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Original Article

Diversity of the On-Farm Crop Dry Spell Adaptation Technologies in Isingiro Town Council, Isingiro District, Uganda

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Extended Dry Spell, Extended Dry Spell Adaptation Technologies (EDSATs), Soil and Water Conservation, Soil Fertility, Crop Productivity.

ABSTRACT

Isingiro Town Council is located within Uganda's diagonal eco-region referred to as the "cattle corridor" and is synonymous with extreme climatic conditions, particularly dry spells, and intermittent floods (Egeru, 2016). Dry spells create a crisis among the highly rain-fed dependent farming Households (HH) in the study area. Some farming practices among HH are believed to contribute to Crop Dry Spell Adaptation (DSA). An exploratory survey was conducted to collect data from 125 crop farmers. The selection of respondents was through purposive and referral sampling methods in this study that were aimed at determining the diversity and extent of implementation of on-farm crop-specific Dry Spell Adaptation Technologies (DSATs) for major crops grown at the HH level. These include Bananas (98.4%), Beans (69.6%), Maize (43.2%) plus Fruits (4.0%) as per results from generated summary tables from Stata 14 analysis. 99.2% of the farmers who can define DSA are aware that some of their farming practices contribute to its attainment. DSATs for bananas include; up-rooting underground corms (75.2%), pruning (72.0%), de-suckering and pruning (70.4%), weeding before seeding (68.8%), mulching (67.2%) and staking with nylon strings or poles (64.0%) among others. DSAT for beans includes; strip/row planting with hoe weeding (68.8%), hoe weeding (68%), and beans-banana inter-cropping (16.8%) among others. strip/row planting with hoe weeding (44.8%), hand weeding (42.4%), and maize-banana inter-cropping (5.6%) among others. DSATs among fruits include; pruning and weeding and mulching each is implemented by 4.8% of the fruit farmers while spraying against flower abortion is done by 4%. planting with manure, watering/irrigation, and using water catchment basins each is implemented by 2.4% of the fruit farming HH among others. Farmers tend to implement diverse DSATs on crops where there they expected more Returns on Investment

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INTRODUCTION

Isingiro district where the Area of Study lies is within Uganda's diagonal eco-region ranging from the southwestern to northeastern part of the country commonly referred to as the "cattle corridor" (Egeru, 2016). In this predominantly semi-arid region, local communities rely mainly on rain-fed crop and livestock production for their livelihood (McGahey, 2015), as there is evidence of increasing changes in extreme events such as extreme maximum temperature, warm days, warm nights, and the duration of warm spells (Omondi et al., 2014). This area experiencing increased incidences of dry spells, changing of crop growing seasons, increased incidences of pests and diseases as well as soil erosion as a result of Climate Change coupled with poor infrastructure and connectivity set-up, poor soil nutrient, composition, low agricultural input access and use, and/or land degradation are escalating the food insecurity situation within the District (Okaka & Nagasha, 2018).

Dry spells are sequences of days without precipitation, which can affect societies in many ways, including negative effects on water security and increased agricultural losses (Sanchi et al., 2021). Drought in Uganda is associated with moisture deficiency and animal death, water stress, increased pests and diseases, crop death, and reduced crop yield leading to human and livestock mortality, reduced food security, yields, income, and sources of revenue in general (Twongyirwe et al., 2019).

Climate-related risks such as prolonged dry spells are becoming more frequent and intense with negative impacts on agricultural livelihoods and food security due to failed crop harvests and livestock productivity in an agrarian country like Uganda (Mubiru et al., 2018). As such, dry spells are associated with significant societal, economic, and environmental consequences among agriculture-dependent communities due to the fact that dry seasons reduce yields, cause stunting of plant growth, and increase incidences of diseases and invasive weed species (David et al., 2020). The effects of dry spells are usually exacerbated by farmers' low levels of responsive capacity (Bernard & Emmanuel, 2017).

Drought mostly affects farmers located in marginal areas where there are low levels of access to adaptation technologies and high dependence on rain-fed agriculture (Jha & Jha, 2011). In such circumstances, farmers are kept in cyclic poverty, and chronic food insecurity, which can lead them to migrate to other areas, and in many cases, continued agitation for food aid (Mugambiwa, 2016). In Sub-Saharan Africa, drought occurrences coupled with low investments in agricultural production limit the economic performance of most of the 70-80% of the population that depends on the sector (Akwango et al., 2016).

In Uganda, local farmers are vulnerable to starvation in times of environmental stress, drought, and floods because of their dependence on rain-fed agriculture (Turyahabwe et al., 2013).

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According to (Melesse et al., 2013), local communities highlighted that some of the effects of climate variability and change on subsistence agriculture in Isingiro District, as cited in decreasing order of severity, include a decrease in crop productivity, frequent outbreaks of pests/diseases, frequent droughts, frequent floods, reduced water/pasture for livestock, and unreliable rainfall patterns among others. These have severely hampered agricultural activities in the villages, making local communities vulnerable in most cases, to the verge of famine and loss of livelihoods.

The ability of farmers to store up to 35,000 litres of water per season led to a shift in family labour from fetching water to other income-generating activities. Moreover, the increased availability of water improved milk yield considerably. Water shortage during the dry season is a major constraint in smallholder crop-livestock systems in East African Community (ECA) region, and women and youths travel up to 6 km daily in search of water (Kabirizi et al., 2014). The same study found that the application of goat, cattle and poultry manure with drip irrigation significantly increased cabbage yield.

Watering cans and sprinklers are considered to be the most important dry spell adaptation technologies based on the assessed performance measures (efficiency, effectiveness, equity, acceptability, urgency and institutional compatibility). The watering cans are widely used by farmers because of the low acquisition cost, easy use and time-saving (Mfitumukiza et al., 2020). Nutrient supply to banana fields relies largely on on-farm recycling of nutrients from mulching with banana and other plant wastes, kitchen waste and other weeds plus crop residues, and on imported cattle manure other than mineral fertilizer (Braber et al., 2021).

As such, Climate Smart Agriculture (CSA) not only improves Soil Organic Carbon (SOC) pools but also helps to improve other soil properties and the overall quality of the soil (Datta et al., 2022). CSA practices can thus be used to adapt to climate change in the landscape due to increased Organic Matter content (Recha et al., 2022). The application of biodegradable solid waste among farmers of Mbarara city led to boosting crop productivity through increased crop yields. Among all the strategies, compositing was the main innovative strategy that would boost crop productivity (Twesigye et al., 2022).

In order to offset the projected (likely) negative impacts of increasing temperatures and depressed rainfall, farmers have to practice moisture conservation farming practices such as mulching, shade systems, agro-forestry and water harvesting to sustain moisture in banana plantations in most parts of Uganda. In addition, the application of manure and fertilizers is necessary to ensure that banana plants can get nutrients from the top layers of the soil. The introduction of drought-tolerant banana varieties is necessary for sustainable banana production under the worst-case scenarios of climate change (Sabiiti et al., 2018).

