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Original Article

Contribution of Dry Spell Adaptation Technologies to Crop Productivity 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

Extended Dry Spell Adaptation Technologies (EDSATs) can improve crop resilience to Extended Dry Spells (EDS). This study was aimed at determining the contribution of EDSATs to crop productivity in the Isingiro Town Council. An exploratory survey was conducted to collect data from 125 farmers. The selection of respondents was made through purposive and referral sampling methods. Key informant interviews were conducted with 05 Production Department staff. Data was analysed using Stata 14 to generate summary tables. Results revealed that the farmers' priority crops are Bananas, beans and maize grown by 98.4%, 69.6% and 43.2% of the farmers, respectively. 99.2% of the farmers are aware that their technologies contribute to Extended Dry Spells Adaptation (EDSA). Weeding is done by 68.8%, 68.4% and 43% of Bananas, Beans and Maize farmers, respectively. Inter-crops of beans-bananas, maize-bananas and maize-beans are implemented by 16.8%, 5.6% and 3.2% of the farmers, respectively. Application of manure is implemented by 60%, 5.6% and 4.8% of the farmers for all crops. Mulching is done by 67.2% and 7.2% of the banana and beans farmers. Contributions of weeding bananas, beans and maize contribute 65.2%, 94% and 88.6%, respectively to productivity. Inter-crops of beans-bananas, maize-banana and maize-beans contribute 122%, 57.1% and 35% to improved beans, maize, and beans productivity, respectively. Factors challenging the implementation of the crop EDSATs include; farmers' economic status, availability of extension services, farmer exposure and availability of inputs, among others. The sustainability of EDSATs is hindered by a lack of investment funds and lack of consistent technical support, among others. Therefore, there is a need for the formulation of policy provisions that favour the availability of credit facilities to all farmers to enable them to manage all the limiting factors to the implementation and sustainability of EDSATs.

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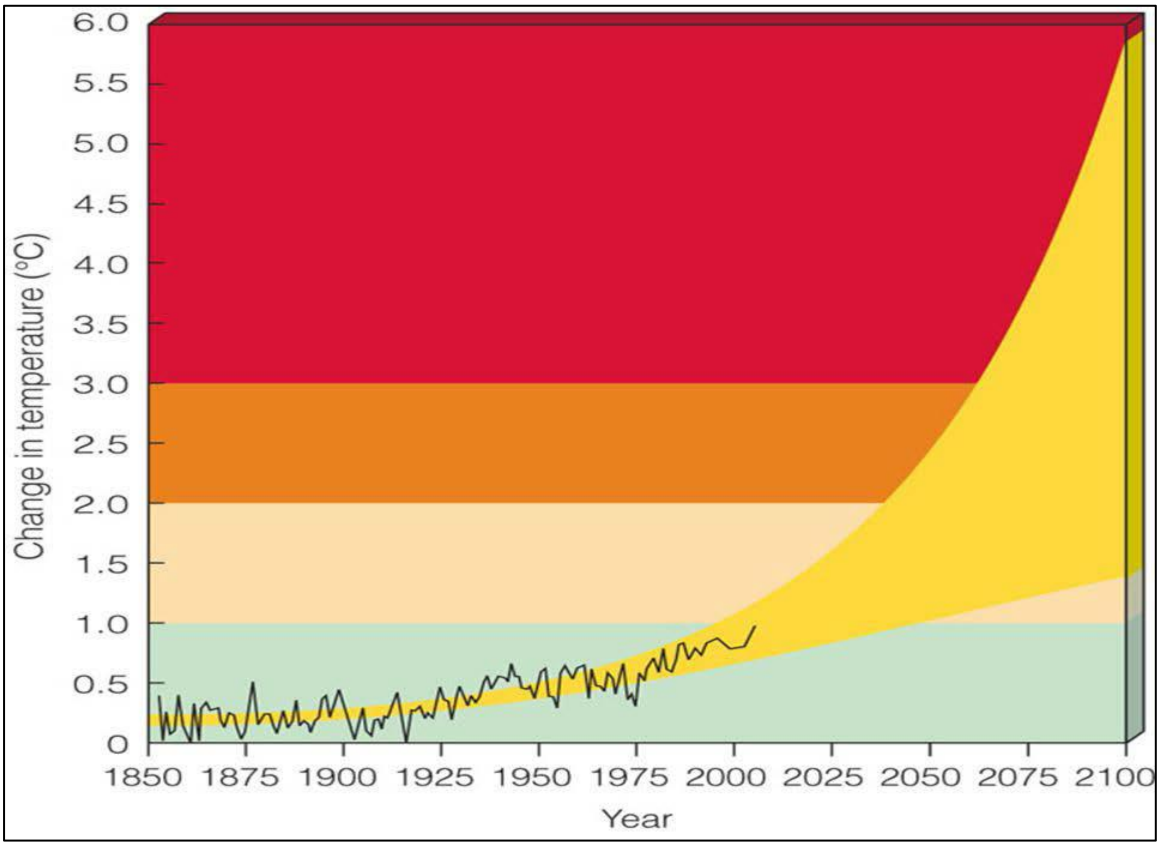
INTRODUCTION

