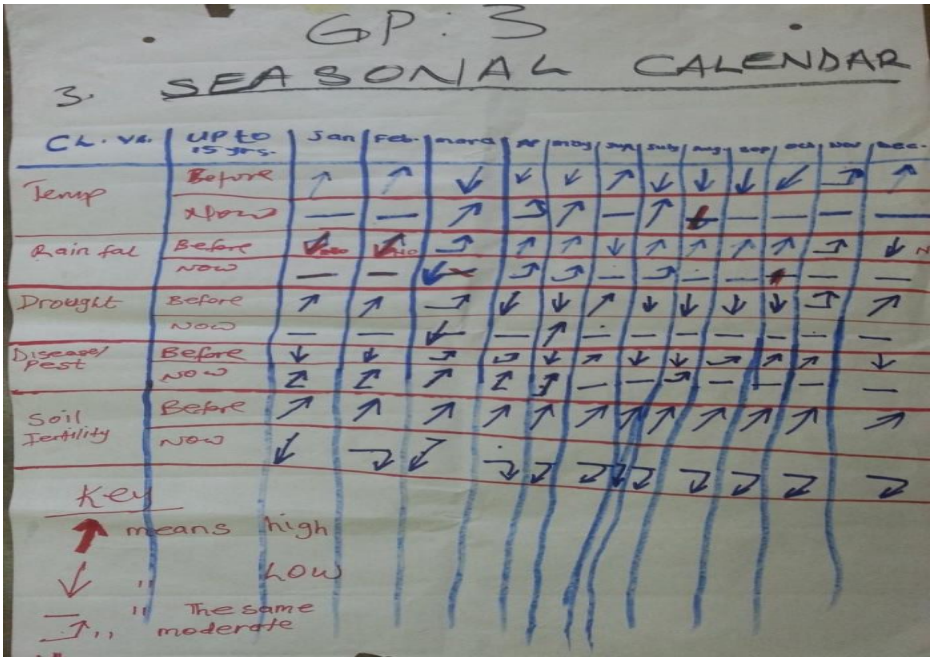

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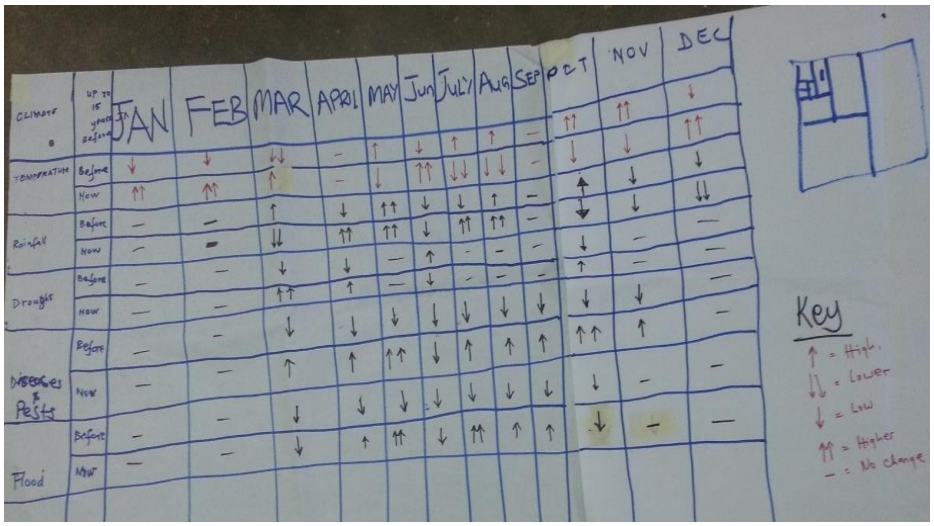

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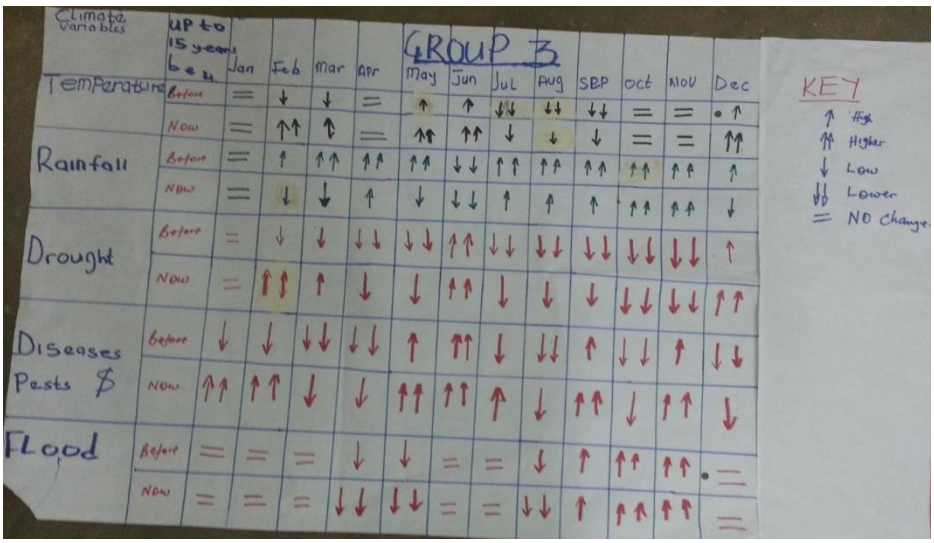


Figure 2: Seasonal calendar for a) Vuura Sub-county, b) Warr Sub-county and c) Wadelai Sub-county, comparing seasonal changes now and 15-30 years ago.

3.1.4 Climate factors of importance to farmers

Based on farmers' perceptions of climate change, they listed a number of climate factors they consider to be harmful to their farming operations (compare with time line and seasonal calendar). The most hazardous climatic events were prioritized by site basing on the perceived impact on the growth and productivity of the communities' crop resources. Participants scored each hazard on a scale of 1 to 10 depending on the level of damage the hazard has or poses on crop production and seed system, and the total score for all factors combined was expected to add to 10 (Figure 3). In other words, the scoring was based on relative importance of the observed hazards. This implies that the factors that scored zero were less serious compared to others.

In Vuura sub-county farmers considered droughts, pests and diseases and soil infertility to be the most important climate factors in the area. Similarly, in Warr sub-county, drought, pests and diseases and rainfall patterns (delayed and heavy rains) were identified as the most important climate hazards affecting crop and seed production. In Wadelai sub-county on the other hand, farmers identified drought, pest and diseases and floods as the most important climatic hazards affecting yield and quality of crop production.

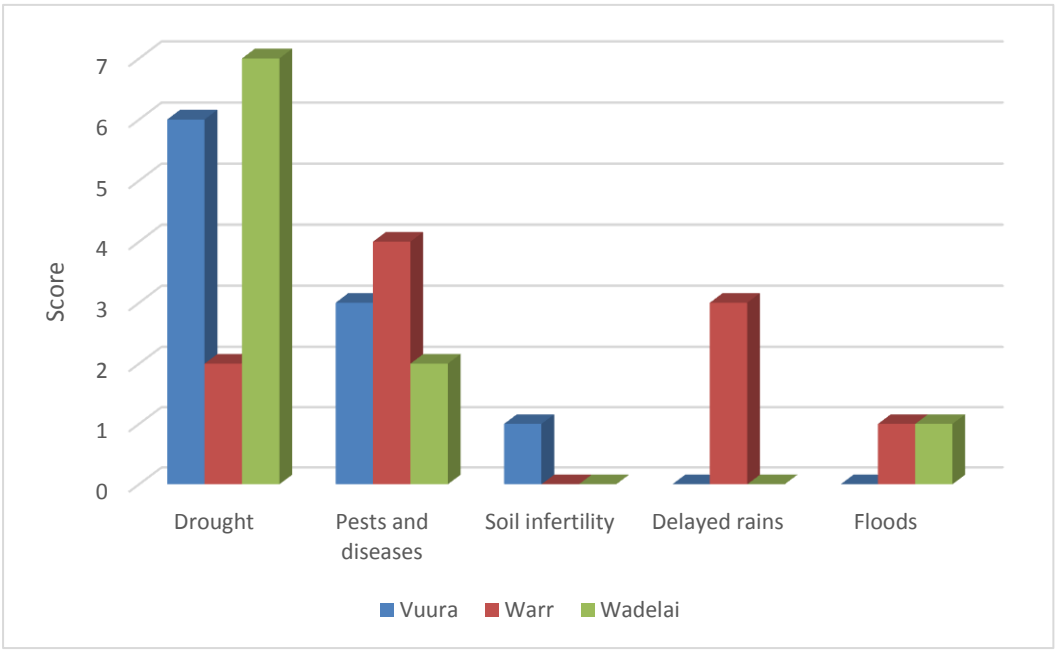


Figure 3: Climate factors considered most important by farmers in Vuura, Warr and Wadelai Sub Counties

3.1.5 Farmers coping and adaptation measures in response to perceive climate changes

In response to the perceived climate changes farmers in the three locations indicated to have employed some measures to cope with or adapt to the changes. These are summarised below per sub-county.

Vuura sub-county

- Timely ploughing and planting to optimize the erratic rainfall
- Use of improved varieties of seeds and tubers supplied to them by the government in collaboration with AGRA and DANIDA. Noted crops and varieties were NASE 14, TME14 for cassava, and improved banana suckers
- Employing improved technologies of farming such as use of ox-ploughs and tractors to improve the soil properties to support crop production.

Warr sub-county

- Using seed of improved varieties e.g. for banana cultivation
- Selecting crops which are resistant to the observed hazards e.g. sorghum, cassava and sweet potatoes for drought
- Employing timely production practices
- Integrating plants with shorter maturity period like Cowpeas (*Boo*) and Jute mallow (*Otigo*)
- Incorporating other farming enterprises such as vegetables, livestock, poultry and fish farming into their agro-ecosystem
- Applying crop rotation
- Applying technical guidelines from sensitization fora by the government (NARO), local leaders and International partners like ISSD, to help farmers prepare for risks.

Wadelai sub-county

- Introduction of new crops with known resistance to pests e.g. NASE 14 Cassava
- Adoption of agricultural practices like row planting and using seed of high yielding varieties such as Sesame 2
- Planting crops which are more easily destroyed by floods on highlands and others which need a lot water such as rice in lowlands
- Seed production put in place by FARSON seed production group
- Employing crop rotation to check pest and disease pressure
- Employing timely operations like timing of the season/ changing of season, looking for what to grow/plant and when to do it
- Incorporating conservation / organic agriculture into the farming system. This requires training on such practices and assessment of their performance in relation to increasing resilience of seed systems.

3.2 Effect of climate factors on local crop production and seed systems

3.2.1 Effect of climate factors on crop production

Generally, farmers perceived the impact of climate change in comparison to failed or successful crop yields. Farmers noted that changes in climatic conditions influence the whole crop system, i.e. rainfall patterns and dynamics (onset, cessation and quantity) can result into hazardous events like droughts, floods, pest and disease outbreak hence posing direct impact on crop production practices like field preparation, planting and other general field management practices. The communities also noted an increased rate of change in rainfall patterns and temperatures thus rendering their crop production systems more vulnerable to climatic hazards.

In all communities, farmers reported that climate change has inevitably affected their crop production cycles, food availability and security. This could be felt and understood much further as an elder in Agiermarch LSB, Warr Sub County, Zombo district narrated:

"In the past years the climate had good and conducive weather condition which supported any food and crop production in this area, we even had two planting season unlike these days, we had enough rainfall and conducive sunshine, it was also much easier to predict the rainy season calendar which would make it easier for us to prepare our garden and get ready for planting, we were aware when the rain would start and when it would end unlike nowadays we are not sure when to plant our crops because the season where we are not expecting rain, it does rain and we had never experienced such seasonal floods in our garden with this unexpected long droughts '*Oroo*' in the rainy season. The weather has changed".

3.2.2 Effect of climate factors on seed systems

From community discussions, the following seed systems were recognised by the farmers:

1) Farmer saved seed and local markets. Farmers indicated that they save seed for most of the crops they grow. This involves positive selection of crops and storing them for the next season. If a farmer does not have enough seed, they can still get some seed from their neighbours either as gifts or barter. Farmers also get seed from local markets in the event that their saved seed is not enough for the season. This seed system is generally informal and the most practiced in the studied sub-counties. Crops for which farmers keep seed are mainly maize, beans and groundnuts. Root crops like cassava and sweet potatoes are also obtained from farmers' gardens for the next season crop.

2) Community-based seed multiplication. Farmers recognised this system for seed multiplication especially for cassava where communities have been receiving improved cuttings, multiply them and distribute to the members at cost recovery. This system has mainly been promoted by Abi ZARDI, AGRA and DANIDA.

3) Seed distribution. Seed distribution was also recognised by farmers as a source of seed for the community. Seed distribution is mainly done by government programmes especially NAADS that provides seed for specific crops depending on community prioritisation. The working modality is that a farmer who receive seed are expected to pay back to the group in kind, which seed can then be given to another member of the group.

4) Local seed business. Local seed business is recognised by the community as a source of quality seed for farmers. The groups visited were dealing in different crops, but the driving factor was that the seed they produce must be locally demanded in their communities. LSBs obtain foundation seed from research which they multiply using standard seed production procedures and inspections. The seed is then sold within the community as quality declared seed.

5) Commercial seed. Farmers recognise the existence of commercial seed especially for maize from agro-dealers. However, farmers indicated to have limited access for such seed due to lack of supply in their localities, high price of seed and sometimes the quality of seed is not good to justify the investment.

Given the recognition of these seed systems, farmers went ahead to discuss how the perceived climate factors are affecting these various systems. Table 1 shows the effect of climate variables on the different seed systems. For each seed system, analysis was done on climate effects on seed production, seed quality, and marketing and distribution. However, there was no much information from farmers regarding the formal sector, so discussions were limited to the systems they are more familiar with.

Table 3 *Effect of climate factors on various seed systems*

No.	Seed system	Variable	Effect of climate variables
1	Farmer saved seed	Production	• Delayed rains affect yield (quality and quantity) of seed • Low yields due to increased levels of pests and diseases • Intense and frequent rains damage crops; cause soil erosion and affects other crop production practices due to flooded fields • Changing seasons compromise the levels of viability of the seeds • Poor crop yields affect farmer seed saving behaviour
		Quality	• Bad seasons compromise the quality of the seed, storage pests and diseases also affect seed quality
2	Community-based seed multiplication	Production	• Fluctuation in yields due to changed seasons and increased outbreak of pest and diseases
		Quality	• Quality of seed affected by bad weather
		Distribution and/or marketing	• Not enough seed or planting material to reach all the farmers Lack of seed in cases of delayed rains
3	Seed distribution	Production	• In poor seasons, NAADS is not able to get enough quality seed on time to distribute to all farmers since their main source of seed is community • New crop varieties distributed e.g. NASE 14 for cassava, K132 for beans
		Quality	• Quality of seed is sometimes not guaranteed as it's based on truth in labelling. • Sometimes seed source is not clear and poor seed germination has been observed with some seed
		Distribution	• Seed is distributed late sometimes affecting the production cycle
4	Local seed business	Production	• Poor yields • Poor seasons affect supply of foundation seed from research stations thus LSBs are not able to get FS in time e.g. seed potato, ground nuts • Poor seasons affect supply of foundation seed from research stations thus LSBs are not able to get FS in time e.g. seed potato, ground nuts
		Quality	• Too much rainfall affects quality of seed, creating losses for LSBs
		Distribution and marketing	• Failure to supply enough seed in time

3.3 Crops and varieties most affected by various climate factors

The farming communities identified the most important climate factors, and for each climate factor they identified crops and varieties that were most vulnerable (Table 4).

Pests and diseases (such as cassava mosaic, white flies and glow worms) were identified as affecting cassava production in the area.