Capable farmers cope with these shocks by adopting irrigation technologies, agroforestry, changing crop varieties and planting times but they are a small percentage while the bigger percentage react to weather shocks by reallocating land to different dry spell adapted crops since this is a cheaper option (Agamile et al., 2021). Good agriculture practices applying principles of minimum soil disturbance, crop residue retention and crop diversification through intercropping have the potential to cause adaptation to in-season dry spells due to increased infiltration and moisture conservation through reduced evaporation as a result of increased biological activity, beneficial pore structure and surface protection through crop residues (Thierfelder et al., 2017).

The availability of water, technology materials and respective accessories, cheaper technological options, technical support, and funding was the most considered important opportunities for drought adaptation technologies by the farmers (Mfitumukiza et al., 2020). Agriculture is affected by climate change because it depends on climatic factors like temperature and rainfall (Mulatu et al., 2020).

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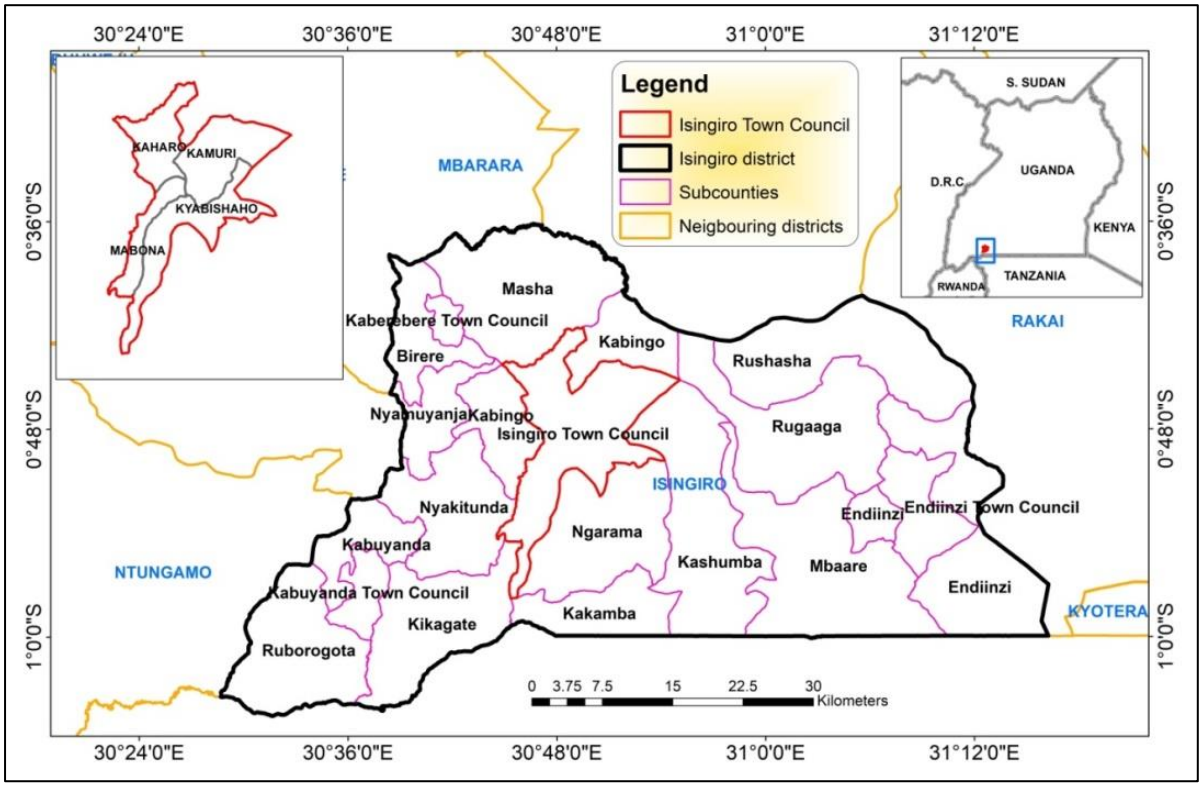
Although it is evident that farmers in Isingiro District are implementing Dry Spell Adaptation Technologies (DSATs) in their farming practices (Tumwesigye et al., 2018), no research has been conducted to determine the level at which each of these technologies is implemented at the community level. This study was carried out to establish the level of implementation of the DSATs among farmers in the Isingiro Town Council, Isingiro District.

METHODOLOGY

Study Area

The study was carried out in the 5 Wards; Kamuri, Kyabishaho, Mabona, Rwekubo and Kaharo Wards of Isingiro Town Council, Isingiro District which is located in South-Western Uganda. This is within Uganda's semi-arid region which is synonymous with extreme climatic conditions, particularly drought and intermittent floods (Egeru, 2016). From this study, the three priority crops grown in their order include; bananas, beans, maize, and fruits. Farmers affirmed that they are all affected by the extreme climatic conditions. In the Isingiro district, smallholder farmers predominantly depend on banana production and in the presence of severe drought, most household heads vacate their families to other areas looking for ways of feeding their family members during times of Extended Dry Spells (EDS) (Tumwesigye et al., 2018). During such seasons, the water and food sectors of Isingiro Town Council are affected as a result of the negative impacts of climate change (Zizinga et al., 2015). As such, the majority of crop production activities are done in the rainy season because agriculture in the district is mostly rain-fed and at the subsistence level.

Figure 1: Location of Isingiro Town Council in Isingiro District



Source: Own GIS work

A Survey was carried out among well-known Dry Spell Adaptation Technologies implementing Households (HHs) in the 5 Wards of Kamuri, Kyabishaho, Mabona, Rwekubo and Kaharo Wards of Isingiro Town Council, Isingiro District

As such, the selected HH were not randomly but purposively selected based on the fact that they

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are known for implementing Dry Spell Adaptation Technologies (DSATs) in their farming practices. Non-probability purposive/judgemental and Snowball/chain referral sampling methods were used in the selection of HHs within the study area. Structured questionnaires were used to collect data from 125 HHs. This sample size was determined from the total population of HHs practising DSATs on farming practices they carry out when growing their crops in the study area using the formula proposed by Yamane (1967) (Madow, 1968).

$n=N1+(e^2)$

Where: n = Sample size, N = Total population of households in the sub-county, and e = error tolerance (was set at 10%).

A review of the Production Annual Work-plans indicates that the department has supported the implementation of DSATs with 180 households in Isingiro Town Council between the years 2017 to 2022. This generated a sample of 118 households. For this study, a sample of 125 households was used for purposes of representativeness and generalization of the results by adding seven households. Questionnaire responses from HHs, observations and Technical Officers' input were collected between December 2022 and January 2023.

Data Analysis

Data collected from observations and the household survey was analysed using descriptive statistics. Stata 14 was used to generate frequency tables, percentages, and column graphs to summarise and present the survey results.