Agricultural activities are affected by climate change effects due to their direct dependence on climatic factors, but they could also be a solution for climate change through the widespread adoption of mitigation and adaptation actions (Mulatu et al., 2020).

Humanity is heading toward a major challenge of having to increase food production by about 50% by 2050 to cater for an additional three billion inhabitants amidst arable land shrinking and degradation, soil nutrient deficiencies, increased water scarcity, and uncertainty due to present and predicted climatic changes (Vadez et al., 2012).

IPCC has already indicated that at the end of the 21st century, the global average temperature possibly will be increased by 1.4 ºC to 5.8 ºC (*Figure 1*), and this terrific increase in temperature has tremendous effects on the atmosphere, biosphere, hydrosphere, lithosphere, and ecosystem (Qin et al., 2020).

Figure 1: Global average temperature changes from 1850 to 2100



Source: (Ashraf et al., 2020).

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Limitation (or absence) of rainfall leads to dry seasons (rainfall breaks), thereby affecting the vegetation growing period since the rainfall distribution can be irregular and difficult to predict. Such erratic (or unpredictable) rainfall can cause heavy economic losses to smallholder farmers, resulting in food insecurity and poor livelihood (Winkler et al., 2017). Climate-related risks such as prolonged dry spells, are becoming more frequent and intense with negative impacts on agricultural livelihoods and food security (Mubiru et al., 2018).

Uganda is an agrarian country, meteorological drought is the most pronounced, characterised by reduced rainfall deficiencies (15% less than the annual average of 46 inches), reduced soil moisture and water supplies (National Vulnerability and Risk Atlas of Uganda, 2019). Many changes and variability in climate have already been felt by farmers in Isingiro such as heat waves, ravaging wind storms and catastrophic droughts (Okaka & Nagasha, 2018). Soil moisture drought also called agricultural drought have additional impacts on natural ecosystems including reduced germination, stunted growth, serious damage to the photosynthetic apparatus, a decrease in net photosynthesis, and a reduction in nutrient uptake. (Nadeem et al., 2019).

Drought, defined by prolonged moisture deficiency, is a climate change hazard that is perceived to be triggered by anthropogenic practices like deforestation, swamp reclamation, and overstocking of livestock, among others (Mbolanyi et al., 2017). Drought intensity and severity have risen globally in the past two decades causing adverse impacts on water resources, vegetation, people, and their livelihoods (Gleick, 2014). The warmest six years have all been since 2015, with 2016, 2019, and 2020 being the top three with indistinguishably small differences in average global temperatures among these years with average global temperature in 2020 being about 14.9 °C, 1.2 (± 0.1) °C above the pre-industrial (1850-1900) (Croeser, 2023).