Droughts and delayed rains affected mainly Sesame (simsim), maize and rice. Simsim is a long season crop and requires enough precipitation during the growing season. Delayed rains and in-season droughts affect the growth and productivity of the crop. Similarly maize and rice are long season crops requiring well distributed rains, most importantly during the critical grain formation stages.

Table 4 *Crops and varieties most affected to key climate factors in Vuura, Warr and Wadelai sub-counties*

Sub County	Climate factors	Crops most affected
Vuura	Droughts	Sorghum, Beans, Ground nuts
	Pests and diseases	Bananas, Sorghum
	Soil infertility	Bananas, Sorghum, Beans
Warr	Droughts	Beans, Ground nuts, Irish potatoes, Maize
	Pests and diseases	Ground nuts, Maize
	Rainfall (heavy)	Beans, Ground nuts, Irish potatoes
	Floods	Beans, Cowpeas
Wadelai	Drought	Sesame (*Simsim*), Maize, Rice
	Pests and diseases	Cassava
	Floods	Beans, Soy beans

3.4 Areas and production landscapes most affected by severe impact of climate change

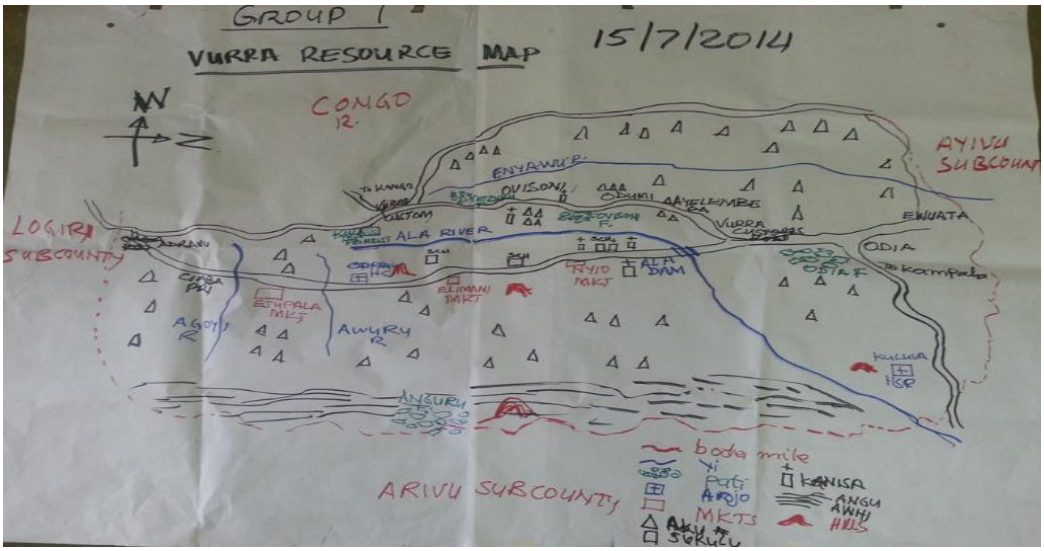
Using resource mapping, farmers identified resources and production areas in their communities that are important for crop production and seed systems. From the resource maps, communities further identified areas and production landscapes that are most affected by severe impacts of climate change. The impacts were related to the most important climate factors identified earlier by the communities. Figure 4 a, b and c, show the community resource maps for Vuura, Warr and Wadelai sub-counties respectively.

The major production resources identified in Vuura Sub County were agricultural fields, a river, planted forests, a water dam and good road network. In Warr, farmers identified rivers, forests, agricultural fields and good transport network (roads and bridges) as the main resources sustaining their crop production and seed systems. Similarly, in Wadelai, farmers identified river Nile, agricultural fields, forest, and good road network as key resources. Socially binding resources like schools, churches and markets were also identified as important across the three study sub-counties.

The effect of climate factors on these resources varied by location. In Vuura and Warr sub-county, communities identified the forest and hills as the production landscapes most affected by climate hazards. The hills are mostly affected by heavy rainfall causing soil erosion. The forest on the other hand is under threat by human activities such as fuel wood collection and expansion of farm land since it is considered to be more fertile that the current farming lands. In Wadelai, communities identified three villages - Ocayo Lower, Ocayo Upper and Parabi as the most affected by floods. Flooding of river Oraa happens almost seasonally, affecting these three villages.

In terms of vulnerability of farmers, all communities agreed that all people are affected. They however also noted that women and children are most affected. Climate changes cause food shortages and it is mainly women who suffer looking for food to feed their families. Children suffer from malnutrition and under nutrition as a result of food shortages. Men on the other hand, seek alternative sources of income mainly moving to off-farm labour such as quarrying, brick making and trading.

a)



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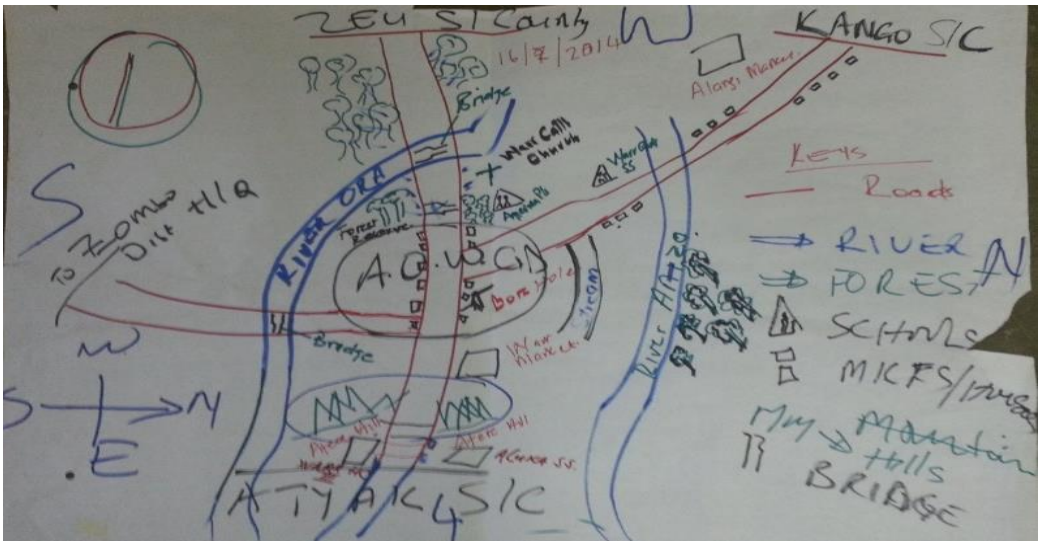

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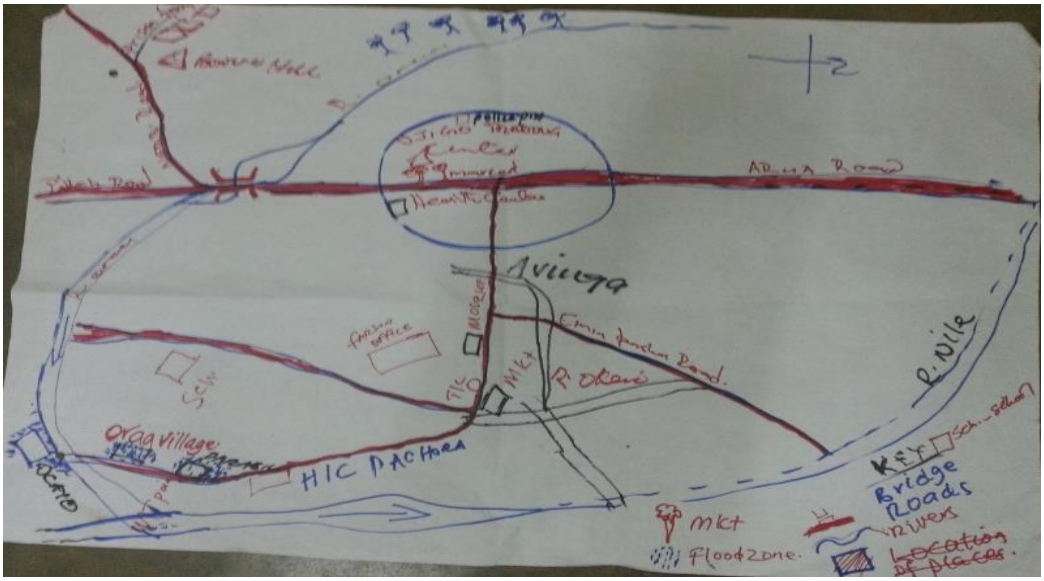

Figure 4: Resource map for a) Vuura sub-county, b) Warr sub-county, and c) Wadelai sub-county

3.5 Existing crops and varieties with climate resilient characters within the communities

3.5.1 Crops perceived to have climate resilient characters

Based on the climate factors discussed with the communities, they went ahead to identify crops and varieties with climate resilient characters. Using matrix ranking, farmers identified and ranked crops/varieties that they considered to be more adaptable to the current climate changes.

Three most withstanding crops were identified per prioritized climatic hazard and ranked from 1 to 3 basing on their level of resilience to that particular hazard (1: low, 3: high). These were subsequently ranked against the major climate hazards in order to come up with crops considered more adaptable to current climate changes. These would then be integrated into the LSB, along the already existing LSB crops. To obtain the overall level of resilience of a crop to a particular climatic hazard, a crop's rank was multiplied by the score indicating the level of importance of a particular climatic hazard. Tables 5, 6, and 7 show the matrix ranking of crops against climate hazards to obtain the most climate resilient crops in Vuura, Warr and Wadelai sub-counties.

Table 5 Crops perceived to be resilient to particular climate hazards in Vuura sub-county

Crop	**Drought**			**Pests and Diseases**			**Soil infertility**		
	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***
Bananas	2	6	**12**	-	3	-	-	1	-
Sorghum	1	6	**6**		3	-		1	
G/nuts	-	6	**-**	1	3	**3**	3	1	**3**
Beans		6		2	3	**6**	1	1	**1**
Cassava	3	6	**18**	3	3	**9**	2	1	**2**

Table 6 Crops perceived to be resilient to particular climatic hazards in Warr sub-county

Crop	**Drought**			**Pests and Diseases**			**Delayed rains**			**Floods**		
	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***
Cassava	3	2	**6**	2	4	**8**	1	3	**3**		1	-
Bananas	2	2	**4**	1	4	**4**	-	3	**-**	1	1	**1**
Sorghum	1	2	**2**	3	4	**12**	2	3	**6**	-	1	**-**
Yams	-	2	**-**	-	4	**-**	-	3	**-**	3	1	**3**
Rice	-	2	**-**	-	4	**-**	-	3	**-**	2	1	**2**
Vegetables		2	**-**		4		3	3	**9**			

Table 7 *Crops perceived to be resilient to particular climatic hazards in Wadelai sub-county*

Crop	**Drought**			**Pests and Diseases**			**Rainfall Patterns**			**Floods**		
	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***	Crop rank	Hazard Score	**Total***

F. Millet	2	7	**6**	3	2	**6**	1	0	**0**	2	1	**2**
Sorghum	1	7	**4**	-	2	**-**		0	**-**	1	1	**1**
Rice	-	7	**-**	2	2	**4**	3	0	**0**	3	1	**3**
Maize	-	7	**-**	1	2	**2**	1	0	**0**	-	1	**-**
Cassava	3	7	**21**	-	2	**-**		0		-	1	**-**

- Crop not prioritized for that particular hazard, * Highest score indicates level of importance of a crop to a particular hazard

3.5.2 Climate resilient varieties

Four cell analysis and special matrix exercise provided detailed information of over 165 different varieties belonging to 15 different major food and cash crops from three different study sites (Annexes 2, 3, 4). Variety level information included local production status, variety characteristics, seed sources, and seed self-sufficiency status at community level. Further, the matrix ranking tool helped to identify the priority varieties which considered by farmers as most resilient to the key climate hazards in specific study sites. Climate resilient varieties are analysed in detail in each study site as below:

3.5.2.1 Climate resilient varieties of different crops in Vuura sub-county, Arua district

A total of 55 varieties of 10 different crops was analyzed in Vuura sub-county (Table 8). The majority of varieties is local (38 varieties). Farmers reported 91% of the varieties to be sourced from informal seed systems which included own stock, neighbours and local market. The remaining 9% were acquired from intermediary (LSB, NGOs) and formal seed systems (NAADS, NARO, seed companies). Only 20% of seed of the different varieties are sufficiently available at community level while 80% are available to an insufficient to medium extent (Figure 5).

Table 8. List of crops and varieties studied in Vuura sub-county, Arua district

Crop	Beans	Ground nuts	Cowpea	Cassava	Banana	Irish potato	Sweet potato	Sorghum	Finger millet	Rice
Variety	8	4	3	10	11	3	8	4	2	2

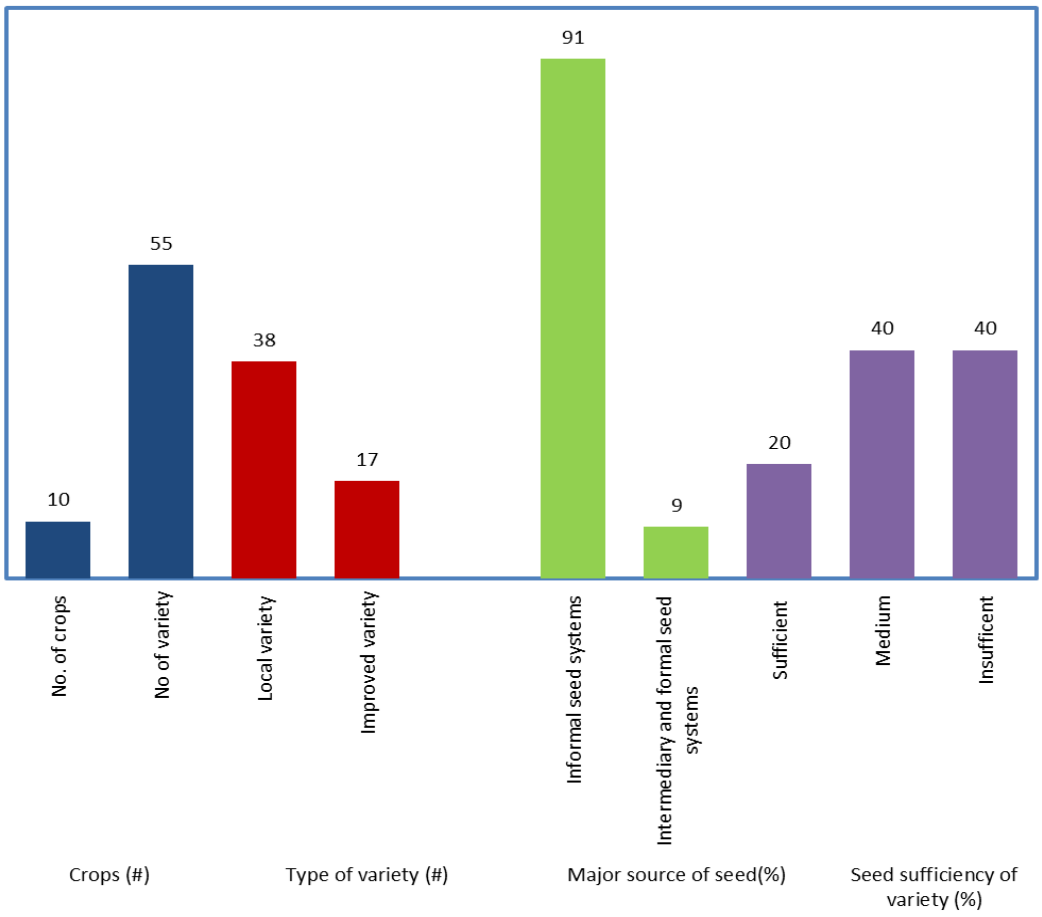

Figure 5: Major crops and their varieties, source of seed (seed systems) and seed sufficiency status in Vuura sub-county, Arua district

A matrix ranking of 55 varieties of 10 crops with specific climate hazards viz. droughts, disease, pest and soil infertility was carried out. Resilient varieties are prioritised based on highest total cumulative rank. Rank I to III are considered as the most resilient ones. This resulted in 17 local varieties and 5 improved varieties being most resilient in Vuura sub-county, Arua district (Table 9-18).