RESULTS

To identify the dry spell adaptation technologies used per crop enterprise in Isingiro Town Council, Isingiro District.

Farmers' Understanding of DSA

From *Figure 2*, a consolidated 97.6% have an understanding of Dry Spell Adaptation by definition. The farmers' own definitions of EDSA indicate that 82 (65.6%) understand crop dry spell adaptation to be a combination of water harvesting, irrigation and mulching of the irrigated crop fields aimed at sustained food production even during the extended dry spells when there is water stress in the soil. 14 (11.2%) respondents consider EDSA to be the storage of harvests of crops with long storage shelf life like millet, maize, beans and cassava which can be food during long dry spells. These crops when dried can be preserved in good storage conditions. 5 (4%) respondents consider EDSA to be all about Soil and Water Conservation (S&WC) technologies among which are trenches, cut-off drains, water basins, grass rows and fodder hedge rows that help to collect water and conserve soil that would be eroded through forces of water erosion. This preserves both soil moisture as well as soil fertility for crop production. 4 (3.2%) respondents consider EDSA to either be early planting to maximize favourable weather days during the crop growing cycle as it facilitates crops to reach a resilient stage against dry spells. Crop diversification in any growing season takes advantage of the fact that if one crop fails any other crops can yield a harvest. Early planting helps crops to cross the critical vulnerable stage of growth or growing dry spell adapted crops which are resilient to the impacts of the EDS. 2 (1.6%) respondents consider it to be; Knowing which activities to do when throughout the year for sustained crop productivity. 1 (0.8%) respondent each defined EDSA as either Good agronomic practices, growing crops with long storage shelf life, harvesting food crops sustainably, implementing activities that ensure having food on the table through all seasons, applying manure to crops for improved crop vigour creating resilience against impacts of dry spells, crop pests and diseases or mulching for moisture conservation. 3 (2.4%) affirmed that they could not define DSA and yet practically are observed to implement DSATs in their farming practices.

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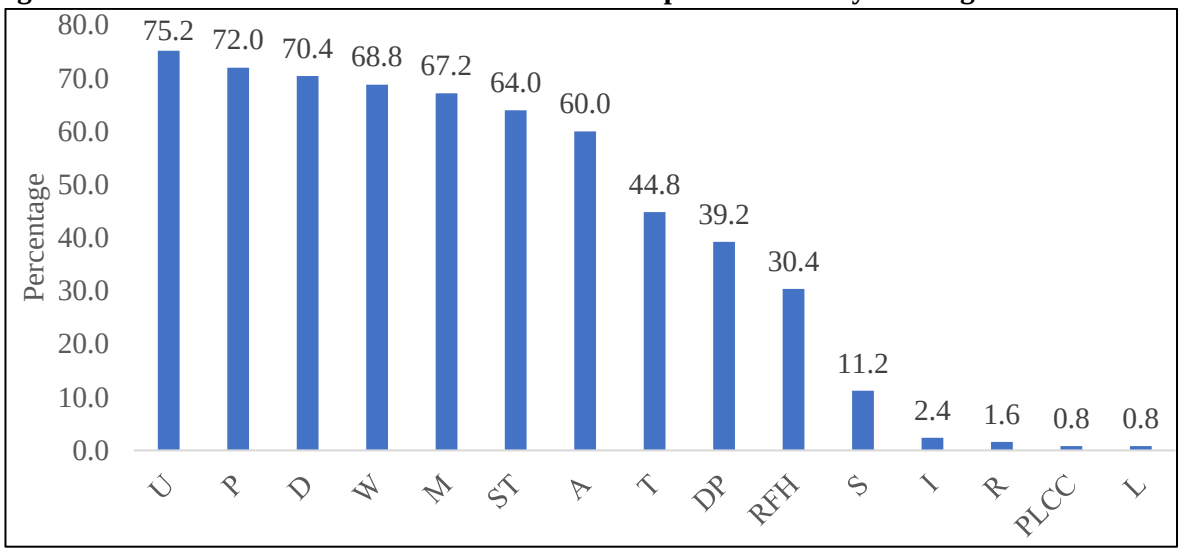
Figure 2: the various Banana EDSATs and level of implementation by farming HHs



KEY FOR BANANA EDSATs: U: Uprooting underground corms, P: Pruning, D: De-suckering and thinning, W: Weeding before seeding, M: Mulching, ST: Staking with nylon strings or poles, A: Application of manure, deep cultivation, and mulching, T: Trenches, retention ditches & basins, DP: Decomposition pits/basins, RFH: Ring fork hoeing/forking around the mat & deep ploughing, S: Surface Manure application, I: Irrigation, R: Rabbit urine application; PLCC: Planting leguminous cover crops; L: Liquid manure application

This is a wide scope of farmers' understanding of EDSA. And in a nutshell, these definitions reflect that the community is implementing strategies to adapt to extended dry spells in thematic areas including water harvesting and moisture conservation, natural and regenerative processes such as nutrient recycling, nitrogen fixation, soil regeneration and management of pests in food production process and selection of crops that can be dried and stored for a longer time, like beans and maize, in order to have food during the time of EDS hazard.

Banana EDSATs and The Level of Farmer Adoption

From *Figure 3*, a total of 15 Banana EDSATs are being implemented by the farming HHs. These adaptation technologies and their level of adoption include; Uprooting underground corms (75.2%), Pruning (72.0%), De-suckering and pruning (70.4%), Weeding before seeding (68.8%), Mulching (67.2%) and Staking with nylon strings or poles (64.0%). Others include; Application of manure, deep cultivation, and mulching (60.0%), Trenches, retention ditches & basins (44.8%), Decomposition pits/basins (39.2%), Ring fork hoeing/forking around the mat & deep ploughing (30.4%), Surface Manure application (11.2%), Irrigation (2.4%), Rabbit urine application (1.6%), Planting leguminous cover crops (0.8%) and Liquid manure application (0.8%).