For Africa in particular, the 4th IPCC Assessment Report (IPCC 2007) indicates that the continent is warming faster, all year round, than the global average, a trend that is likely to continue. By the year 2100, it is predicted that temperature changes will lie within ranges of about 1.4 ^{o}C to nearly 5.8^{o}C increase in mean surface temperature compared to 1990 and the mean sea level rise between 10 cm to 90 cm. The Equatorial countries of Cameroon, Uganda, and Kenya, for example, will be about 1.4^{o}C warmer. This represents a rate of warming to 2050 of about 0.2 ^{o}C per decade (Kotir, 2011).

All extreme temperature indices indicate that the cattle corridor continues to experience warming conditions (Owoyesigire et al., 2016). The Uganda National Development Plan 2020/21 – 2024/25 acknowledges the fact that Uganda has in the past decade, experienced several risks that have had devastating effects on the households, communities, and the economy at large. Natural disasters like floods and dry spells have cost the economy and impacted the lives of the people. Between 2004 and 2013, droughts affected close to 2.4 million people and in 2010 caused an estimated loss and damage value of USD 1.2 billion, equivalent to 7.5% of Uganda's 2010 gross domestic product (NPA, 2020).

The cattle corridor of Uganda (Where Isingiro District lies) reportedly receives less rainfall compared to the rest of the country, therefore resulting in water stress challenges (Fagan et al., 2015). Climate models project increased drought areas across many regions in the 21st century, suggesting droughts are intensifying in magnitude and severity globally (Cook et al., 2014). Droughts impose significant adverse effects on water resources, agricultural sector performance and the overall economic performance of many countries (Kilimani et al., 2018).

Droughts can compromise a wide range of ecosystem services, including provisioning services such as food, fuel, and freshwater; regulating services such as pollination and pest regulation; and support services such as soil

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fertility and nutrient cycling (Marambanyika et al., 2021).

Droughts may result in significant, long-term economic losses in a range of sectors. Losses may be local to the drought-affected area, or they may be widespread through economic value chains and by cascading losses to other sectors and the national or global economy. In some regions of the world, drought may cause or exacerbate food shortages and food insecurity, unemployment, poverty, inflation, conflict, and internal displacement or migration (Kilimani et al., 2018).

Droughts can compromise a wide range of ecosystem services, including provisioning services such as food, fuel, and freshwater; regulating services such as pollination and pest regulation; and support services such as soil fertility and nutrient cycling. Significant or persistent droughts may alter ecosystem functions and compromise ecosystem goods and services, resulting in diminished or damaged ecological functioning (Marambanyika et al., 2021).

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Drought can cause significant human health impacts, and the socioeconomic environment in which drought occurs influences the resilience of affected populations. In poorer or marginalised communities, drought may exacerbate existing health disparities. Drought impacts food production systems and agricultural value chains and can contribute to nutritional deficiencies. Drought can also exacerbate gaps in sanitation and hygiene coverage and reliability, which may disproportionately affect women and girls when they are responsible for household water supply (Edwards et al., 2019).

Cultural and social constructs underlie how water is perceived, valued, and managed in different societies. In many cultures and belief systems, water is strongly tied to cultural heritage and religious and spiritual practices. These may inform a social understanding of the causes and solutions for drought and may support communities in coping with drought. Further, drought impacts can vary in severity based on gender, ethnic group, religion, livelihood strategies, and other societal roles and vulnerabilities (Agamile et al., 2021).

These shocks threaten food security and broader aspects of welfare for smallholder farmers in tropical countries like Uganda. While farmers can use a variety of mechanisms to cope with these shocks, such as adopting irrigation technologies, agroforestry, changing crop varieties and planting times, the majority cannot afford these adaptations. Most smallholder farmers react to weather shocks by reallocating land to different crops. The situation is particularly difficult for female farmers, for whom the barriers to either adopting shock-mitigating technologies or increasing their off-farm employment are often much higher than for men (Agamile et al., 2021).