Table 9: Matrix ranking of bean varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1= lowest)			Total & Resilient variety rank (I=highest)
			Drought	Diseases-Pests	Soil Infertility	
Asikua	Local	Early maturing, old variety, white colour seed, high yielding, easy to cook, good taste (sweet), high market demand	1	4	4	9
K132	Improved	Newly introduced variety, high yielding, seed expensive, high market demand	8	7	7	22 **(II)**
Gombili	Local	White long seed, old variety	5	6	2	14 **(III)**
Esoko Osu	Local	High yielding, old variety, yellowish seed, easy to cook, sweet taste, low price	3	5	6	14 **(III)**
Nabe 4	Improved	Early maturing, very new introduction, seed scarce in the market, market demand	4	2	3	9
Nabe 7	Improved	Early maturing, very new introduction, seed scarce in the market, market demand	2	1	1	4
Nabe 15	Improved	Early maturing, very new introduction, seed scarce in the market, market demand	7	8	8	23 **(I)**
Nabe 16	Improved	Early maturing, very new introduction, seed scarce in the market, market demand	6	3	5	14 **(III)**

Table 10: Matrix ranking of groundnut varieties perceived to be resilient in different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1= lowest)			Total & Resilient variety rank (I=highest)
			Drought	Diseases-Pests	Soil Infertility	
Serenut 3	Improved	Red colour and large size seed, high yielding, sweet in taste and can be eaten as raw, high market demand	3	2	2	7 **(II)**
Red Beauty	Recycled (improved)	High yielding, sweet in taste and can be eaten as raw, high market demand	4	1	4	9 **(I)**
Serenut 4T	Improved	Take longer time to germinate, high yielding, nutritious	2	4	3	9 **(I)**
Serenut 2T	Improved	Tan colour and large size seed, not sweet, affected by droughts, susceptible to pest, it is not economical variety	1	3	1	5

Table 11: Matrix ranking of cowpea varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1= lowest)			Total & Resilient variety rank (I=highest)
			Drought	Diseases-Pests	Soil Infertility	
Madi Osubi	Local	White colour seed, old variety, good market, delicious taste, high yielding, highly adaptable-grow anywhere, durable, drought resistance	1	1	1	3
Odumbaku	Local	Early maturing, old variety, seed with black & white spot, most delicious taste than any other varieties, grows in selected areas and faster, high demand in market, yield few seed, few people store seed	3	3	3	9 **(I)**
Ayaraayara	Local	Brown seed, old variety, take long in cooking, less delicious, seed mostly eaten, no market demand, grows in any area	2	2	2	6 **(II)**

Table 12: Matrix ranking of Cassava varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1= lowest)			Total & Resilient variety rank (I=highest)
			Drought	Diseases-Pests	Soil Infertility	
Omo	Local	Early maturing 12 months variety, cream colour stem, well adapted to the soils of local area, tubers sweet in taste, drought tolerance, planting material easily available, high market for tubers	9	9	10	28 **(II)**
Nase 14	Improved	Early maturing 9 months variety, new introduction, tubers sweet in taste depending on soil, well adapted to the soils of local area, high market for cutting, planting materials are not abundant and expensive	10	10	9	29 **(I)**
TME 14	Improved	Early maturing 9 months variety, old variety, peeling tuber is thick, tubers sweet in taste depending on soil, high market for cutting, planting materials are not abundant and expensive	5	1	6	12
TME 204	Improved	Stem tall, few or no branches, green broad leaves, tubers sweet in taste, drought resistance, nearly lost	6	4	4	14

		due to susceptible to diseases, labour intensive				
Bukalasa	Improved	Stem tall, old variety, two types i.e. one has brown leaves and another green leaves, leaves are small , tubers sweet in taste, nearly lost due to susceptible to diseases, labour intensive	2	6	3	11
Nyapamutu	Local	Broad dark leave, tubers bitter in taste, high yielding, nearly lost due to susceptible to diseases, labour intensive	3	2	5	10
Ariwara	Local	Late maturing 3 years variety, old variety, tubers bitter in taste, drought tolerance, less labour intensive , pest resistance (the leaves are not eaten by pests maybe because they are bitter)	8	7	7	22
Malukua	Local	Stem tall, early maturing variety, old variety, tubers sweet in taste, drought tolerance, less labour intensive, pest resistance	7	8	8	23 **(III)**
Giligili	Local	Early maturing variety, tubers bitter in taste, disease resistance	4	5	2	11
Basemenge	Local	Late maturing variety, old variety, high yielding, tubers bitter in taste, nearly lost due to susceptible to disease, labour intensive	1	3	1	5

Table 13: Matrix ranking of plantain varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)			Total & Resilient variety rank (I=highest)
			Drought	Diseases-Pests	Soil Infertility	
Abua Enya	Local	It is sweet, big fruits, short maturity of 1 year, less susceptible to diseases	10	2	10	22 (**IV)**
Membuva	Local	Eaten when ripened,1.5 years maturity period, small tubers, disease tolerant and drought tolerant	8	3	6	17
Opun	Local	Fetches good money, big tubers, disease tolerant but takes too long to mature i.e. 2 years	9	11	9	29 **(II)**
Bugoya	Local	Sweet when ripened, disease tolerant, long tubers and eaten when ripened	3	1	2	6
Serera	Local	Less tasty, Soft when ripe, bitter when not ripened, whitish-yellow in color and mostly used in making bread	2	4	1	7
Bukura	Local	Drought resistant, short tubers, eaten after boiling	1	5	5	11
Nyatule	Local	Quick maturing, fetches a lot of money, disease tolerant but drought prone	7	10	8	25 **(III)**
Mucakala	Local	Quick maturing, fetches a lot of money, disease tolerant but drought prone	5	6	3	14
Makimba	Local	Sweet when ripened, disease tolerant, long tubers and eaten when ripened and high prices	6	9	4	19
Sira	Local	Grows 1.5 years, sweet when boiled, disease tolerant and drought resistant	11	8	11	30 **(I)**
Auombetisi	Local	Sweet when ripe, disease tolerant	4	7	7	18

Table 14: Matrix ranking of Irish potato varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Major source(s) of seed	Climate hazards (Ranking 1=lowest)			Total & Resilient variety rank (I=highest)
			Droughts	Diseases-Pests	Soil Infertility	
Mamanakutu (emve/white)	Local	White in colour, early maturing, high yielding, very soft when cooked	1	2	1	4
Mamanakutu (eka/red)	Local	Red in colour, not easily got, few people know about it, the market is high, very soft when cooked, susceptible to pest, low yielding	2	1	2	5 **(II)**
Mamanakutu (payipulu/ purple)	Local	Purple in colour, high yielding, soft when cooked, cooks very fast, smell like paraffin when raw	3	3	3	9 **(I)**

Table 15: Matrix ranking of sweet potato varieties perceived to be resilient in different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)			Total & Resilient variety rank (I=highest)
			Drought	Diseases-Pests	Soil Infertility	
Ayira	Local	Leaves are slender, mode of entering is a bit round, less profitable	3	7	2	12
Andinyaku	Local	Brown in colour, it enters larger than the rest, more profitable	4	5	4	13
Karamoja	Local	Pealing is white but inside is a bit yellow, good taste	2	6	3	11
Okilipa	Local	Pealing is white inside but it is hard with some fibers, takes long time to grow	8	1	8	17 **(I)**
Ewa maku	Local	Leaves are larger round, it enters big but round, takes long time to grow	7	4	6	17 **(I)**
Koko maku	Local	Leaves are small and round, sweet in taste, tolerant to drought, marketable	5	3	5	13
Olamu	Local	Leaf stocks are brown, it enters in brown colour, enters very fast, marketable, very sweet in taste, takes few days to grow	1	8	1	10
Anyauu maku	Local	Leaf stocks are brown, it enters in brown colour but a bit long, sweet in taste	6	2	7	15 **(II)**

Table 16: Matrix ranking of finger millet varieties perceived to be resilient in different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Major source(s) of seed	Climate hazards (Ranking 1=lowest)			Total & Resilient variety rank (I=highest)
			Droughts	Diseases-Pests	Soil Infertility	
Anya Eka (red millet)	Local	Long maturing 4 months variety, red grain colour, larger grain size, high yielding, coiled fingers, tolerant to drought and resistance to disease	1	2	1	4
Anya Emve (white millet)	Local	Short maturing 3 months variety, white grain colour, smaller grain size, spread fingers, good taste for food consumption, drought tolerant, seed are easily available locally	2	1	1	5 **(I)**

Table 17: Matrix ranking of sorghum varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Major source(s) of seed	Climate hazards (Ranking 1=lowest)			Total & Resilient variety rank (I=highest)
			Droughts	Diseases-Pests	Soil Infertility	
Godo	Local	Long maturing 12 months variety, tall stalk, long leaves, high yielding, high market demand, drought tolerant	4	4	4	12 **(I)**
Akindi	Local	Early maturing 6 months, medium stalk, medium leaves, low yield, less resistance to pest and disease	2	2	2	6
Mugusa	Local	Short maturing 6 months variety, short stalk, shorter leaves, high yielding	3	3	3	9 **(II)**
Epuripur	Improved	Early maturing 4 months variety, short stalk, short leaves, spear head, newly introduced variety, high demand in market	1	1	1	3

Table 18: Matrix ranking of rice varieties perceived to be resilient to different climate hazards in Vuura sub-county, Arua district

Variety name	Types of variety	Major source(s) of seed	Climate hazards (Ranking 1=lowest)			Total & Resilient variety rank (I=highest)
			Droughts	Diseases-Pests	Soil Infertility	
Nerica 4	Improved	Early maturing 4 months, high yielding , resistance to diseases, high market, cooks quickly, good taste, labour is cheap in term of weeding	2	1	1	4
Madingili	Local	Late maturing 6 months, needs several weeding, very low market, poor eating quality, difficult to find seed	1	2	2	5 **(I)**

3.5.2.1 Climate resilient varieties of different crops in Warr Sub County, Zombo district

A total of 77 varieties of 11 different crops were analyzed in Warr sub-county, Zombo district (Table 19). The majority of varieties is local (59 varieties). Farmers reported that 74% of seed is sourced from informal seed systems which included own stock, neighbours and local market. The remaining 26% was acquired from intermediary (LSB) and formal seed systems (NAADS, NARO, seed companies). 51% of seed of the different varieties are sufficiently available at community level while 49% are insufficient to medium (Figure 6).

Table 19: List of crops and varieties studied in Warr sub-county, Zombo district

Crop	Beans	Groundnuts	Cowpea	Cassava	Banana	Sweet potato	Irish potato	Yam	Sorghum	Finger millet	Onion
Variety	12	7	2	15	14	7	3	3	6	4	4

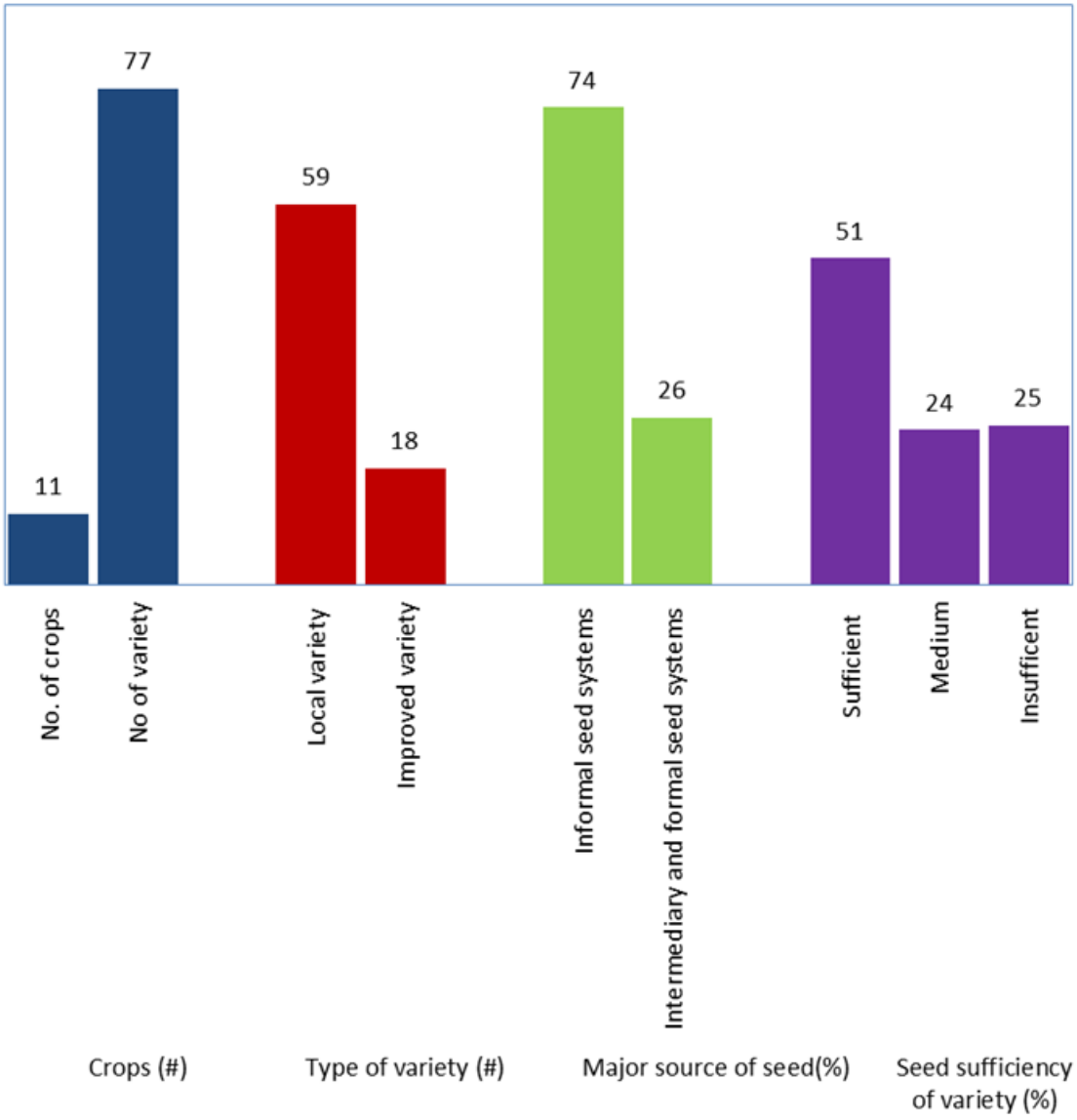

Figure 6: Major crops and their varieties, source of seed (seed systems) and seed sufficiency status in Warr sub-county, Zombo district

A matrix ranking of 77 varieties of 11 crops exposed to specific climate hazards viz. droughts, disease, pest, delayed rain and soil infertility was carried out. Resilient varieties are prioritised based on highest total cumulative rank. Rank I to III are considered as most resilient ones. This resulted into 22 local varieties and 4 improved varieties being the most resilient varieties in Warr sub-county, Zombo district (Table 20-29).