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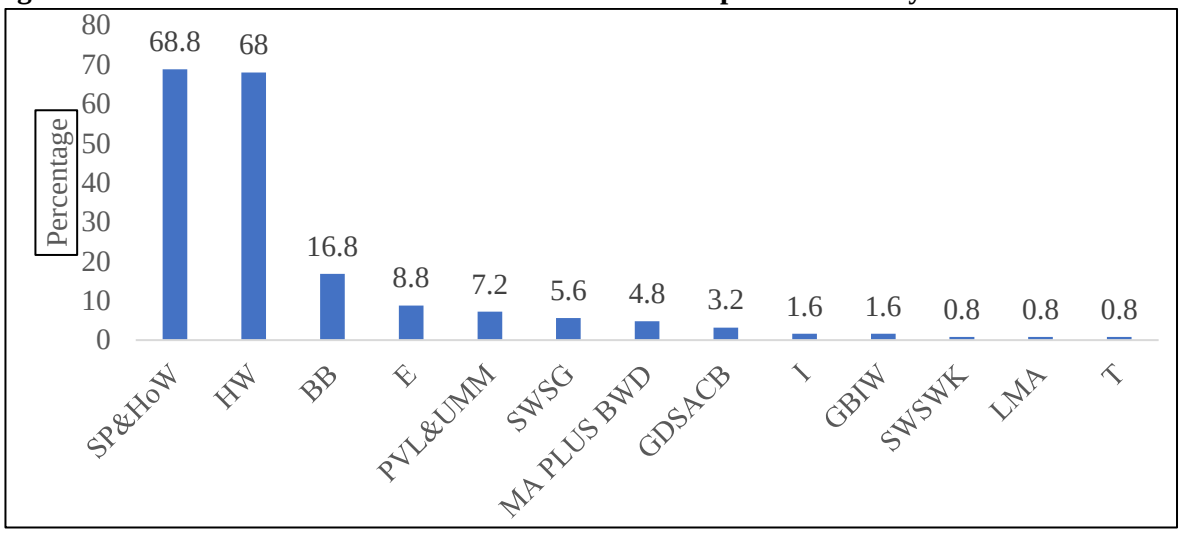
Figure 3: The various Beans EDSATs and their level of implementation by farmers

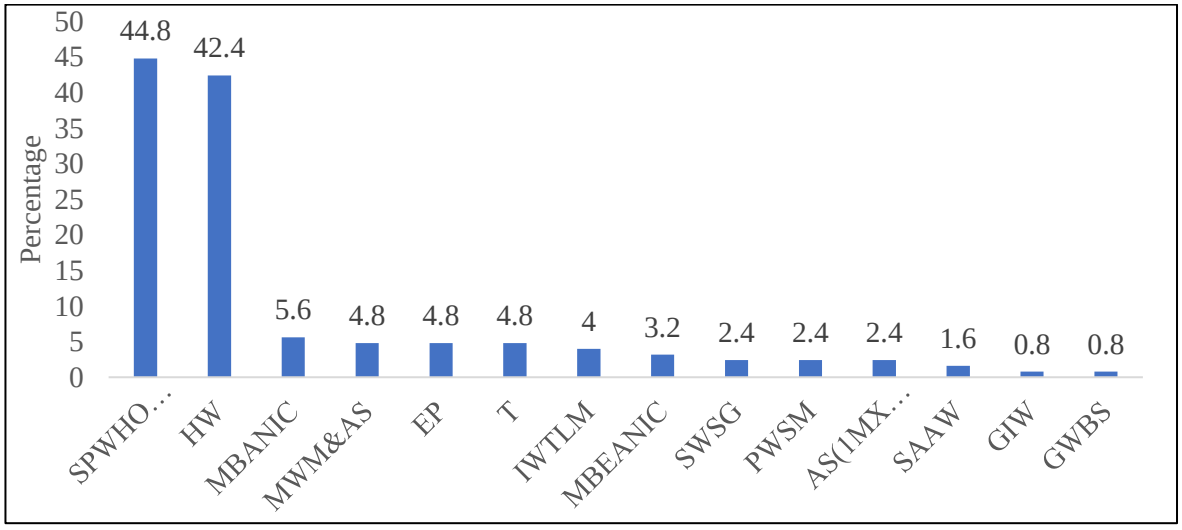


KEY FOR BEANS EDSATs: SP&HoW: Strip/Row Planting with Hoe Weeding, HW: Hand Weeding (Scattered planting), BB: Beans - Banana Intercrop, E: Early Planting, PVL&UMM: Plant on Virgin Land & Use Materials to Mulch, SWSG: Spray with Super Grow, MA PLUS BWD: Manure Application plus burry weeds to decompose, GDSACB: Growing Dry Spell Adapted Climbing Beans, I: Irrigation, GBIW: Growing Beans in Wetlands, SWSWK: Spray with Selective Weed Killer, LMA: Liquid Manure Application, T: Trenching

Maize EDSATs and Level of Farmer Adoption

From *Figure 4*, a total of 14 Maize EDSATs are being implemented by the farming HHs. These adaptation technologies and their level of adoption include; strip/row planting with hoe weeding (44.8%), hand weeding (42.4%) and maize-banana inter-cropping (5.6%). Each monoculture with manuring & appropriate spacing, early planting and thinning shared 4.8% while irrigation with tithonia liquid manure had 4% and maize-bean inter-cropping had 3.2%. Spraying with super grow, planting with solid manure and appropriate spacing each shared 2.4%. Spraying with armyworm is done by 1.6% of the farming HH while growing maize in wetlands and growing maize with bio-slurry each shared 0.8% of the farming HHs.

Figure 4: Various Maize EDSATs being implemented by farmers



KEY FOR MAIZE EDSATs: SPWHOEW: Strip/Row Planting with Hoe Weeding, HW: Hand weeding, MBANIC: Maize-Banana Intercropping, MWM&AS: Monoculture with manuring and appropriate spacing EP: Early Planting, T: Thinning, IWTLM: Irrigation with Tithonia Liquid Manure, MBEANIC: Maize-Beans Intercropping, SWSG: Spray with Super Grow, PWSM: Plant with Solid Manure, AS(1MX1M): Appropriate Spacing, SAAW: Spray Against Army Worm, GIW: Growing Maize in Wetlands, GWBS: Growing with Bio Slurry

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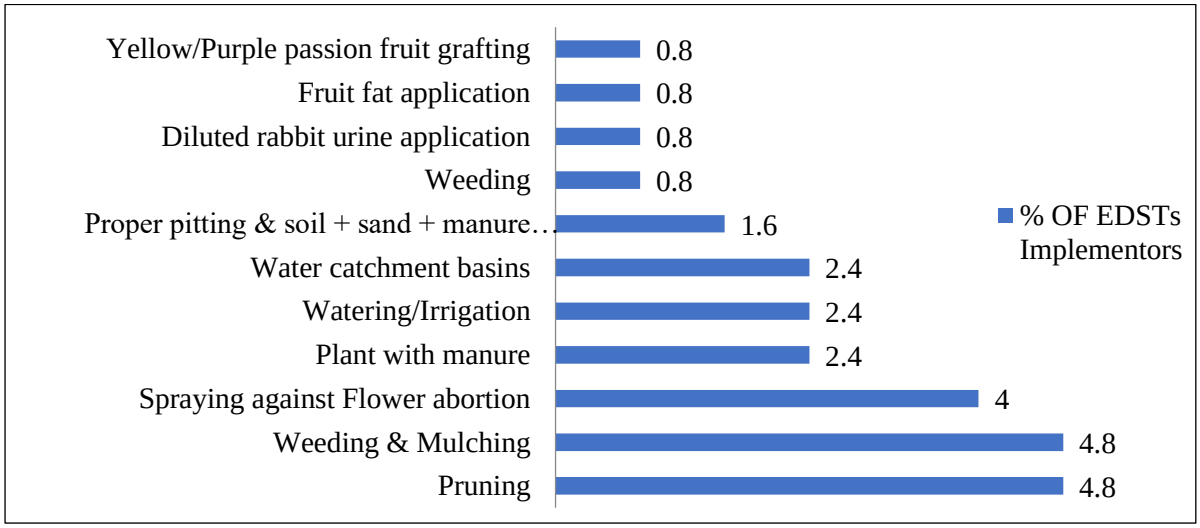
Fruit EDSATs and Level of Farmer Adoption