The main coping responses to dry season falls under the following thematic area: soil moisture conservation technologies which enhance soil moisture, control soil erosion and enhance water catchment, soil fertility enhancement, on-farm diversification, improved inputs and management, local innovations and food storage in sacks and granaries and water in built underground reservoirs with tarpaulins inside, mulching gardens with grasses and dry banana leaves and stems, and small-scale hand irrigation (Twongyirwe et al., 2019). Other innovations include the use of manure and improved crop varieties, intercropping, planting of food security crops, the establishment of kitchen gardens, rainwater harvesting for domestic and agricultural use, and the use of organic pesticides, all aimed at enhancing agricultural productivity and improving food security. Incentives for adopting soil fertility practices included increased crop yields, improved soil fertility, and enhanced plant

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germination potential and growth rates. (Mubiru et al., 2018).

Crop diversification is a risk management strategy (acts as insurance) against rainfall variability as different crops are affected differently. A well-designed gender-sensitive crop diversity strategy can mitigate risks and improve nutrition. Crop diversification as a risk management and adaptation strategy is efficient on limited land holdings, improves soil fertility and boosts crop yields, among other benefits (Vernooy, 2022). Poor post-harvest handling of agricultural produce is a major constraint in Uganda (Strecker et al., 2022).

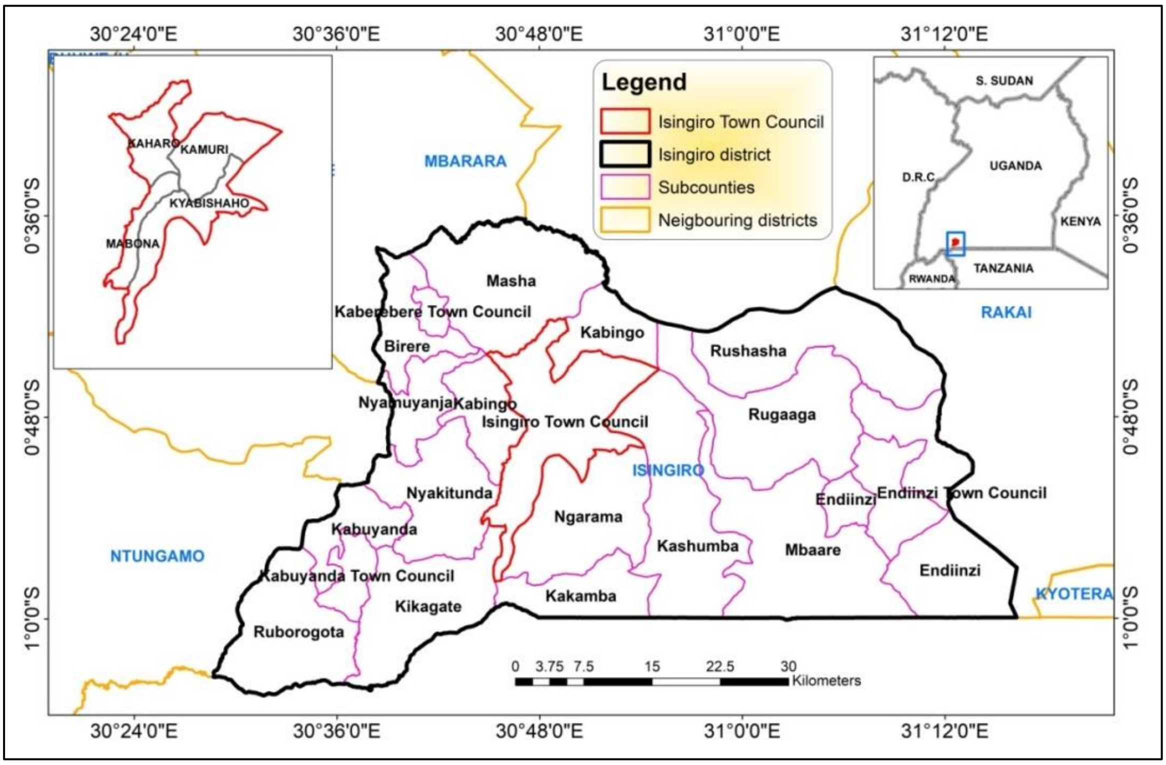
Although it is evident that farmers in Isingiro District are implementing Dry Spell Adaptation Technologies (DSATs) in their farming practices (Tumwesigye et al., 2018), no research has been conducted to determine the contribution of each of them to crop productivity. This study was carried out to establish the contribution of each of the DSATs to crop productivity 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 and maize and farmers affirmed that they are all affected by the extreme climatic conditions. In the Isingiro district, where smallholder farmers predominantly depend on banana production and in the presence of severe drought, most household heads vacated their families to other countries looking for ways of feeding their family members during the drought season (Tumwesigye et al., 2018). Thus, Isingiro Town Council is vulnerable to the impact of climate change (Zizinga et al., 2015), and the water and food sectors are negatively affected. 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 2: Location of Isingiro Town Council in Isingiro District