Table 20: Matrix ranking of Beans varieties perceived to be resilient in different climate hazards in Warr Sub County, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Sepia	Local	Pure yellow bean, with tendril, big seed with round in shape, prone to drought, pest and disease prone, taste is better, yield 14 Basins/acre, readily available market	8	9	6	1	24
Sokodibi	Local	Light yellow bean, less tendril, big flat shaped seed, prone to pest and diseases, taste is better, yield 14 Basins/acre, readily available market	2	10	3	2	17
Nyaraciga	Local	White bean, taste is better, yield 18Basins/acre, readily available market	10	11	12	8	41 **(I)**
K132	Improved	Red spotted bean, yield 21 Basins/acre, readily available market	12	12	8	9	41 **(I)**
Nyakalanga (Nabe 15)	Improved	Red & white spot bean, yield 21 Basins/acre	3	6	9	7	15
Nyarawora	Local	White bean, yield 18 Basins/acre	9	7	7	5	28 **(III)**
Laulau	Local	White bean, yield 18 Basins/acre	1	1	10	3	15
Rikini	Local	Brown bean, small size, yield 12 Basins/acre	6	5	11	6	28 **(III)**
Ocidu	Local	Black bean, yield 12 Basins/acre	5	4	2	4	15
Orucu	Local	Wild type bean, but eaten, drought and pest- disease resistance, no market	11	8	1	12	32 **(II)**
Nabe 17	Improved	Red in colour	4	2	4	10	20
Nabe 19	Improved	Red spotted bean	7	3	5	11	26

Table 21: Matrix ranking of groundnuts varieties perceived to be resilient ito different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Full	Local	White seed, many seed in a shell, high yield (8bags/acre), high market, , good for food consumption, resistance to pest and diseases	1	1	3	2	7
Nya Lugbara	Local	Red seed, small size seed, 2 seed per shell, hard shell, yield 6bags/acre, high market, resistance to pest and diseases	5	5	4	5	19 **(II)**
Nya Cap	Local	White seed, big size seed, 2 seed per shell, yield is 10bags/acre, high market, resistance to pest and diseases	4	3	5	4	16 **(III)**
Rosco	Local	Long maturing variety, red seed, big size seed, shell is big, yield 12bags/acre, tasteless	3	4	1	3	12 **(IV)**
Nya Judongo	Local	Red seed, many seeds in a pod, long shell	2	2	2	1	7
Kalanga Mundu (Pawpaw like)	Improved	Long maturing variety, hard shell, very big size shell, climb high on tree, seed cannot be replanted	6	6	6	6	24 **(I)**

Table 22: Matrix ranking of cowpea varieties perceived to be resilient to different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Ngor thindo	Local	Leaves eaten, it is not a runner variety, market readily available	2	2	1	2	7 **(I)**
Oboo Alwala	Local	A runner variety, growing even during dry season, market readily available	1	1	2	1	5

Table 23: Matrix ranking cassava varieties perceived to be resilient to different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Nyapamitu	Local	Early maturing, dark stem, good yield, resistance to pest and disease, mainly for home food consumption, mo market	4	3	15	9	31
Nyamateo	Local	White stem, few but big tubers, lower yield, do not last in soil, bitter in taste	5	15	6	15	41 **(III)**
Nyamatia	Local	Gives many branches, no market, resistance to pest, last longer in the soil	10	14	11	14	49 **(II)**
Longe	Local	Grows very tall, low yielding, bitter in taste, do not last in the soil	7	1	8	8	24
Nyaru dota	Local	Greenish stem, thin leaves	11	13	14	12	50 **(I)**
Nyatoma	Local	It has whitish stem	6	11	5	7	29
Nya Lucy	Local	Has dark stem, good yield, bitter in taste	2	12	12	13	39 **(IV)**
Nya Brother	Local	Early maturing, reddish stem, grows short	9	2	1	10	22
Therengule	Local	Early maturing, white stem	8	7	13	6	34
Nya Caritas	Local	Early maturing, short stem	3	8	2	2	15
Nya Olama	Local	Greenish stem at early stage and high yield	12	9	10	5	36 **(V)**
Nyakawegi	Local	Mature early	1	10	9	11	31
Nase 14	Improved	Early maturing, newly introduced, gives many branches	15	4	7	4	30
TME 204	Improved	Early maturing, gives many branches	14	5	4	1	24
Akena 0067	Improved	Early maturing, gives many branches	13	6	3	3	25

Table 24: Matrix ranking sweet potato varieties perceived to be resilient to different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Nyakenya	Local	Early maturing, dark stem, good yield, resistance to pest and disease, mainly for home food consumption, mo market	5	1	7	4	17 **(III)**
Nya Omayo	Local	White stem, few but big tubers, lower yield, do not last in soil, bitter in taste	6	7	2	7	22 **(II)**
Nya dwii	Local	Gives many branches, no market, resistance to pest, last longer in the soil	3	3	5	2	13
Ukidi	Local	Grows very tall, low yielding, bitter in taste, do not last in the soil	4	2	3	6	15
Dudu	Local	Greenish stem, thin leaves	7	5	6	5	23 **(I)**
Nyar Agara	Local	It has whitish stem	2	4	1	3	10
Nyar NARO	Local	Has dark stem, good yield, bitter in taste	1	6	4	1	12

Table 25: Matrix ranking of plantain varieties perceived to be resilient to different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)I
			Drought	Disease-Pests	Delayed rain	Flood	
Nakitamba	Local	Short stands, small suckers, mainly for market, plant die soon, difficult to maintain	1	10	14	12	37 **(III)**
Sira	Local	Brown stand, mainly for market and food	4	2	2	1	9
Nya-judongu	Local	Long stand, drought tolerant, easy to grow, readily available market	14	1	1	2	18
Bonkra	Local	White stand, suckers with 3 corners, easy to grow, readily available market,	12	11	3	9	35 **(IV)**
Nyakizungu	Local	White stand, long suckers, readily available market, susceptible to pest	11	12	4	4	31
Bogoya	Local	Long maturing variety, white colour long stand, long sucker	5	14	6	5	30
Nyabolu-lyec	Local	Short stand, long maturing variety	2	4	10	7	23
Gonja	Local	Long maturing variety, long stand	6	9	11	8	34
Nyabuthe	Local	Long maturing variety, short stand	7	6	12	14	39 **(II)**
Fearias	Improved	Medium stand, newly introduced variety	8	8	9	3	28
Nyakakwa	Local	Long maturing variety, short stand	3	7	13	11	34
Serere	Local	White stand, susceptible to pest	13	13	8	13	47 **(I)**
SS 14 (mpologoma)	Improved	Long stand, long sucker, newly introduced variety	10	3	5	6	24
M 17 improved	Improved	Medium stand, long suckers, newly introduced variety	9	5	10	10	34

Table 26: Matrix ranking yam varieties perceived to be resilient to different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Mayuni	Local	Planted in swamp, tasteless, watery, not easy to get planting material, market available	3	1	2	1	7
Maule	Local	Planted in high land, tasteless, watery, not easy to get planting material, market available	2	2	1	3	8 **(II)**
Mulugu	Local	Cripping plant, tasteless, watery, not easy to get planting material, market available	1	3	3	2	9 **(I)**

Table 27: Matrix ranking Irish potato varieties perceived to be resilient to different climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Nya-judongu	Local	Tuber round, white in colour, small in size, the taste is more delicious and thicker, both food and market	3	3	3	3	12 **(I)**
Victoria	Improved	Tuber round, reddish in colour, big in size, yellowish flesh, 40% tasty and watery sometimes, mainly for market and food	2	2	1	2	7 **(II)**
Rwengume	Local	Tuber round, red in colour, medium in size compared to Victoria seeds, flesh is white, tasty, produce many seed-tubers but small in sizes, mainly for market	1	1	2	1	5

Table 28: Matrix ranking of sorghum varieties perceived to be resilient to particular climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Serena	Improved	Early maturing, new variety, white and red colour grain, hard to grind, highly affected by birds, market is readily available	2	5	6	1	14 **(III)**
Ndhumu	Local	Early maturing, white grain colour, tall variety, highly affected by birds, market readily available	3	6	4	5	18 **(II)**
Nyakawere	Local	Early maturing, red colour grain, short variety, easy to grinds, eaten by birds seriously, market readily available	6	3	5	6	20 **(I)**
Awulumba	Local	Early maturing, red colour grain, short variety, eaten by birds seriously, easy to grind, market available readily	5	1	1	4	11
Goma	Local	Early maturing, red seed, short variety, destruction by birds is high, less demand in market	4	4	3	2	13
Nyang	Local	White seed, tall variety, sweet stem while chewing like sugar cane, eaten as snacks	1	2	2	3	8

Table 29: Matrix ranking of finger millet varieties perceived to be resilient to particular climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)I
			Drought	Disease-Pests	Delayed rain	Flood	
Akwopa Nyara	Local	Early maturing, reddish grain, yield 5bags/acre, drought and disease resistance	4	3	4	2	13 **(I)**
Nyangwen	Local	Early maturing, red grain, yield 5bags/acre, drought and disease resistance	2	4	2	3	11
Nya judongo	Local	Early maturing, red grain, small seed, yield 4bags/acre	3	2	3	4	12 **(II)**
Seremi 2	Improved	Very new introduction, lack of knowledge about variety	1	1	1	1	4

Table 30: Matrix ranking of onion varieties perceived to be resilient to particular climate hazards in Warr sub-county, Zombo district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank (I=highest)
			Drought	Disease-Pests	Delayed rain	Flood	
Nya judongu	Local	Small in size, reddish and whitish inside, tasty and smells good, tolerant to droughts,	3	2	3	4	12 **(I)**
Hai	Local	Whitish inside, has quir smell, no market	1	4	2	3	10 **(II)**
Bulb onions	Improved	Round and bug, reddish in outside colour, white inside thicker, commercial potential variety	2	1	1	2	6
Lilly onions	Improved	Use part is only the leaves, green in colour, farmers do not know much about this variety	4	3	4	1	12 **(I)**

3.5.2.1 Climate resilient varieties of different crops in Wadelai sub-county, Nebbi district

38 varieties of 10 different crops were analysed in Wadelai sub-county, Nebbi district (Table 31). Majority of varieties are local (24 varieties). Farmers reported that 68% of the seed is sourced from informal seed systems which included own stock, neighbours and local market. The remaining 32% come from intermediary (LSB) and formal seed systems (NAADS, NARO, seed companies). 34% of seed from the varieties is sufficiently available at community level while 66% are insufficient to medium (Figure 7).

Table 31: List of crops and varieties studied in Warr sub-county, Zombo district

Crop	Beans	Groundnuts	Cowpea	Sesame	Cassava	Sweet potato	Sorghum	Finger millet	Rice	Pumpkin
Variety	3	4	2	3	4	3	5	4	5	5

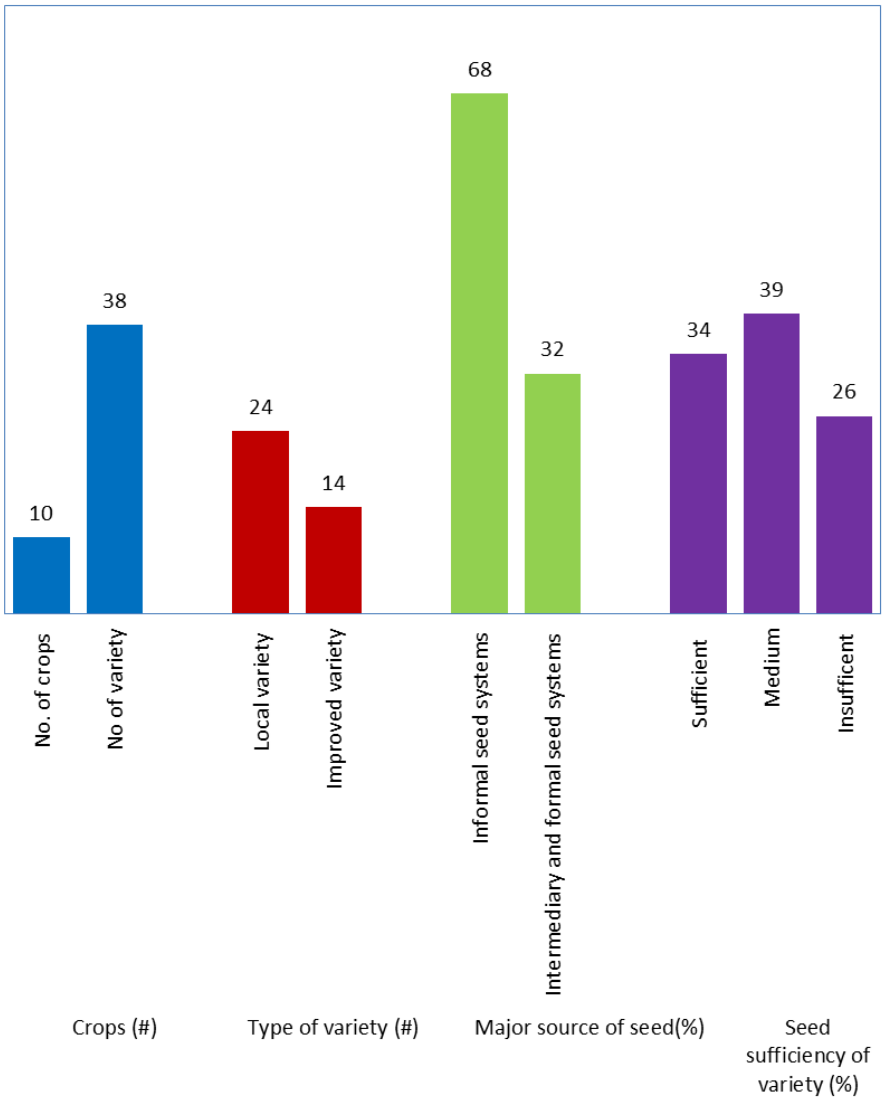

Figure 7: Major crops and their varieties, source of seed (seed systems) and seed sufficiency status in Wadelai sub-county, Nebbi district

A matrix ranking of 38 varieties of 10 crops with specific climate hazards viz. droughts, disease, pest, delayed rain and soil infertility was carried out. Resilient varieties are prioritised based on highest total cumulative rank. Rank I to III are considered as most resilient ones. This resulted into 23 local varieties and 8 improved varieties being the most resilient varieties (Table 31-40).