From *Figure 5*, a total of 11 Fruit EDSATs are being implemented by the farming HHs. These adaptation technologies and their level of adoption include; Pruning and Weeding and Mulching each is implemented by 4.8% of the fruit farmers while Spraying against Flower Abortion is done by 4%. Planting with manure, Watering/Irrigation and Using Water Catchment Basins are each implemented by 2.4% of the fruit farming HH. While Pitting and Planting with appropriate soil mixture (i.e., Soil + Sand + Manure) is done by 1.6% of the fruit farmers. Weeding, Application of Diluted Rabbit Urine, Fruit Fat Application and Grafting Purple Passion Fruit as Scion and Yellow variety as Root Stock are implemented by 0.8% of Fruit Farmers.

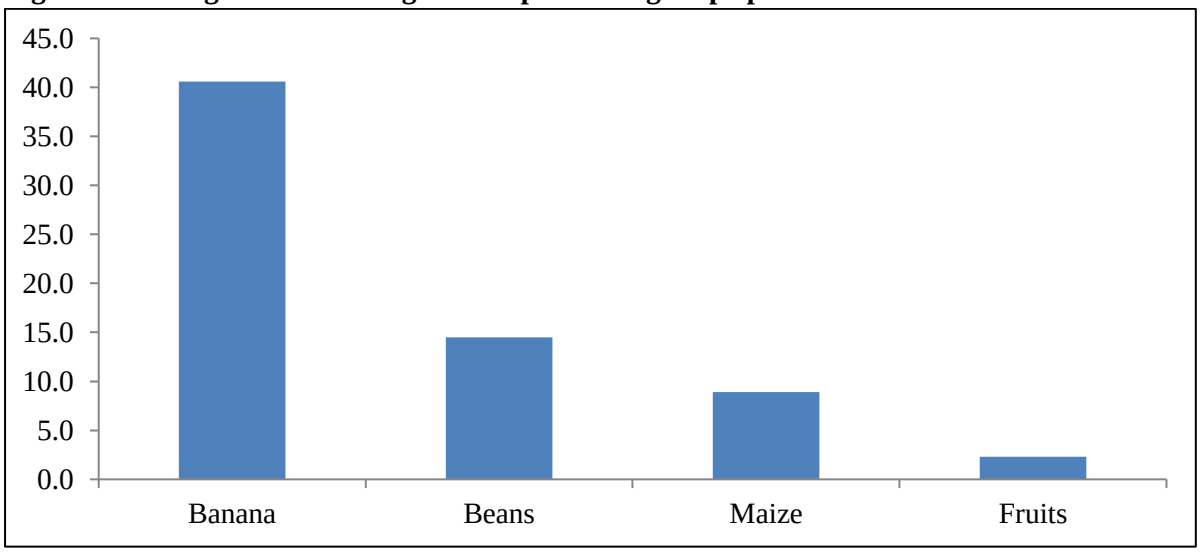
Figure 5: The level of implementation of fruit EDSATs by fruit farmers.



Level of Crop Specific DSAT implementation at the HH level

Figure 6 indicates an analysis of the average percentage of farmers involved in the implementation of the EDSATs for any crop. Banana which is grown by most farmers in Isingiro Town Council has 15 DSATs implemented by 40.6% of the farming HHs, beans rank number 2 with 13 DSATs implemented by 14.5%, Maize ranks number 3 with 14 DSATs implemented by 8.9% and lastly Fruits with 11 DSATs implemented by 2.3%.

Figure 6: Average % of Farming HHs implementing crop-specific EDSAT



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DISCUSSION

Banana EDSATs

Respondents reported that cheaper technologies using locally available materials and require manual labour like; de-suckering which reduces competition among plants on the same mat for scarce resources including water, weeding which reduces competition for resources e.g., soil water and nutrients and mulching using banana remains which helps in the preservation of soil moisture by reducing evaporation. Staking helps to provide support for the weight of heavy bunches on weak or snapped plants and the application of organic manure among farmers with livestock helps in increasing organic matter content which improves water retention (Nansamba et al., 2022). This ensures healthy and strong plants that can withstand EDS.

Other practices mentioned like Ring fork hoeing/forking around the mat soften the soil and improves water percolation into the root zone. Decomposition pits/basins improve the soils in the two parameters of organic manure availability and moisture conservation. The banana waste materials previously used for surface mulching are now being buried by farmers in these pits/basins and at decomposition provide drainage pits/basins that feed the stools with nutrients of banana origin which are of importance to bananas themselves.

Focus Groups Discussions also yielded more interesting information including; when it rains, practices to stimulate growth such as fertilization, de-leafing, de-suckering, and weeding, which is often suspended during prolonged dry seasons and replanting of the banana in case the effects have been severe and some stools too weak to regenerate. To manage Dry Spell associated winds, practices to buffer bananas include; Practices to strengthen the root system are employed including replanting, deep organic matter application, mulching and Staking. Many of these practices are routine management in rain-fed banana production.

Set-backs on the Popularity of Some EDSATs

Surface manure application is losing popularity due to the fact that it tends to lead to surface root growth due to a search for nutrients leading to unstable stools that are easily blown away by dry spell winds. Rabbit Urine application for pest repulsion and liquid manure is still very low due to low levels of rabbit rearing at the HH level. Planting of leguminous cover crops and tithonia liquid manure application is also very low due to a lack of technical knowledge and availability of seeds. However, we note that all these reduce water deficits through mulches and increase organic matter content for improved crop resilience to Extended Dry Spells (EDS). Technologies that involve the use of locally available materials and are less labour-intensive are more popular compared to those which require the installation of expensive technological equipment like irrigation though farmers view them as being very critical from the farmer's perspective.

Calberto et al., (2018) in a survey carried out at the global level, it was found that 'To address the effects of a delay in the start of the rainy season, which is the equivalent of a prolonged dry spell, irrigation was most frequently mentioned as a dry spell adaptation technology. Through irrigation, the water deficit is addressed directly with the supply of water. However, (UBOS, 2017) notes that the district has ample water sources for developing irrigation schemes and water reservoirs for crop and livestock production which explains why there are still low levels of implementation. These include Rivers Kagera and Rwizi plus Lakes Nakivale and Rwamurunga in addition to permanent wetlands spread out in all Lower Local Governments.