Table 31: Matrix ranking of beans varieties perceived to be resilient to different climate hazards in in Wadelai sub-county, Nebbi district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Ngor mayellow	Local	Three month variety, yellow bean, big size, sweet taste, green stem, hairy stem, yield 3-4 bags/acre	2	2	1	1	6 **(II)**
Ngor matar	Local	Two months variety, green stem, big seed, 2 bags/acre	1	1	2	1	5 **(III)**
Nabe 15	Improved	Two months variety, new variety in demonstration, green stem, round seed, high yield, sweet taste, expensive seed	3	3	3	1	10 **(I)**

Table 32: Matrix ranking of sesame varieties perceived to be resilient to different climate hazards in in Wadelai sub-county, Nebbi district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Ogali	Local	Three months variety, black seed, big size, good taste, light green stem, greenish pod split into two, yield 2 Bags/acre	3	1	2	1	7 **(II)**
Arutu	Local	White seed, big pods 2-3 partitioning, pale yellow stem, yellow pod split into four, yield 2 Bags/acre	2	2	1	2	7 **(II)**
Sesame II	Improved	Purple colour stem, strong, new introduction, yield 3-4 Bags/acre	1	3	3	3	10 **(I)**

Table 33: Matrix ranking of cowpea varieties perceived to be resilient to different climate hazards in in Wadelai sub-county, Nebbi district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Boo/Agodra	Local	Grow well in upland not in swamp, it doesnot need much rain, takes 3 months, 100kg/acre	2	2	1	2	7 **(I)**
Atotofoto	Improved	Needs more water to grow, take 3 months, yield 250kg/acre	1	1	2	1	**5**

Table 34: Matrix ranking of groundnut varieties perceived to be resilient in different climate hazards in in Wadelai sub-county, Nebbi district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Njinji	Local	Short plant, small seeds, soft shell, yield 7 bags/acre, resistance to pest and diseases	4	4	4	1	13 **(I)**
Nyar-arabi/ Ful-matar	Local	Short plant, while-red seeds, with many seeds, green leaves, drought tolerant, yield, yield 5 bags/acre	3	2	2	1	8 **(III)**
Red beauty	Local	Small red seed, sweet taste, yield 6 bags/acre	3	3	3	1	10 **(II)**
Serenut 4 (series)	Improved	Newly introduced variety	1	1	1	1	4

Table 35: Matrix ranking of cassava varieties as perceived to be resilient to particular climate hazards in Wadelai sub-county, Nebbi district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				
			Drought	Diseases-Pests	Delayed rain	Floods	Total & Resilient variety rank, (I=highest)
Longe NASE 3	Improved	More branches, brownish colour stake, tuber white colour, good taste, yield 30 bags/acre, disease resistance	4	4	4	4	16 **(I)**
TME 14	Improved	Less branches, stake with light red colour, cutting are expensive, yield 35 bags/acre	2	3	1	3	9 **(II)**
Nyapa mito	Local	Plant taller, late maturing variety, less branches, tuber bitter in taste, susceptible to diseases, yield 30 bags/acre	1	1	2	2	6
Ocola	Local	Plant taller, many branches, tuber bitter in taste, yield 30 bags/acre, disease resistance, drought tolerant	3	2	3	1	9 **(II)**

Table 36: Matrix ranking of sweet potato varieties as perceived to be resilient to particular climate hazards in Wadelai sub-county, Nebbi district

Variety name	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Drought	Diseases-Pests	Delayed rain	Floods	
Nyambale	Local	Three months variety, red in colour, green vine, yield 60 bags/acre	3	2	3	1	9 **(II)**
Mon too	Improved	Three months variety, yellow in colour, green vine yield 50 bags/acre	1	3	1	2	7
Nyakampala	Local	Red in colour, green vine, yield 30 bags/acre	2	3	2	3	10 **(I)**

Table 37: Matrix ranking of sorghum varieties as perceived to be resilient to particular climate hazards in Wadelai sub-county, Nebbi district

Variety names	Types of varieties	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Ndumu	Local	Seven months variety, grow tall, red grains, yield 15 bags/acre	3	3	3	1	10 **(I)**
Cerena	Improved	Three months variety, grow short, red or white seed, yield 14 bags/acres	1	1	1	2	5
Yeleyele	Local	Three months variety, grow tall, yield 14 bags/acre	2	1	2	1	6 **(III)**
Maweli	Local	Five months variety, grow tall	2	2	2	2	8 **(II)**
Ipuripur	Improved	2.5 months variety, grows short, white seed, yield 18 bags/acre	2	1	2	1	6 **(III)**

Table 38: Matrix ranking of finger millet varieties as perceived to be resilient to particular climate hazards in Wadelai sub-county, Nebbi district

Variety names	Types of varieties	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Angungu	Local	Three months variety, old variety, fist shape head, white grain, yield 3 bags/acre	3	2	3	1	9 **(III)**
Nyadyei 2	Improved	Two months variety, 3 fingers leaves, single stem, yield 3.5 bags/acre	2	1	2	1	6
Ceremy	Improved	Three months variety, fist shaped head, red grains, yield 3.5 bags/acre, new introduction	3	3	3	3	12 **(I)**
Ayakra	Local	Two months variety, 3 fingers leaves, red grains, yield 2 bags/acre	3	2	3	2	10 **(II)**

Table 39: Matrix ranking rice varieties as perceived to be resilient to particular climate hazards in Wadelai sub-county, Nebbi district

Variety names	Types of varieties	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
NERICA 4	Improved	Three months variety, light brown grain, yield 6-8 bags/acre	2	3	3	4	12 **(III)**
NERICA 2	Improved	Three months variety, light brown grain, thin in shape, yield 4-6 bags/acre	3	5	2	3	13 **(II)**
NERICA 1	Improved	Three months variety, light brown grain, thin in shape, yield 4-6bags/acre	5	4	5	2	16 **(I)**
Super NERICA	Improved	Five months variety, white grain, large size grain, grow taller, yield 6-7 bags/acre	1	1	1	5	8
Upland rice	Improved	Three months variety, white grain, getting seed becoming difficult , yield 5-6 bags/acre	4	2	4	1	11

Table 40: Matrix ranking of pumpkin varieties as perceived to be resilient to particular climate hazards in Wadelai sub-county, Nebbi district

Variety	Types of variety	Variety characteristics	Climate hazards (Ranking 1=lowest)				Total & Resilient variety rank, (I=highest)
			Droughts	Diseases-Pests	Delayed rain	Floods	
Jita	Local	Good taste, drought tolerance, leaves can be eaten, availability of market, high yield	5	4	5	3	17 **(I)**
Nyaralur	Local	Very long runner on ground, cover much land, early maturing, low yield	1	1	2	2	6
Atolo	Local	Good taste, does not need much land, high yielding	2	3	4	4	13 **(III)**
Nyangebu	Local	Good taste, does not need much land, high yielding	3	5	3	5	16 **(II)**
kondo-matar	Local	Not very good taste, very long runner, leaves not tasty, susceptible to droughts	4	2	1	1	8

3.6 Seed systems in which climate resilient varieties fall

An analysis of source of seed for each variety in Tables 9 to 40 shows three major clusters of seed systems:

i) Informal seed systems where farmers reported source of seed from own stock, neighbours and local market.
ii) Intermediary seed systems where farmers reported LSB and NGOs as source of seed.
iii) Formal seed system. This is mainly NAADS, NARO, and Seed companies as source of seed.

In Vuura sub-county, Arua district, a total of 26 varieties were ranked highest and considered to be the most resilient varieties. Seed of 22 of these varieties is sourced from informal seed systems while seed of the remaining 4 varieties comes from intermediary and formal seed systems (Table 41).

In Warr sub-county, Zombo district, a total of 28 varieties were ranked highest and considered to be the most resilient varieties. Seed of 25 of these varieties seed is sourced from informal seed systems while seed of the remaining 3 varieties comes from intermediary and formal seed systems (Table 42).

In Wadelai *s*ub-county, Nebbi district, a total of 26 varieties were ranked highest and considered to be the most resilient varieties. Seed of 17 of these varieties is sourced from informal seed systems while seed of the remaining 9 varieties comes from intermediary and formal seed systems (Table 43).
The analysis above shows that 75% of the seed of climate resilient varieties is sourced from informal seed systems while the remaining 25 % are acquired from intermediary and formal seed systems.

Table 41: Highest ranking resilient varieties and their key seed systems in Vuura sub-county, Arua district

Crop	Variety name	Types of variety	Major source(s) of seed	Seed systems
Beans	K132	Improved	NGO, NAADS, LSB	Intermediary and formal
	Gombili	Local	Own stock, neighbours, local market	Informal
	Esoko Osu	Local	Own stock, neighbours, local market	Informal
	Nabe 15	Improved	Seed companies, NARO, NGO l	Intermediary and formal
	Nabe 16	Improved	Seed companies, NARO, NGO	Intermediary and formal
Groundnut	Serenut 3	Improved	Neighbours, Local market	Informal
	Red Beauty	Recycled (improved)	Neighbours, Local market	Intermediary
	Serenut 4T	Improved	Neighbours, Local market	Informal
Cowpea	Odumbaku	Local	Neighbours, Local market	Informal
	Ayaraayara	Local	Neighbours, Local market	Informal
Cassava	Omo	Local	One stock, neighbours	Informal
	Nase 14	Improved	NARO, NGO, LSB, Neighbours	Intermediary and formal
	Malukua	Local	Own stock, neighbours	Informal
Plantain	Abua Enya	Local	Own stock, neighbours	Informal
	Opun	Local	Own stock, neighbours	Informal
	Nyatule	Local	Own stock, neighbours	Informal
	Sira	Local	Own stock, neighbours	Informal
Irish potato	Mamanakutu (eka/red)	Local	Local market	Informal
	Mamanakutu (payipulu/ purple)	Local	Local market	Informal
Sweet Potatoes	Okilipa	Local	Neighbours, own stock	Informal
	Ewa maku	Local	Neighbours, own stock	Informal
	Anyauu maku	Local	Neighbours, own stock	Informal
Finger millet	Anya Emve (white millet)	Local	Own stock, neighbours, local market	Informal
Sorghum	Godo	Local	Own stock, neighbours, local market	Informal
	Mugusa	Local	Own stock, neighbours, local market	Informal
Rice	Madingili	Local	Own stocks, neighbours	Informal

Table 42: Highest rankling resilient varieties and their key seed systems in Warr sub-county, Zombo district

Crop	Variety name	Types of variety	Major source(s) of seed	Seed systems
Beans	Nyaraciga	Local	Local market	Informal
	K132	Improved	NAADS, LSB, NARO	Intermediary and formal
	Nyarawora	Local	Local market	Informal
	Rikini	Local	Local market	Informal
	Orucu	Local	Own stock	Informal
Groundnut	Nya Lugbara	Local	Local market	Informal
	Nya Cap	Local	Local market	Informal
	Kalanga Mundu (Pawpaw like)	Improved	Local market	Informal
Cowpea	Ngor thindo	Local	Neighbours, local market	Informal
Cassava	Nyamateo	Local	Local market	Informal
	Nyamatia	Local	Local market	Informal
	Nyaru dota	Local	Local market	Informal
Sweet potato	Nyakenya	Local	Neighbours	Informal
	Nya Omayo	Local	Neighbours	Informal
	Dudu	Local	Neighbours	Informal
Banana	Nakitamba	Local	Local market	Informal
	Nyabuthe	Local	Local market	Informal
	Serere	Local	Local market	Informal
Yam	Mulugu	Local	Local market	Informal
Irish potato	Nya-judongu	Local	Local market	Informal
	Victoria	Improved	NAADS, LSB, NARO	Intermediary and Formal
Sorghum	Serena	Improved	NAADS, NARO, Local market, neighbours	Intermediary and Formal
	Ndhumu	Local	Local market, neighbours	Informal
	Nyakawere	Local	Local market, neighbours	Informal
Finger millet	Akwopa Nyara	Local	Local market	Informal
	Nya judongo	Local	Local market	Informal
Onion	Nya judongu	Local	Local market, neighbours, own stock	Informal
	Lilly onions	Improved	Local market, neighbours	Informal

Table 43: Highest rankling resilient varieties and their key seed systems in Wadelai *s*ub-county, Nebbi district

Crop	Variety name	Types of variety	Major source(s) of seed	Seed systems
Beans	Ngor mayellow	Local	Own stock	Informal
	Nabe 15	Improved	NARO, LSB	Intermediary and formal
Sesame (simsim)	Ogali	Local	Owen stock, Local market	Informal
	Arutu	Local	Owen stock, Local market	Informal
	Sesame II	Improved	NARO, LSB	Intermediary and formal
Cowpea	Boo/Agodra	Local	Owen stock, Local market	Informal
Groundnuts	Njinji	Local	Own stock	Informal
	Nyar-arabi/ Ful-matar	Local	Own stock	Informal
	Red beauty	Local	Own stock	Informal
Cassava	Longe NASE 3	Improved	NARO	Formal
	TME 14	Improved	NARO	Formal
	Ocola	Local	Own stock, neighbours	Informal
Sweet potato	Nyambale	Local	Own stock, neighbours	Informal
	Nyakampala	Local	Local market	Informal
Sorghum	Ndumu	Local	Own stock, neighbours, local market	Informal
	Maweli	Local	Own stock, neighbours, local market	Informal
	Ipuripur	Improved	Imported	Informal
Finger millet	Angungu	Local	Own stock, neighbours, local market	Informal
	Ceremy	Improved	LSB	Intermediary
	Ayakra	Local	Own stock, neighbours, local market	Informal
Rice	NERICA 4	Improved	NARRO, NAADS, LSB	Intermediary and formal
	NERICA 2	Improved	NARRO, NAADS, LSB	Intermediary and formal
	NERICA 1	Improved	NARRO, NAADS, LSB	Intermediary and formal
Pumpkin	Jita	Local	Own stock, neighbours	Informal
	Nyangebu	Local	Own stock, neighbours	Informal
	Atolo	Local	Own stock, neighbours	Informal

3.7 Integrating climate resilient crops/varieties into LSB

The current LSB crop variety portfolio of the three study sites is shown in Table 44. LSBs are currently producing quality seed of improved varieties of beans, soya, groundnut, sesame, cassava, Irish potato, rice, and millet. Tthere is scope to further strengthen LSBs as sustainable businesses by:

- Addition of new climate resilient varieties of existing crops that LSBs are already involved with. Potential varieties are suggested in Table 45. These include both improved and local varieties.

- Addition of new crop varieties in existing LSBs. It is suggested that Table 41,42,43 provide ample basis for discussion and selection of new crop varieties for this purpose.

Table 44: LSB current seed crops and varieties in three study sites

Sub-county	District	LSB name	Crops	Variety name
Vuura	Arua	Nyio Ajia	Beans	K132
			Soya	Maksoy 3N
			Groundnut	Red beauty
			Rice	NERICA 4
			Cassava	Nase 14
Warr	Zombo	Agiermach Ogiebu	Beans	K132
			Irish potato	Victoria
Wadelai	Nebbi	Watembu	Simsim	Sesame 2
			Millet	Seremi 2
			Rice	NERICA 4

Table 45: Potential additional climate resilient varieties for LSBs' in three study sites

Sub-county	District	LSB name	Crops	New potential resilient varieties	Seed sufficiency status at sub-county level
Vuura	Arua	Nyio Ajia	Beans	Nabe 15 (improved)	Insufficient
				Nabe 16 (improved)	Insufficient
				Esoko Osu (local)	Insufficient
			Groundnut	Serenut 3 (improved)	Medium
				Serenut 4T (imporved)	Medium
			Rice	Madingili (local)	Medium
			Cassava	Malukua (local)	Medium
Warr	Zombo	Agiermach Ogiebu	Beans	Nyaraciga (local)	Medium
				Orucu (local)	Insufficient
				Rikini (local)	Insufficient
			Irish potato	Nya-judongu (local)	Medium
Wadelai	Nebbi	Watembu	Simsim	Arutu (local)	Medium
			Millet	Ayakra (local)	Medium

Chapter 4: Discussions

4.1 Introduction

In effort to enhance the resilience potential of the LSBs in the study areas, this study explored farmers perception on climate change and its' influence on local crop and seed production as way of identifying gaps for strengthening the adaptive potential of the LSBs in the highland area, West Nile and Nile belt ago-ecologies of West Nile amidst climate change challenges. As stated by authors (Louwaars and de Boef, 2012, McGuire and Sperling, 2013) the resilience potential of a seed system is a complexity of social-ecological assets, bio-physical features, and institutional linkages that aim at improving the production of and access to good quality seed of a desired crop cultivar at an opportune time. Such a scenario calls for a proactive, informed and empowered team of stakeholders across the overall seed production and exchange chain. In this study, all targeted communities had enabling social-ecological assets, bio-physical features, levels of awareness and institutional linkages to strengthen their LSBs amidst the climate change. These assets included land, infrastructure network, socially binding structures e.g. farmer groups, churches, schools, mosques through which information and technologies are shared. All these structures form the basis for strengthening crop and and/or seed production and marketing amidst challenges of climate change.

4.2 Farmers' perceptions of climate variability and current local innovations for adaptation

All communities were well aware of the challenges in crop production due to climate change although there were minimal variations in the perceptions on the extent, frequency and intensity of the climate hazards. Drought, floods, pest and diseases and unreliable rainfall patterns were ranked as the most limiting climate hazards across sites with farmers highlighting an unpredictable rainfall pattern as the main driving factor for all challenges in their agro-ecosystems. Of all the identified climate hazards, the intensity and frequency of droughts were perceived as the major climate hazard. This concurs with UNDP (2013) where Uganda in general, is reported to be experiencing more intense and frequent droughts than it has ever historically recorded. Conversely, the Nile belt agro-ecological zone also noted floods as one of the major limiting factor to crop production and this could be probably due to its location in relation to river Nile. In this study, farmers perceived the impact of climate variability in relation to the extent it was affecting their crop resource production and the supportive infrastructure.

The effect of climate change on crop production was perceived in relation to the diminishing levels in quantity and quality of the affected crop resources yield. All communities suggested that there is need to integrate climate smart options into their LSBs as a way of enhancing their resilience potential amidst effects of climate change.

A number of innovations were being implemented by farmers to adapt to the perceived changes in climate. The innovations were generally related to adjustment in crop and land management practices. Timely planting was mentioned as a key adjustment for almost all crops. Since rains generally came late and ceased early, farmers ensured timing of operations to optimise soil moisture at critical growing stages of the crops. However, limited resources to ensure timely land preparation was noted as a challenge. Most of the farmers still use local tools – hand hoe for land opening and cultivation which is very slow and therefore they find themselves late in season. Secondly, there is one main distinct growing season and farmers grow most of their crops in this season. Managing three or four plots of different crops with limited labour and mechanisation also creates delays for the farmers.

Use of improved varieties has been applied mainly for cassava. Varieties that are tolerant to pests and diseases and early maturing ones are existent in the zone. There have also been a number of initiatives that have supported access to planting materials for cassava for example AGRA, DANIDA and Abi ZARDI. Other measures included diversification of farm enterprises to include livestock, crop rotation, intercropping, incorporation of early maturing crops, and soil and water conservation measures. Shifting to off-farm work was also noted as a measure for coping with climate changes.

Response strategies reported by farmers in West Nile zone are comparable with measures identified by climate change research community in Uganda and Africa as a whole as detailed by various authors (for example Kurukulasuriya and Mendelsohn, 2006; Mubiru and Magunda, 2010; Nzuma et al., 2010, and Kansiime et al., 2014). These measures provide tactful approaches for the crop to survive adverse conditions thus ensuring farmers obtain some yield. However, integration of approaches has been proposed including both technological and management innovations as the most appropriate for adaptation to occur. For example, farmers are currently timing the rainy season, but instances of no rain at all when anticipated were also reported. Thus the need to integrate appropriate weather forecast and irrigation could be adopted. In the context of farmers and LSBs, there are implications on access to such information and cost of installing and managing expensive irrigation equipment. In the current context, the study dwelt more on integration of climate resilient crops, though it should be kept in mind that innovations to enhance crop productivity amidst climate variability require integrated measures.

4.3 Climate resilient varieties for LSB

Farmers were aware that crops have different levels of response to climate hazards and qualitatively prioritised specific crop resources in relation to particular hazards (Tables 3 and 4). Cassava was prioritized as the best commodity amidst all the climate hazards across all study sites thus posing as a key crop resource in the entire West Nile agro-ecological zone. Cassava is a major food and cash crop in West Nile and substantial research has been done to develop varieties that are suited to the climate conditions and also tolerant to pests and diseases. Notable is the work for Abi ZARDI and EAAPP program implemented by NARO to develop a centre of excellence for cassava in Uganda targeting mainly West Nile and Northern agro-ecologies.

Other crop resources with promising levels of resilience were bananas, sorghum and finger millet for West Nile, highland area and the Nile belt respectively (Tables 3 and 4). Given that the major climate challenge noted in highland areas of West Nile was droughts, bananas play an important role in ensuring food security since they have ability to withstand dry spells. According to Jassogne et al. (2013) the permanent canopy, root systems, and mulch from the banana plants prevent soil erosion and degradation in Uganda's hilly landscape, thus making the crop more adaptable to current climate variations in these areas. In addition, banana coffee systems have been proved to generate more income for smallholder farmers, and can help them cope with the effects of climate change, which is the major farming system in highland areas of West Nile. It is therefore logical that farmers in the highland areas perceive bananas to be an important adaptation crop to recurrent droughts.

Similarly, sorghum and finger millet were perceived as important adaptation crops against droughts, and pests and diseases. Sorghum and millets have proved important crops especially in the semi-arid areas of Africa and thus hold great potential to provide food and income security in the region as well, responding to increased droughts. However, the challenges associated with these crops as observed from the study responses were mainly on the productivity and commercialisation of the crops. Farmers considered these crops as 'inferior', with limited market value thus farmers showed limited interest to integrate them in their local seed businesses. Wambugu and Mburu (2014) note that through improved access to high-quality certified seed technology, intensification of production, transfer of good agronomic skills and use of inputs, and

stronger market links, farmers could increase productivity of sorghum by two fold as well as volumes traded.

Local vegetables such as cow peas, *malakwang*, *boo, otigo* and *akeyo* were also considered to be important adaptation crops mainly due to their short maturity period and ability to withstand droughts. However, their business potential was also not clear to LSBs thus reluctance to consider them as LSB crops. This is because local vegetables majorly belong to informal seed system, with no or limited seed buying behaviour for farmers.

Varieties identified to have climate resilient characteristics were mainly local varieties, or released varieties that have been recycled by farmers over time. These varieties were mainly in the informal sector (farmer-saved, exchange, local market). Integration of such crops in LSB requires analysis of their market potential given that seed of these crops is mainly saved from farm or just exchanged.

4.4 Capacity building for LSBs

McGuire and Sperling (2013) highlight eight principles to a resilient seed system and among them is the need to nurture a systems perspective that focuses on strengthening knowledge, institutional linkages and response to processes and social dynamics rather than the physical properties of the system like seed. This thus calls for a holistic approach that integrates farmers and other stakeholders concerns as regards developing and sustaining climate resilient LSBs. This approach builds on understanding the stakeholders' capacity and identification of knowledge and technology gaps to efficient crop production process and production practices amidst climate hazards.

During the study a number of capacity building areas were identified. These range from knowledge enhancement of what varieties and practices to employ, to introduction of new innovations and crop varieties, technological improvements (such as labour saving technologies, irrigation and weather forecast), and support for farmers' access to credit. These capacity building areas will however be further validated by farmers and also corroborated with data from household survey in order to develop an appropriate capacity building plan.

Chapter 5: Conclusion and recommendations

This study has documented farmers' perception of climate change, identified seemingly adaptable crops, and options for counteracting the detrimental effects of the climate hazards in relation to seed production. Generally all the communities were aware of the changes in climate and the vulnerability of their local crop/seed production systems hence livelihoods to the identified climate hazards. Such awareness and perception provides a strong basis upon which an intervention addressing the challenges of crop production amidst climate change can thrive. This study has thus presented opportunities for improving the adaptive potential of local crop production and seed systems in the highland area, West Nile grassland and Nile belt ago-ecologies.

In Vuura sub-county, farmers considered droughts, pests and diseases and soil infertility to be most important climate factors in the area. Similarly, in Warr sub-county, drought, pests and diseases and rainfall patterns (delayed and heavy rains) were identified as the most important climate hazards affecting crop and seed production. In Wadelai sub-county on the other hand, farmers identified drought, pest and diseases and floods as the most important climatic hazards affecting yield and quality of crop production.

In response to the perceived climate changes, farmers in the three study sites indicated to have employed some measures to cope or adapt to the changes. For example in Vuura sub-county farmers adapted through use of seed of improved varieties and by employing improved technologies of farming such as use of ox-ploughs and tractors to improve the soil properties to support crop production. In Warr sub-county crops that are resilient to the observed hazards were sorghum, cassava and sweet potatoes (for drought periods).Here the applied measures were the integration of plants with a shorter maturity period like cowpeas (*Boo*) and Jute mallow (*Otigo*) and the incorporation of other agricultural activities such as vegetable cultivation, livestock, poultry and fish farming into their agro-ecosystem as well as applying crop rotation. In Wadelai sub-county the adoption of agricultural practices like row planting and using high yielding varieties like Sesame 2, employing crop rotation to check pest and disease pressure and incorporating conservation / organic agriculture into the farming systems were identified as measures taken.

Detailed information of over 165 different varieties belonging to 15 different major food and cash crops from three different study sites was analysed to identify varieties which are resilient to different climate hazards. In Vuura sub-county, a total of 55 varieties of 10 different crops was analyzed. Study crops included beans, cowpea, groundnuts, banana, Irish potato, sweet potato, sorghum, finger millet and rice. The majority of these varieties are local (38 varieties) and farmers reported that 91% of the seed of the different varieties was sourced from informal seed systems which included own stock, neighbours and local market. The remaining 9% came from intermediary (LSB, NGOs) and formal seed systems (NAADS, NARO, seed companies). Only 20% of seed from different varieties are sufficiently available at community level while 80% are available to an insufficient to medium extent. A total of 26 varieties was ranked as most resilient. The seed of 22 of these varieties is acquired from informal seed systems while the seed of the remaining 4 varieties is acquired from intermediary and formal seed systems.

In Warr sub-county, Zombo district, a total of 77 varieties of 11 different crops was analysed. Study crops included beans, cowpea, groundnuts, cassava, banana, sweet potato, Irish potato, yam, sorghum, finger millet, rice, and onion. The majority of these varieties are local (59 varieties) and farmers reported that 74% of seed of the different varieties was sourced from informal seed systems which included own stock, neighbours and local market. The remaining 26% came from intermediary (LSB) and formal seed systems (NAADS, NARO, seed companies). 51% of seed from different varieties are sufficiently available at community level while 49% varieties seed are available to an insufficient to medium extent. A total of 28 varieties was

ranked as most resilient. The seed of 25 of these varieties seed is acquired from informal seed systems while the seed of the remaining 3 varieties comes from intermediary and formal seed systems

In Wadelai sub-county, Nebbi district, a total of 38 varieties of 10 different crops was analyzed. Study crops included beans, groundnuts, cowpea, sesame, cassava, sweet potato, sorghum, finger millet, rice and pumpkin. Majority of these varieties are local (24 varieties) and farmers reported that 68% of the seed of different is sourced from informal seed systems which included own stock, neighbours and local market. While 32% of the seed of different varieties comes from intermediary (LSB) and formal seed systems (NAADS, NARO, seed companies).The seed of 34% of the different varieties is sufficiently available at community level while 66% varieties seed are available to an insufficient to medium extent. A total of 26 varieties was ranked as most resilient. The seed of 17 of these varieties is acquired from informal seed systems while the seed of the remaining 9 varieties comes from intermediary and formal seed systems.

The current LSB crop portfolio at the three study sites features improved varieties of beans, soya, groundnut, sesame, cassava, Irish potato, rice and millet. However, there is scope to further strengthen LSBs in terms of sustainability by making strategic choices to include new additional climate resilient varieties of existing crops or adding new resilient crops. The following recommendations are made to integrate the result of the present study:

- Sharing study findings with LSB executive committee, LSB members, Abi-ZARDI team and other local seed sector stakeholders: One of the first step is to share the findings of the current study. This step creates awareness about the potential climate resilient crops and varieties in each sub-county/at district level. The expected output of this is to select the prioritized new crops or varieties for the LSBs. Potential aaddition of new climate resilient varieties in Vuura sub-county are beans (Nabe 15, Nabe 16, Esoko osu), groundnut (Serenut 3, Serenut 4T), rice (Madingili) and cassava (Malukua). Climate resilient varieties suggested in Warr sub-county are beans (Nyaraciga, Orucu, Rikini) and Irish potato (Nya judongu) and in Nebbi sub-county simsim (Arutu) and millet (Ayakra). This includes both improved and local varieties.

- Seed demand and supply study by LSBs: In order to market the prioritized climate resilient crops or varieties a thorough understanding of local seed demand and supply is necessary. The current study shows that seed of new proposed climate resilient varieties is available to an insufficient to medium extent at sub-county level. However a detailed study should be carried out by LSBs to analyse the business viability of seed of climate resilient new varieties.

- Participatory Variety Selection (PVS) of the identified crops and varieties should be conducted to identify varieties with adaptive traits and ascertain farmers' perceptions of climate variability and the associated hazards. This will improve farmers' capacity to perceive climatic variability and hence provide a strong basis for predicting environmental hazards due to climate change and designing best coping strategies. It was also noted that farmers prefer to grow crops in the second and long rainy season. Additionally, communities experienced drought and floods at different times of the year. Some demonstrations can be done in season one, including counter-season crops PVS so that farmers can judge whether it pays off.

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Annexes 1

Tool synthesis on impact climate change on local livelihood/crop production/seed system

No.	Tool	Objective	Targeted Research questions
1.	Community Resource Map	Identification of the key resources in the community and their vulnerability to climate change and devise options for adaptation	2,3,4,5,
2.	Time line	Understanding the dynamics in the community's agricultural production and seed system in relation to climate change	1,2,3,4,5
3.	Seasonal calendar	Documenting community perception on occurrence and change in climate factor or climate induced factors in the last 15years or before in study/project site	1,2,3,4,5,6
5.	Matrix Ranking	Understanding how farmers prioritize and evaluate the crops and varieties' resilience to climate change	5,6,7,8,9
6.	Stakeholder identification and flow chart	Identifying and understanding the key stakeholders to be involved in the LSBs of climate resilient crops/varieties	8,9

Tool 1: Community resources and vulnerable areas identification

Primary objective

- Identify the major resources in the community that support crop production hence livelihoods
- Identify main areas in the community village/study site that are affected by different climatic hazards (e.g. Drought, Floods, Pest and disease etc.) and assess their risk.
- Identify options for improvement and adaptation

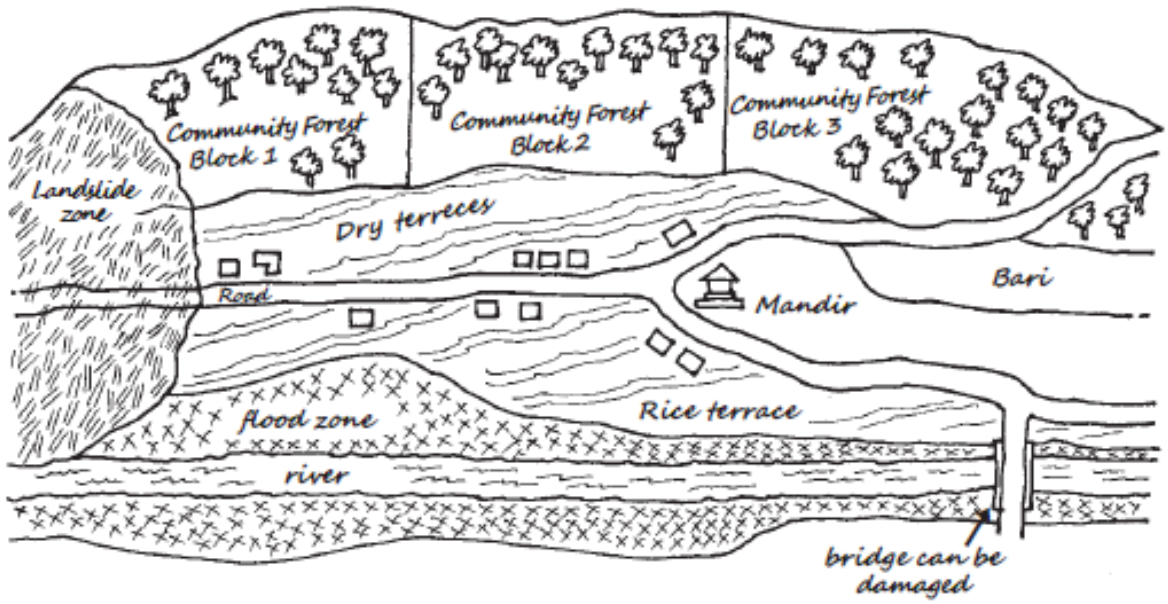
Note: This tool exactly work as Village resource mapping

Materials

- Large piece of brown paper
- Different colours of marker pen
  Or
- clean floor with colour powder/chalk

Time: 45 minutes

Setting: Mixed groups



Process

1. Share the purpose of the exercise with farmers
2. Ask with them to develop a map of their village on large piece of brown paper or on floor
3. Identify major resources (water source, forest, pasture/grazing land, crop production etc, ...) that being used for their local livelihoods/food security purpose
4. Go more details for Crop production: if there are clear zones for specific crop, this can be shown in map using colour/symbols
5. Ask with them to identify the areas that are most affected by drought, floods, soil erosion,..... (indicate by different colours or symbols)

Facilitate the discussion

Use above map, to facilitate discusison by using few guiding questions:

1. Which areas of the community are most affected by which hazards?
2. Who are affected most in most vulnerable areas of community/study site (poor, small-holder etc)
3. Which specific crops or livelihood assets are most affected by the different hazards?