Rwangire (2019) lists several dry spell adaptation technologies considered as Indigenous Agricultural knowledge practices relating them to these findings; 100% of the farmers practice weeding, pruning, de-trashing, and mulching with banana leaves and leaf sheaths. Mulching with ferried grass was at 22.5%, uprooting

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rhizomes/corms at 63.7%, Trenching at 95.1%, Manure application (66.7%) and staking at 61.8%.

Sabiiti, et al., (2018) recommend that; “In order to offset the projected (likely) negative impacts of increasing temperatures and depressed rainfall, farmers would have to practice moisture conservation farming practices such as mulching, shade systems, agro-forestry and water harvesting to sustain moisture in banana plantations in most parts of Uganda. In addition, the application of manure and fertilizers will be necessary to ensure that banana plants can get nutrients from the top layers of the soil. Introduction of drought tolerant banana varieties is necessary for sustainable banana production under the worst-case scenarios of climate change.”

According to Nansamba et al., (2022), Farmers reported the application of organic fertilizers, particularly farm manures, as desirable but were constrained by its insufficient supply and high cost except those who reared livestock e.g., cows, goats and chickens. Other drought coping options deployed by respondents included irrigation, weeding, staking of weak plants (particularly for late-season drought), tying of disintegrated pseudo stems with banana fibres, intercropping with trees and cover crops, heaping of soil around exposed plant roots and sucker removal (they leave three to four plants per mat). Even though mulching was the most used coping practice (55.8%), many of the farmers (81.7%) pointed out irrigation as the most effective measure to mitigate drought effects on banana production. Some of these strategies such as mulching, application of manure and construction of water retention trenches form basic plantation management and soil-water conservation practices by Ugandan banana farmers (NARO 2019).

Good husbandry involving clean weeding, de-suckering, pruning, manuring, and mulching produces vigorous plants that are more tolerant to weevil damage which when in existence makes bananas more prone to the impacts of extended dry spells.

Beans EDSATs

Strip/Row Planting with Hoe Weeding is the leading DSAT because operations within the beans garden are made much easier and faster as it saves time say to weed using a hoe than using hands. The removed weeds are used for mulching the loosened soil around the roots area. This conserves moisture and wider space for roots to spread out and at the decomposition of the weeds, mulch increases organic matter content in the soil.

When beans are planted in a scattered manner all over the garden, hand weeding is the common approach to weed removal practised by 68% of the farmers. Scattered beans in the garden require more care in avoiding damage to the beans' root system as well as uprooting some accidentally. The removed weeds are piled in small heaps and left to decompose.

Beans-Banana intercropping is mainly practised among farmers with only banana plantations as the only available land for crop farming. In most cases, this is where early planting is done and exploits the advantage of ground mulching with banana remains (a common practice in banana plantations) which creates some preserved moisture and shade by the banana plants. Beans planted in banana plantations provide the earliest harvests but are known to affect adversely the performance of the banana plants. Only done for lack of land and that is why it is practised by only 16.8% of the farmers.

The practice of early planting by 8.8% of the farmers exploits the limited growing periods to facilitate the cross-over of the growth period of the beans that are so prone to the adverse effects of the dry spell. It is slowly gaining prominence to challenges associated with bean-crop failure as a result of the short available growing period due to EDSs.

Planting beans on Virgin Land and using all plant materials to Mulch secure assured good yields keeping other factors constant. It is a type of Conservation Agriculture (CA) practice that exploits principles of minimal soil disturbance, permanent soil cover using crop residues and

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cover crops and plant associations including legumes (Friedrich et al., 2009). This practice depends on biological processes to work as it enhances the biodiversity in an agricultural production system on a micro- as well as macro level. In addition, such sites have very high-water infiltration capacities, reducing surface runoff and thus soil erosion plus loss of soil fertility significantly.

Spraying with Super Gro is undertaken with farmers subscribing to Dinarpharm and others procure from Agro-inputs dealers. Super Gro is a natural fertilizer that will increase your agricultural yield by more than three times what you would get from synthetic or chemical fertilizer. Super Gro makes other agricultural treatments a farmer uses (like fertilizer, insecticides, and pesticides), perform better by helping them penetrate deeper, stick better, stay longer and work more effectively. The limitation in the use of Super Gro at 5.6% is ascribed to the cost involved in securing it.

The practice of Manure Application plus burry weeds to decompose has proven to be beneficial to the Bean crop in farming HH that practice Beans-Banana intercropping where other practices like early planting come into play. Planting beans in a manured and well-mulched Banana plantation at the onset of the very first rains provides a longer growing beans season, assuring the farmer of a fairly good harvest.

The growing Dry Spell Adapted Climbing Beans is by 3.2% of the farmers. These beans are said to yield a harvest over a longer growing period and with a much higher yield per plant. Irrigation at 1.6% is not so much an adopted mode of DSA for the bean's enterprise because of the high initial investment cost involved in its installation. Growing beans in Wetlands at 1.6% of farming households is ascribed to the fact that immediate neighbours to these resources tend to monopolize their use and are very few. Wetlands have higher moisture content and are more fertile providing higher yields.

Spraying with selective weed killer, liquid manure application and trenching in the beans enterprise all at 0.8% are all ascribed to the cost of securing the technology, low numbers of livestock and the labour-intensive nature of implementing the technologies. Weed killers are expensive on the market and the would-be users are ignorant about them. Liquid manures require the availability of livestock, other materials and expertise in their preparation and utilization which is not readily available among the farming HH. Trenching is labour-intensive and has high costs involved during establishment.

Set-backs on the Popularity of Some Beans EDSATs

The major setbacks to the implementation of Beans EDSATs include; Lack of livestock as a source of Organic Manure, income level of the farmer, cost of inputs from the Agro-Chemical shops, lack of some local materials and lack of technical expertise required for the implementation of the technology.

Maize EDSATs

Maize in the study area is mainly grown for eating by roasting. The major maize EDSATs that farmers implement surround the traditional hoe at 44.8% and hand at 42.4% weed management and inter-cropping practices at 5.6%. Manuring, Early Planting and Thinning each are implemented by 4.8% of the farmers as they facilitate improved organic manure content, maximization of the utilization of available limited moisture for maize growth and reduction of competition. 4% of farmers involved in spraying with tithonia liquid manure consist of those who had special training and also have liquid manure preparation tanks. In a Maize-Beans intercropping system implemented by 3.2%, beans are planted 4 weeks after maize has germinated. This is meant to ensure that the two crops can both yield at harvest. The beans provide a cover crop and also fix nitrogen in the soil to the benefit of maize and maize also provides stakes for the climbing bean varieties. Spraying with Super Grow, Planting with Organic manure and Appropriate spacing each share 2.4%

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of the farming HH. These Dats improve soil nutrient content and provide appropriate growing space per maize stool. 1.6% of the farming HH spray against Army Worm which devastates potential maize harvests during Dry Spells. 0.8% of the farmers either grow maize in wetlands due to the availability of moisture or grow maize with bio-slurry for both nutrients and moisture enrichment.