Assets	climate hazards
a.....	.....
b.....	.....

4. How is the community coping living in most hazard prone areas?
5. How frequently are the above hazards occurring in community?
6. Do they see increasing trend in occurrence of such hazards in recent one decade or so?
7. What can be done to minimise or adapt with these hazards?

Tool 2: Time line

Primary objective

- Understand the temporal dynamics in the community's agricultural production and seed system in relation to climate change

Materials

- Large piece of brown paper
- Different colours/marker pen
  Or
- Clean floor with colour powder/chalk

Time: 1 hour

Setting: Mixed group (including elderly to youth farmers)

Process

Share the purpose of the exercise with farmers

Ask the participants to prepare a matrix presenting the most important events in the community that have direct or indirect impact on their agricultural development and adaptation to climate change i.e.;

- Years when crop production yielded exceptionally low
- Development of infrastructure
- Establishments of initiatives to support crop production and seed system
- Degradation of the ecosystem
- Which adaptive strategies have been employed

Tool 3: Seasonal calendar

Primary objective

- Document community perception on occurrence and change in climate factor or climate induced factors in the last 15 years or before in study/project site

Materials

- Large piece of brown paper
- Different colours/marker pen
  Or
- Clean floor with colour powder/chalk

Time: 45 minutes

Setting: Mixed group (including elderly to youth farmers)

Climate Variables/ Indicators	Up to 30 years before	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Temperature	Before												
	Now												
Rainfall	Before												
	Now												
Drought	Before												
	Now												
Disease-pest	Before												
.....	Before												
	Now												
.....													

Other social economic factors;

- Flood
- Deforestation
- Management practices

Process

Share the purpose of the exercise with farmers
Ask with them to develop a matrix of various months as shown in above figure
Ask them to record major climatic factor (use Tool 1, Tool 2 to identify the climatic factors)
Record community perception on trend/time and compare with 30 years and now:

Temperature: Very high, very low
Rainfall: Most rainy months, most dry months
Drought: Drought period

Facilitate the discussion

Use above map, to facilitate discussion by using few guiding questions:

1. Which climatic event(s) are most recurring?
2. Which climatic factor is newly observed?
3. In which months are the extreme climatic events most observed?
4. Which areas of the community are most affected by the changes?
5. How these changes are impacting local crop production and seed systems?
6. Which crops and varieties are most affected by the changes?
7. Which crops and varieties are withstanding the changes?
8. In which seed system do the resilient crops and varieties best fit?

Tool 4: Matrix ranking
Primary objective

- Understanding how farmers prioritise evaluate the crops and varieties' resilience to climate change
- Evaluating the factors influencing the seed system of the crops and varieties that have climate resilient characters to adapt to climate change

Materials

- Large piece of brown paper
- Different colours/marker pen
- Coloured cards

Time: 1 hour

Setting: Different groups per gender, if possible identify one group of youth farmer

Resilient characters	Crop /variety	Crop /variety	Crop /variety	Crop /variety
Drought tolerance	5	3	3	4
Tolerance to pest and diseases	3	1	3	4
Tolerance to floods	5	3	3	4
Hail stone	1	4	2	5
Seed security	-	-	-	-

1= Low/ Bad; 4= High/ Good

Process

Form three separate groups –only men, only women, only youth
Share the purpose of the exercise in separate groups
Make a matrix with the crops /varieties and hazards as identified in tool 4 and ask the participants to;

- Rank the crop/variety for each resilient character
- If there are four varieties/ crops the best crop/variety gets four, etc.

A weighted ranking of crops/varieties can be calculated as the product of the value for the criteria and the score for each specific variety so that all varieties are compared with each other.

Facilitate the discussion

- Inquire from farmers in which seed systems do these varieties best fit?
- How can these crops/varieties be part of the LSB?

Characteristics	Farmer-saved	Individual farmer to entrepreneur	Community based	Local seed businesses	National private companies	Regional and multinational companies	Cash crop value chains	Close value chains
General description	Traditional for food and subsistence crops(informal	More entrepreneurial for local crops	Development oriented with support through NGO programs - intermediaries	Emerging seed producing and marketing groups with a market orientation and seed entrepreneurship	Emerging and vibrant system with many companies with strong focus on maize but including other crops, marketing through agro-dealers or input schemes (formal)	Own varieties and basic seed; structured quality seed production, direct marketing and through agro dealers (informal).	Semi public and private system with distribution through commodity organizations (informal)	Closed system with export commodities (formal)
Type of crop	Food crops	Food and cash crops	Major food and cash crops	Major food and cash crops	Major food and cash crops	Cash crops	Small holder cash crops	Plantation and green house cash crops
Major crops	Beans, cowpea, pigeon pea, green grams, millet, sorghum, open pollinated maize, banana, sweet potato, cassava	Indigenous vegetables, spices, and medicinal plant	Beans, rice, maize, sorghum, cassava, sweet potato, potato, fruits	Cassava, beans groundnuts, simsim, sorghum, potato, soya beans, rice	Maize (high breed and OPV)t, sun flower, brewing sorghum, beans, rice, groundnut	Maize (high breed), sunflower(high breed) and vegetables, pasture crop	Coffee, cocoa, cotton	Sugar cane , tea, oil palm, tobacco, flowers
Type of varieties	Local varieties and introduce and recycled improved varieties	Local indigenous varieties	Improved varieties released through public programmes	Improved varieties released through public programmes, popular local indigenous varieties	Improved varieties released through public breeding companies	Improved varieties released through private breeding companies	Improved varieties released through public breeding programmes	Improved varieties released through private breeding programmes
Type of seed quality	Farmer saved (informal)	Farmer saved (informal)	Standard/ quality declared	Standard/ quality declared	Certified/ standard	Certified/ (quality declared seed for vegetables and pastures)	quality	Quality
Type of distribution and	Framer-saved and exchange, local	Local market	Distribution and marketing	Marketing	Marketing through agro-dealers and input	Direct marketing and through agro-dealers	Distribution and marketing	Seed input for use within value

marketing market schemes chain

Source: ISSD Africa, 2012, ISSD Uganda briefing note + LSB seed system added

Annexes 2 Overview of farmers knowledge on different crops and varieties in Vuura sub-county, Arua district

Overview of farmers knowledge on food legumes and oil seed crops documented in Vuura sub-county, Arua district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Beans	Asikua	X		Early maturing, old variety, white colour seed, high yielding, easy to cook, good taste (sweet), high market	X				Own stock Neighbours Local market	X		
	K132		X	Newly introduced variety, high yielding, seed expensive, high market value			X		NGOs, NAADS, LSBs		X	
	Gombili	X		Has White long seed, old variety				X	Own stock Neighbours Local market	x		
	Esoko Osu	X		High yielding, old variety, yellowish seed, easy to cook, sweet taste, low price		X			Own stock Neighbours Local market			
	Nabe 4		X	Early maturing, very new introduction, seed scarce in the market, marketable				X	Seed Companies, NARO, NGOs			X
	Nabe 7		X	Early maturing, very new introduction, seed scarce in the market, marketable				X	Seed Companies, NARO, NGOs			X
	Nabe 15		X	Early maturing, very new introduction, seed scarce in the market, marketable				X	Seed Companies, NARO, NGOs			X
	Nabe 16		X	Early maturing, very new introduction, seed scarce in the market, marketable				X	Seed Companies, NARO, NGOs			X
Ground nuts	Serenut 3		X	Red colour and large size seed, high yielding, sweet in taste and can be eaten as raw, high market demand	X				Neighbours Local market		X	
	Serenut 4T		X	Take longer time to germinate, high yielding, nutritious		X			Neighbours Local market		X	

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	Red Beauty		?	High yielding, sweet in taste and can be eaten as raw, high market demand	X				Neighbours Local market		X	
	Serenut 2T		X	Tan colour and large size seed, not sweet, affected by droughts, susceptible to pest, it is not economical variety			X		Neighbours Local market		X	
Cowpea	Odumbaku	X		Early maturing, old variety, seed with black & white spot, most delicious taste than any other varieties, grows in selected areas and faster, high demand in market, yield few seed, few people store seed			X		Neighbour, local market, own stock		X	
	Madi Osubi	X		White colour seed, old variety, good market, delicious taste, high yielding, highly adaptable-grow anywhere, durable, drought resistance	X				Neighbour, local market	X		
	Ayaraayara	X		Brown seed, old variety, take long in cooking, less delicious, seed mostly eaten, no market demand, grows in any area				X	Local market, Neighbour,			X

Overview of farmers knowledge on Root, Tubers and Bananas (RTBs) crops documented in Vuura sub-county, Arua district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Cassava	Omo	X		Early maturing 12 months variety, cream colour stem, well adapted to the soils of local area, tubers sweet in taste, drought tolerance, planting material easily available, high market for tubers	X				Own stock, Neighbours	X		
	Nase 14		X	Early maturing 9 months variety, new introduction, tubers sweet in taste depending on soil, well adapted to the soils of local area, high market for cutting, planting materials are not abundant and expensive (not for free)			X		NARO, NGOS, LSBS, Neighbours			X
	TME 14		X	Early maturing 9 months variety, old variety, peeling tuber is thick, tubers sweet in taste depending on soil, high market for cutting, planting materials are not abundant and expensive			X		Own stock, Neighbours		X	
	TME 204		X	Stem tall, few or no branches, green broad leaves, tubers sweet in taste, drought resistance, nearly lost due to susceptible to diseases, labour intensive								
	Bukalasa		X	Stem tall, old variety, two types i.e. one has brown leaves and another green leaves, leaves are small , tubers sweet in taste, nearly lost due to susceptible to				X	Own stock, Neighbours		X	

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
				diseases, labour intensive								
	Nyapamutu	X		Broad dark leave, tubers bitter in taste, high yielding, nearly lost due to susceptible to diseases, labour intensive				X	Own stock, Neighbours		X	
	Ariwara	X		Late maturing 3 years variety, old variety, tubers bitter in taste, drought tolerance, less labour intensive , pest resistance (the leaves are not eaten by pests maybe because they are bitter)		X			Own stock, Neighbours		X	
	Malukua	X		Stem tall, early maturing XX months variety, old variety, tubers sweet in taste, drought tolerance, less labour intensive, pest resistance		X			Own stock, Neighbours		X	
	Giligili	X		Early maturing XX months variety, tubers bitter in taste, disease resistance				X	Own stock, Neighbours		X	
	Basemenge	X		Late maturing variety, old variety, high yielding, tubers bitter in taste, nearly lost due to susceptible to disease, labour intensive				X	Own stock, Neighbours			
Banana	Abua Enya	X		It is sweet, big tubers, short maturity of 1 year, less susceptible to diseases	X				Own stock, Neighbours	X		
	Membuva	X		Eaten when ripened,1.5 years maturity period, small tubers, disease tolerant and drought tolerant	X				Own stock, Neighbours		X	
	Opun	X		Fetches good money, big tubers, disease tolerant but	X				Own stock, Neighbours		X	

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
				takes too long to mature (2years)								
	Bugoya		X	Sweet when ripened, disease tolerant, long tubers and eaten when ripened		X			Own stock, Neighbours		X	
	Serera		x	Less tasty, Soft when ripe, bitter when not ripened, whitish-yellow in color and mostly used in making bread				X	Own stock, Neighbours			X
	Bukura	X		Drought resistant, short tubers, eaten after boiling				X	Own stock, Neighbours			X
	Nyatule	X		Quick maturing, fetches a lot of money, disease tolerant but drought prone				X	Own stock, Neighbours	X		
	Mucakala	X		Quick maturing, fetches a lot of money, disease tolerant but drought prone			X		Own stock, Neighbours	X		
	Makimba	X		Sweet when ripened, disease tolerant, long tubers and eaten when ripened and high prices		X			Own stock, Neighbours			X
	Sira	X		Grows 1.5 years, sweet when boiled, disease tolerant and drought resistant		X			Own stock, Neighbours	X		
	Auombetisi	X		Sweet when ripe, disease tolerant			X		Own stock, Neighbours		X	
Irish potato	Mamanaku tu eka (red)		x	Red in colour, not easily got, few people know about it, the market is high, very soft when cooked, susceptible to pest, low yielding			X		Local market			X
	Mamanaku tu emve (white)		x	White in colour, early maturing, high yielding, very soft when cooked	X				Local market		X	
	Mamanaku		x	Purple in colour, high				X	Local			X

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	tu purple (payipulu)			yielding, soft when cooked, cooks very fast, smell like paraffin when raw					market			

Overview of farmers knowledge on major Cereal crops documented in Vuura sub-county, Arua district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Sorghum	Godo	X		Long maturing 12 months variety, tall stalk, long leaves, high yielding, high market demand, drought tolerant	X				Own stock, Neighbours Local market		X	
	Akindi	X		Early maturing 6 months, medium stalk, medium leaves, low yield, less resistance to pest and disease			X		Own stock, Neighbours Local market			X
	Mugusa	X		Short maturing 6 months variety, short stalk, shorter leaves, high yielding		X			Own stock, Neighbours Local market		X	
	Epuripur		X	Early maturing 4 months variety, short stalk, short leaves, spear head, newly introduced variety, high demand in market				X	Own stock, Neighbours Local market			X
Finger millet	Anya Eka (red millet)	X		Long maturing 4 months variety, red grain colour, larger grain size, high yielding, coiled fingers, tolerant to drought and			X		Own stock, Neighbours Local market		X	

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	Anya Emve (white millet)	X		resistance to disease Short maturing 3 months variety, white grain colour, smaller grain size, spread fingers, good taste for food consumption, drought tolerant, seed are easily available locally		X			Own stock Neighbours Local market		X	
Rice	Nerica 4		X	Early maturing 4 months, high yielding , resistance to diseases, high market, cooks quickly, good taste, labour is cheap in term of weeding	X				NAADS, LSBs,			X
	Madingili	X		Late maturing 6 months, needs several weeding, very low market, poor eating quality, difficult to find seed			X		Neigbour, Local Market	X		

Overview of farmers knowledge on Sweet Potatoes documented in Vuura sub-county, Arua district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Sweet Potatoes	Ayira	X		Leaves are slender, mode of entering is a bit round, less profitable					Neighbours own stock			X
	Andinyaku	X		Brown in colour, it enters larger than the rest, more profitable					Neighbours own stock		X	
	Karamoja	X		Pealing is white but inside is a bit yellow, good taste					Neighbours own stock			X
	Okilipa	X		Pealing is white upto inside					Neighbours			X

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
				but its hard with some fibres, takes long time to grow					own stock			
	Ewa maku	X		Leaves are larger round, it enters big but round, takes long time to grow					Neighbours own stock			X
	Koko maku	X		Leaves are small and round, sweet in taste, tolerant to drought, marketable			X		Neighbours own stock		X	
	Olamu	X		Leaf stocks are brown, it enters in brown colour, enters very fast, marketable, very sweet in taste, takes few days to grow				X	Neighbours own stock	X		
	Anyauu maku	X		Leaf stocks are brown, it enters in brown colour but a bit long, sweet in taste							X	