Set-backs on the Popularity of Some Maize EDSATs

There are neither processing nor local value-addition factories. In addition, there is no well-developed external market that demands un-processed maize at the farming HH level. But maize is one of the key sources of food within the study area. Wetlands are not easily accessible for the growing of maize due to the laws of the land governing the protection of fragile ecosystems and bio-slurry is only available to farming HHs with livestock and have biogas units that provide them with renewable energy. HHs that use bio-slurry are also not many.

Fruits EDSATs

Pruning the fruiting canopy as a DSAT is practiced by 4.8% of the fruit farmers. This practice increases light penetration, reduces humidity which is a favourable environment for fungal infection, improves leaves-insecticide contact with the leaves during the spraying operation and facilitates reduction in flower and fruit populations, enabling bigger fruits for higher income during the stressful time of the EDS.

Weeding with mulching is done by 4.8% of the farming HH. Weeding fruit trees reduces competition for light, nutrients, and moisture from the soil. This coupled with mulching, conserves moisture, facilitates higher soil microbial activity and decomposition of the mulch creates favourable conditions for better root proliferation. 4% of the fruit farmers spray against flower/fruit abortion. Spraying with super grow and other agrochemicals helps the chemicals to hold on to the leaves longer and thus become more effective in their impact on making the fruit tree more resilient against the EDS.

Organic manure application, watering, and construction of water catchment basins are implemented by 2.4% of the fruit farmers. These replenish the soil nutrient content and improves soil structure, soil water holding capacity and soil microbial activity. All these facilitate improved nutrient uptake by the fruit trees making them more vigorous and hardy against the EDS hazard impact.

Proper pitting and soil mixture at planting practiced by 1.6% of fruit farmers enables the fruit tree to take off vigorously due to the vigorous root system development. This makes the planted fruit seedling hardy against the EDS period. 1% of the utilizing rabbit urine in fruit growing testify to creating excellent performance of the trees making them resilient to the EDS. Undiluted fermented urine is a very good repellent for insects.

Fruit Fat a Pellet organic fertilizer applied by 1% of the fruit farmers provides readily valuable nutrients to a fruit tree when well applied and cultivated into the soil. The tree regains its vigour and becomes resilient to the impacts of EDS. Yellow passion fruit variety is very resilient to EDS due to its well-developed root system, and resistance to disease attacks. Grafting its rootstock with the purple variety scion produces a highly resilient passion fruit tree. This is practiced by 1% of the passion fruit farmers.

CONCLUSION

This study was aimed at determining the diversity and extent of implementation of on-farm crop-specific Dry Spell Adaptation Technologies (DSATs) for major crops grown at the HH level in Isingiro Town Council, Isingiro District. The trend of priority of any grown crops has a commensurate influence on the level of DSAT implementation at the HH level. Bananas which is the most grown crop has 15 DSATs that are implemented by 40.6% of the farming HH, beans 13 DSATs implemented by 14.5%, Maize 14 DSATs implemented by 8.9% and Fruits 11

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DSATs implemented by 2.3%. This study concludes that the importance farmers attach to a given crop and are able to grow it influences their level of willingness to invest in the associated DSATs for improved productivity of the crop during times of Extended Dry Spells.

Recommendations

Government should invest in developing small-scale irrigation schemes, Bio-gas units, and provision of cover crop seeds like Velvet beans which cannot be implemented by small-scale farmers. These can facilitate productive Conservation Agriculture among smallholder farmers.

Encourage farmers to be involved in mixed farming thereby including livestock on the farm to facilitate local production of Organic Manure for soil fertility replenishment. Fruit trees by nature are never cut down for firewood since farmers prioritize the fruit products for firewood. Fruit growing and associated DSATs should be promoted by the government. Extension workers should carry out a survey to determine which fruit trees can perform best in the study area and recommend them to the government for funding among smallholder farmers.

Extension workers should be facilitated to carry out training on the various EDSATs that can be implemented per crop. Farmers should be encouraged to be part of the Government subsidy programme via e-vouchers and be members of a revolving fund. This will give the farmers access to agriculture inputs like organic manure, fertilizers, agrochemicals, equipment, and tools, which can facilitate the boosting of fruit productivity. These also need to be availed in a timely manner.

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REFERENCES

Agamile, P., Dimova, R., & Golan, J. (2021). *Crop Choice, Drought and Gender : New Insights from Smallholders ' Response to Weather Shocks in Rural Uganda*. *72*(3), 829–856. https://doi.org/10.1111/1477-9552.12427

Akwango, D. A., Obaa, B. B., Turyahabwe, N., Baguma, Y., & Egeru, A. (2016). Agro-pastoral choice of coping strategies and response to drought in the semi-arid areas of Uganda Agro-pastoral choice of coping strategies and response to drought in the semi-arid areas of Uganda. *African Journal of Rural Development*, *1*(3), 281–291. http://www.afjrd.org/jos/index.php/afjrd/article/view/22

Braber, H. Den, Ven, G. Van De, Ronner, E., Marinus, W., Languillaume, A., Ochola, D., Taulya, G., Giller, K. E., Braber, H. Den, Ven, G. Van De, Ronner, E., Marinus, W., Languillaume, A., Ochola, D., Taulya, G., Giller, K. E., & Descheemaeker, K. (2021). Manure matters : prospects for regional banana- livestock integration for sustainable intensification in South-West Uganda. *International Journal of Agricultural Sustainability*, *0*(0), 1–23. https://doi.org/10.1080/14735903.2021.1988478

Calberto, G., Blake, D., Staver, C., Carvajal, M., & Brown, D. (2018). The frequency and effects of weather events on banana productivity – results of a global survey. *Acta Horticulturae*, *1196*, 179–186. https://doi.org/10.17660/ActaHortic.2018.1196.22

Datta, A., Nayak, D., Smith, J. U., Sharma, P. C., Jat, H. S., Yadav, A. K., & Jat, M. L. (2022). Climate-smart agricultural practices improve soil quality through organic carbon

Article DOI: https://doi.org/10.37284/ajccrs.2.1.1275

enrichment and lower greenhouse gas emissions in farms of bread bowl of India. *Soil Research*, 1–35. https://doi.org/10.1071/SR21031

David, M., Bernard, B., Anthony, E., Michael, M. S., James, W., Andrew, A., Stephen, K., Zakia, N., Claire, N., & Sciences, C. (2020). *The role of indigenous knowledge (IK) in adaptation to drought by agropastoral smallholder farmers in Uganda*. *19*(January), 44–52.

Egeru, A. (2016). *'Mental drought' afflicts Uganda s cattle corridor*. *July*.

Friedrich, T., Kassam, A., & Shaxson, F. (2009). *Final Report Agricultural Technologies for Developing Countries STOA Project "Agricultural Technologies for Developing Countries" STOA Project "Agricultural Technologies for Developing Countries" CONSERVATION AGRICULTURE (CA)*. *April*.

Jha, V., & Jha, A. (2011). *Traditional Knowledge on Disaster Management: A preliminary study of the Lepcha Community of Sikkim, India*. *10*(January), 173–182.

Kabirizi, J. M., Mugerwa, S., Ndikumana, J., Njarui, D. M. G., Kaganda, S., & Mwilawa, J. (2014). *Climate Change Technologies for Improved Livelihoods of Smallholder Crop-Livestock Farmers in Eastern and Central Africa*. *4*(1), 54–57. https://doi.org/10.5923/j.re.20140401.06

Madow, W. G. (1968). Elementary Sampling Theory. *Technometrics*, *10*(3), 621–622. https://doi.org/10.1080/00401706.1968.10490610

McGahey, V. and. (2015). *Vulnerability and Adaptation to Climate Change in the Semi-Arid Region of East Africa*. https://oaarchive.arctic-council.org/bitstream/handle/11374/44/Vulnerability_%26_Adaptation_to_Climate_Change_in_the_Arctic.pdf

Mfitumukiza, D., Barasa, B., Kiggundu, N., Nyarwaya, A., & Muzei, J. P. (2020). Smallholder farmers' perceived evaluation of agricultural drought adaptation technologies used in Uganda: Constraints and opportunities. *Journal of Arid Environments*, *177*. https://doi.org/10.1016/j.jaridenv.2020.104137

Mubiru, D. N., Radeny, M., Kyazze, F. B., Zziwa, A., Lwasa, J., Kinyangi, J., & Mungai, C. (2018). Climate trends, risks and coping strategies in smallholder farming systems in Uganda. *Climate Risk Management*, *22*(August), 4–21. https://doi.org/10.1016/j.crm.2018.08.004

Mugambiwa, S. S. (2016). *Adaptation measures to sustain indigenous practices and the use of indigenous knowledge systems to adapt to climate change in Mutoko rural district of Zimbabwe*. 1–9.

Mulatu, D. W., Semreab, E., Arega, T., & Yohanes, T. (2020). *Final Technical Report : Machar Marshes Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development Prepared for : Nile Basin Initiative (NBI)*.

Nansamba, M., Sibiya, J., Tumuhimbise, R., Ocimati, W., Kikulwe, E., Karamura, D., & Karamura, E. (2022). Assessing drought effects on banana production and on-farm coping strategies by farmers — a study in the cattle corridor of Uganda. *Climatic Change*, *173*(3–4). https://doi.org/10.1007/s10584-022-03408-w

Okaka, W. T., & Nagasha, I. J. (2018). Perspectives on Mainstreaming Gender Equality (MGE) in Climate Change Adaptation Services for Local Communities Around Lake Mburo National Park (LMNP) in Uganda. *Conference Paper*, *March*, 1–15.

Omondi, P. A. o., Awange, J. L., Forootan, E., Ogallo, L. A., Barakiza, R., Girmaw, G. B., Fesseha, I., Kululetera, V., Kilembe, C.,

Article DOI: https://doi.org/10.37284/ajccrs.2.1.1275

Mbati, M. M., Kilavi, M., King'uyu, S. M., Omeny, P. A., Njogu, A., Badr, E. M., Musa, T. A., Muchiri, P., Bamanya, D., & Komutunga, E. (2014). Changes in temperature and precipitation extremes over the Greater Horn of Africa region from 1961 to 2010. *International Journal of Climatology*, *34*(4), 1262–1277. https://doi.org/10.1002/joc.3763

Recha, J. W., Ambaw, G., Nigussie, A., Radeny, M., & Solomon, D. (2022). Soil Nutrient Contents in East African Climate-Smart Villages: Effects of Climate-Smart Agriculture Interventions. *Agriculture (Switzerland)*, *12*(4), 1–14. https://doi.org/10.3390/agriculture12040499

Rwangire, M. (2019). *Integrating Indigenous Agricultural Knowledge into Moder n Agr Culture al Pr practices for Sustainable Rural Household Food Security in Uganda*. *8*(7), 156–186.

Sabiiti, G., Ininda, J. M., Ogallo, L. A., Ouma, J., Artan, G., Basalirwa, C., Opijah, F., Nimusiima, A., Ddumba, S. D., Mwesigwa, J. B., Otieno, G., & Nanteza, J. (2018). Adapting agriculture to climate change: Suitability of banana crop production to future climate change over Uganda. *Climate Change Management*, *January*, 175–190. https://doi.org/10.1007/978-3-319-64599-5_10

Sabiiti, G., Prediction, I. C., Centre, A., Ininda, J., Ogalo, L., & Ouma, J. (2018). *Adapting Agriculture to Climate Change: Suitability of Banana Crop Production to Future Climate Change Over Uganda*. *January*. https://doi.org/10.1007/978-3-319-64599-5

Sanchi, I. D., Sabo, Y. A., & Hamid. (2021). Critical Review of the Causes and Effects of Dry Spell in 2021 Rainy Season in Danko Wasagu Local Government. *Cross Current Int J Agri Vet Sci*, *3*(8), 66–75. https://doi.org/10.36344/ccijavs.2021.v03i08.001

Thierfelder, C., Chivenge, P., Mupangwa, W., Rosenstock, T. S., Lamanna, C., & Eyre, J. X. (2017). How climate-smart is conservation agriculture (CA)? – its potential to deliver on adaptation, mitigation and productivity on smallholder farms in southern Africa. *Food Security*, *9*(3), 537–560. https://doi.org/10.1007/s12571-017-0665-3

Tumwesigye, W., Atwongyire, D., Ayebare, P., & Ndizihiwe, D. (2018). *Climate Smart Soil and Water Conservation Practices : A Way Forward for Increasing Crop Production Among Smallholder Farmers in South Western Uganda*. *6*(2), 28–37. https://doi.org/10.11648/j.ajaf.20180602.12

Twesigye, N., Twinamatsiko, M., & Tumwesigye, W. (2022). Utilisation of Biodegradable Solid Waste To Boost Crop Production Among Farmers in Mbarara City, South Western Uganda. *American Journal of Agriculture*, *4*(1), 47–57. https://doi.org/10.47672/aja.948

Twongyirwe, R., Mfitumukiza, D., Barasa, B., Naggayi, B. R., Odongo, H., Nyakato, V., & Mutoni, G. (2019). Perceived effects of drought on household food security in South-western Uganda: Coping responses and determinants. *Weather and Climate Extremes*, *24*(February 2022). https://doi.org/10.1016/j.wace.2019.100201

UBOS. (2017). Isingiro District. *The National Population and Housing Census*.

Zizinga, A., Group, E. W., Mwanjalolo, M. J. G., Mugarura, M., & Ababo, P. (2015). *Potential Climate Change Adaptation and Coping Practices for Agricultural Productivity in the Mountain Areas of South Western Uganda Potential Climate Change Adaptation and Coping Practices for Agricultural Productivity in the Mountain Areas of South West*. *July*. https://doi.org/10.9734/JSRR/2015/16351