Annexes 3 Overview of farmers knowledge on different crops and varieties in Warr sub-county, Zombo district

Farmers knowledge on food legumes and oil seed crops documented in Warr sub-county, Zombo district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Beans	Sepia	X		Pure yellow bean, with tendril, big seed with round in shape, prone to drought, pest and disease prone, taste is better, yield 14Basins/acre, readily available market	X				Local market	X		
	Sokodibi	X		Light yellow bean, less tendril, big flat shaped seed, prone to pest and diseases, taste is better, yield 14Basins/acre, readily available market	X				Local market	X		
	Nyaraciga	X		White bean, taste is better, yield 18Basins/acre, readily available market	X				Local market	X		
	K132		X	Red spotted bean, yield 21Basins/acre, readily available market	X				NAADS, LSBS, NARO			X
	Nyakalanga (Nabe 15)		X	Red & white spot bean, yield 21Basins/acre				X	Local market	X		
	Nyarawora	X		White bean, yield 18Basins/acre				X	Local market	X		
	Laulau	X		White bean, yield 18Basins/acre				X	Local market	X		
	Rikini	X		Brown bean, small size, yield 12Basins/acre				X	Local market			X
	Ocidu	X		Black bean, yield 12Basins/acre				X	Local market		X	
	Orucu	X		Wild type bean, but eaten, drought and pest- disease resistance, no market				X	Own stock			x
	Nabe 17		X	Red in colour				X				X
	Nabe 19		X	Red spotted bean				X				x
Ground nuts	Full	X		White seed, many seed in a shell, high yield (8bags/acre), high market, , good for food consumption, resistance to pest	X				Local market		X	

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
				and diseases								
	Nya Lugbara	X		Red seed, small size seed, 2 seed per shell, hard shell, yield 6bags/acre, high market, resistance to pest and diseases	X				Local market		X	
	Nya Cap	X		White seed, big size seed, 2 seed per shell, yield is 10bags/acre, high market, resistance to pest and diseases	X				Local market	X		
	Rosco	X		Long maturing variety, red seed, big size seed, shell is big, yield 12bags/acre, tasteless				X	Local market			X
	Nya Judongo	X		Red seed, many seeds in a pod, long shell				X	Local market	X		
	Kalanga Mundu		X	Long maturing variety, hard shell, very big size shell, climb high on tree, seed cannot be replanted				X	Local market			X
	Serenut Series (2,3---14)		X	Very new introduction, do not have detail knowledge				X	???			X
Cowpea	Ngor thindo	X		Leaves eaten, it is not a runner variety, market readily available				X	Neighbours, Local market			X
	Oboo Alwala	X		A runner variety, growing even during dry season, market readily available				X	Neighbours, Local market		X	

Beans: 1 Basin = 18Kg, Groundnuts 1 Bag = 42Kg

Overview of farmers knowledge on major Root, Tubers and Bananas (RTBs) crops documented in Warr sub-county , Zombo district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local/Improved	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Cassava	Nyapamitu	X		Early maturing, dark stem, good yield, resistance to pest and disease, mainly for home food consumption, mo market	X				Local market		X	
	Nyamateo	X		White stem, few but big tubers, lower yield, do not last in soil, bitter in taste				X	Local market	X		
	Nyamatia	X		Gives many branches, no market, resistance to pest, last longer in the soil		X			Local market	X		
	Longe	X		Grows very tall, low yielding, bitter in taste, do not last in the soil				X	Local market		X	
	Nyaru dota	X		Greenish stem, thin leaves	X				Local market		X	
	Nyatoma	X		It has whitish stem	X				Local market	X		
	Nya Lucy	X		Has dark stem, good yield, bitter in taste				X	Local market	X		
	Nya Brother	X		Early maturing, reddish stem, grows short	X				CARITAS/ NGO	X		
	Therengule	X		Early maturing, white stem	X				Local market	X		
	Nya Caritas	X		Early maturing, short stem		X			CARITAS/ NGO	X		
	Nya Olama	X		Greenish stem at early stage and high yield	X				NAADS	X		
	Nyakawegi	X		Mature early	X				NARO	X		
	Nase 14		X	Early maturing, newly introduced, gives many branches			X		NARO		X	
	TME 204		X	Early maturing, gives many branches			X		NARO		X	
	Akena 0067		X	Early maturing, gives many branches			X					
Sweet potato	Nyakenya	X		Early maturing, peel colour white, flesh yellowish, tuber long and slender, sweet in taste, for food and cash crop both	X				Neighbours	X		
	Nya Omayo	X		Early maturing , red peel colour, tuber round shape, sweet in taste, for food and cash crop both	X				Neighbours	X		
	Nya dwii	X		White peel colour, tuber twisted in shape	X				Neighbours	X		
	Ukidi	X		Early maturing , white peel colour,	X				Neighbours	X		

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local/Improved	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
				thin leave, with hairy stem, sweet in taste, for food and cash crop both								
	Dudu	X		Early maturing , red peel colour, very big tuber size, round leaves, very sweet in taste, for food and cash crop both	X				Neighbours	X		
	Nyar Agara	X		Red peel colour			X		Neighbours	X		
	Nyar NARO		X	Red peel colour, very sweet in taste				X	NARO			X
Banana	Nakitamba	X		Short stands, small suckers, mainly for market, plant die soon, difficult to maintain			X		Local market		X	
	Sira	X		Brown stand, mainly for market and food			X		Local market	X		
	Nya-judongu	X		Long stand, drought tolerant, easy to grow, readily available market	X				Local market, Neighbours	X		
	Bonkra	X		White stand, suckers with 3 corners, easy to grow, readily available market,					Local market, Neighbours	X		
	Nyakizungu	X		White stand, long suckers, readily available market, susceptible to pest	X				Local market	X	X	
	Bogoya	X		Long maturing variety, white colour long stand, long sucker		X			Local market	X		
	Nyabolu-lyec	X		Short stand, long maturing variety				X	Local market	X		
	Gonja	X		Long maturing variety, long stand		X			Local market	X		
	Nyabuthe	X		Long maturing variety, short stand				X	Local market	X		
	Fearias		X	Medium stand, newly introduced variety				X	Namulonge, NAADS	X		
	Nyakakwa	X		Long maturing variety, short stand		X			Local market	X		
	Serere	X		White stand, susceptible to pest	X				Local market	X		
	SS 14 (Mpologoma)		X	Long stand, long sucker, newly introduced variety				X	NAADS	X		
	M 17		X	Medium stand, long suckers, newly introduced variety				X	Namulonge, NAADS	X		
Yam	Mayuni (Bwaisi)	X		Planted in swamp, tasteless, watery, not easy to get planting material, market available				X	Local market	X		

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local/Improved	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	Maule (Kataguna)	X		Planted in high land, tasteless, watery, not easy to get planting material, market available				X	Local market	X		
	Mulugu	X		Cripping plant, tasteless, watery, not easy to get planting material, market available				X	Local market	X		
Irish potato	Nya-judongu	X		Tuber round, white in colour, small in size, the taste is more delicious and thicker, both food and market	X				Local market		X	
	Victoria		X	Tuber round, reddish in colour, big in size, yellowish flesh, 40% tasty and watery sometimes, mainly for market and food	X				NAADS, LSB, NARO		X	
	Rwengume	X		Tuber round, red in colour, medium in size compared to Victoria seeds, flesh is white, tasty, produce many seed-tubers but small in sizes, mainly for market				X	NAADS, LSB, NARO		X	

Overview of farmers knowledge on major cereal crops documented in Warr sub-county, Zombo district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Sorghum	Serena		X	Early maturing, new variety, white and red colour grain, hard to grind, highly affected by birds, market is readily available				X	NAADS, NARO, Local market and neighbor			X
	Ndhumu	X		Early maturing, white grain colour, tall variety, highly affected by birds, market readily available				X	Local market, Neighbours			X
	Nyakawere	X		Early maturing, red colour grain, short variety, easy to grinds, eaten by birds seriously, market readily available	X				Local market, Neighbours	X		
	Awulumba	X		Early maturing, red colour grain, short variety, eaten by birds seriously, easy to grind, market available readily	X				Local market, Neighbours	X		
	Goma	X		Early maturing, red seed, short variety, destruction by birds is high, less demand in market				X	Local market, Neighbours		X	
	Nyang	X		White seed, tall variety, sweet stem while chewing like sugar cane, eaten as snacks				X		X		
Finger Millet	Akwopa Nyara	X		Early maturing, reddish grain, yield 5bags/acre, drought and disease resistance				X	Local market		X	
	Nyangwen	X		Early maturing, red grain, yield 5bags/acre, drought and disease resistance				X	Local market		X	
	Nya judongo	X		Early maturing, red grain, small seed, yield 4bags/acre				X	Local market		X	
	Seremi 2		X	Very new introduction, lack of knowledge about variety								

Overview of farmers knowledge on vegetable crops documented in Warr sub-county, Zombo district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Onion	Nya judongu	X		Small in size, reddish and whitish inside, tasty and smells good, tolerant to droughts,				X	Local market, own stock, neighbours		X	
	Hai	X		Whitish inside, has quir smell, no market				X	Local market, neighbours			X
	Bulb onions		X	Round and bug, reddish in outside colour, white inside thicker, commercial potential variety			X		NAADS, NARO, Local market		X	
	Lilly onions (longo)		X	Use part is only the leaves, green in colour, farmers do not know much about this variety				X	Neighbours, market			X

Annexes 4 Overview of farmers knowledge on different crops and varieties in Warr sub-county, Zombo district

Overview of farmers knowledge on food legumes and oil seed crops documented Wadelai sub-county, Nebbi district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Beans	Ngor mayellow	X		Three month variety, yellow bean, big size, sweet taste, green stem, hairy stem, yield 3-4 bags/acre	X				Own stock	X		
	Ngor matar	X		Two months variety, green stem, big seed, 2 bags/acre				X	Own stock	X		
	Nabe 15		X	Two months variety, new variety in demonstration, green stem, round seed, high yield, sweet taste, expensive seed				X	NARO, LSB			X
Sesame (simsim)	Ogali	X		Three months variety, black seed, big size, good taste, light green stem, greenish pod split into two, yield 2 Bags/acre	X				Own stock, Local market	X		
	Arutu	X		White seed, big pods 2-3 partitioning, pale yellow stem, yellow pod split into four, yield 2 Bags/acre				X	Own stock, Local market		X	
	Sesame II		X	Purple colour stem, strong, new introduction, yield 3-4 Bags/acre			X		NARO & LSB Farson			X
Cowpea	Boo/ Agodra	X		Grow well in upland not in swamp, it doesnot need much rain, takes 3 months, 100kg/acre		X			Own stock, Local market	X		
	Atotofoto		X	Needs more water to grow, take 3 months, 250kg/acre				X	Government and seed companies		X	
Groundnuts	Njinji	X		Short plant, small seeds, soft shell, yield 7 bags/acre, resistance to pest and diseases	X				Own stock	X		
	Nyar-arabi	X		Short plant, while-red seeds, with many seeds, green leaves, drought			X		Own stock		X	

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	Ful-matar			tolerant, yield, 5 bags/acre								
	Red beauty	X		Small red seed, sweet taste yield 6 bags/acre		X			Own stock		X	
	Serenut 4 (series)		X	Newly introduced variety				X	NAADS			X

Overview of farmers knowledge on major Root, Tubers and Bananas (RTBs) crops documented in Wadelai sub-county, Nebbi district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed sufficiency status		
	Common name	Local/Improved	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Cassava	Longe NASE 3		X	More branches, brownish colour stake, tuber white colour, good taste, yield 30 bags/acre, disease resistance	X				Namulonge	X		
	TME 14		X	Less branches, stake with light red colour, cutting are expensive, yield 35 bags/acre			X		Migiera			X
	Nyapa mito	X		Plant taller, late maturing variety, less branches, tuber bitter in taste, susceptible to diseases, yield 30 bags/acre		X			Own stock, Neighbours		X	
	Ocola	X		Plant taller, many branches, tuber bitter in taste, yield 30 bags/acre, disease resistance, drought tolerant	X				Own stock, Neighbours	X		
Sweet potato	Nyambale	X		Three months variety, red in colour, green vine, yield 60 bags/acre	X				Own stock, Local market	X		
	Mon too		X	Three months variety, yellow in colour, green vine yield 50 bags/acre	X				Local market		X	
	Nyakampala	X		Red in colour, green vine, yield 30 bags/acre		X			Local market		X	

Overview of farmers knowledge on major cereal crops documented in Wadelai sub-county, Nebbi district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Sorghum	Ndumu	X		Seven months variety, grow tall, red grains, yield 15 bags/acre				X	Own stocks, Neighbour, local market		X	
	Cerena		X	Three months variety, grow short, red or white seed, yield 14 bags/acres	X				Own stocks, Neighbour, local market		X	
	Yeleyele	X		Three months variety, grow tall, yield 14 bags/acre				X	Own stocks, Neighbour, local market		X	
	Maweli	X		Five months variety, grow tall				X	Own stocks, Neighbour, local market			X
	Ipuripur		X	2.5 months variety, grows short, white seed, yield 18 bags/acre			X		Imported			X
Finger Millet	Angungu	X		Three months variety, old variety, fist shape head, white grain, yield 3 bags/acre	X				Own stocks, Neighbour, local market		X	
	Nyadyei 2		X	Two months variety, 3 fingers leaves, single stem, yield 3.5 bags/acre		X			Own stocks, Neighbour, local market		X	
	Ceremy		X	Three months variety, fist shaped head, red grains, yield 3.5 bags/acre, new introduction				X	LSB			X
	Ayakra	X		Two months variety, 3 fingers leaves, red grains, yield 2 bags/acre				X	Own stocks, Neighbour, local market		X	
Rice	NERICA 4		X	Three months variety, light brown grain, yield 6-8 bags/acre	X				NARO, NAADS, LSB	X		
	NERICA 2		X	Three months variety, light brown grain, thin in shape, yield 4-6 bags/acre				X	NARO, NAADS, LSB	X		

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	NERICA 1		X	Three months variety, light brown grain, thin in shape, yield 4-6bags/acre			X		NARO, NAADS, LSB	X		
	Super NERICA		X	Five months variety, white grain, large size grain, grow taller, yield 6-7 bags/acre	X				Own stock	X		
	Upland rice	X		Three months variety, white grain, getting seed becoming difficult , yield 5-6 bags/acre		X			NGO, NARO, Seed companies		X	

Finger millet, sorghum, rice: 1 Bags = 90Kg

Overview of farmers knowledge on vegetables documented in Wadelai sub-county, Nebbi district

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
Pumpkin	Jita	X		Good taste, drought tolerance, leaves can be eaten, availability of market, high yield	X				Own stock, neighbours	X		
	Nyaralur	X		Very long runner on ground, cover much land, early maturing, low yield			X		Own stock, neighbours			X
	Atolo	X		Good taste, does not need much land, high yielding		X			Own stock, neighbours			X
	Nyangebu	X		Good taste, does not need much land, high yielding		X			Own stock, neighbours			X
	Okondo-matar	X		Not very good taste, very long runner, leaves not tasty, susceptible to droughts				X	Own stock, neighbours		X	
Okra	Otigo	X		Looks green, has small stem, mature in short time, 15 bags, Easy to get the seed, source of income, source of food	X				Own stock	X		

Crop	Variety			Varietal characteristics and local importance	Local production status				Major source of seed	Seed security status		
	Local name of variety	Local	Improved		Many HHs in large area	Many HHs in small area	Few HHs in large area	Few HHs in small area		Sufficient	Medium	Insufficient
	Otigo lweka	X		Grow tall, has bran20 bags ches, long stem, Easy to get the seed, source of income, source of food, resistant to drought	X				Own stock	X		