Source; Own GIS work

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

As such, the selected households were not randomly but purposively selected based on whether they 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 households within the study area. Structured questionnaires were used to collect data from 125 households. This sample size was determined from the total population of households 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 generalisation of the results by adding seven households. Questionnaire responses from HH, 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

The objective of the study was to determine the contribution of Dry Spell Adaptation Technologies (DSATs) to crop productivity in Isingiro Town Council, Isingiro District.

Family size, Land Size and Years Spent Implementing DSATs

The current study acquired 100% response since all interviewed respondents were willing to provide the required information. The key results from respondent HHs of surveyed farmers on Family size, Land size and Years spent implementing Extended DSATs are presented in *Table 1*.

Table 1: Family size, Land size and Years spent in implementing DSATs

Parameter	Mean value for 125 respondents	Units
Family size	7.56	Numbers
Land size	3.87	Acres
Years spent implementing Extended DSATs	10.45	Years

Source: Own Field Survey (January 2023)

Table 1 above shows that from the data collected from 125 respondents, it was found out that the mean family size was 7.56 members, the mean farm size was 3.87 acres, and on average, the EDSAT implementing farmers had taken an average of 10.448 years consciously implementing the technologies.

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Priority Food Crops Grown in Isingiro Town Council

Table 2: Priority food Crops

Rank	Crop	Isingiro T/C	
		No. of HH	**Percentage (%)**
1st	Bananas	123	98.4
2nd	Beans	109	87.2
3rd	Maize	99	79.2

Source: Own Field Survey (January 2023)

From *Table 2*, 123 (98.4%) of the HHs grow bananas, 109 (87.2%) and 99 (79.2%) grow beans and maize, respectively. This is in agreement with Tumwesigye et al. (2022) who confirms that Bananas, Beans and maize are the primary food crops grown in the study area for household food and income security.

Farmers' Understanding of Dry Spell Adaptation

121 (96.8%) of HHs understand that dry spell adaptation is a combination of water harvesting, irrigation, mulching, and soil fertility management all aimed at sustained food production during times of extended dry spells with soil water stress conditions.

Contribution of the Implemented Bananas EDSATs to Food Crop Productivity

From *Figure 3*, the application of manure, deep ploughing to mix the manure with soil and then mulching contributes 122.3% to banana productivity, while planting leguminous cover crops like Velvet bean improves banana productivity by 95.0%. Decomposition pits and application of tithonia liquid manure contribute 82.9% and 80.0%, respectively, to banana productivity. De-suckering as a single operation improves banana productivity by 73.4%, while mulching improves banana productivity by 68.9%. Weeding banana plantations before seeding and surface manure application contribute 65.2% and 65.1% to banana productivity, respectively. Rabbit urine application and irrigation each contribute to banana productivity by 64.9% and 63.3%, respectively. Ring fork hoeing the banana mat combined with deep ploughing contributes 60.0%, while uprooting the corm improves banana productivity by 57.2%. Construction Soil and Water Conservation structures contribute 55.1% to banana productivity. Pruning bananas and staking with either nylon threads or poles each have the potential to contribute to banana productivity by 48.8% and 44.3%, respectively.

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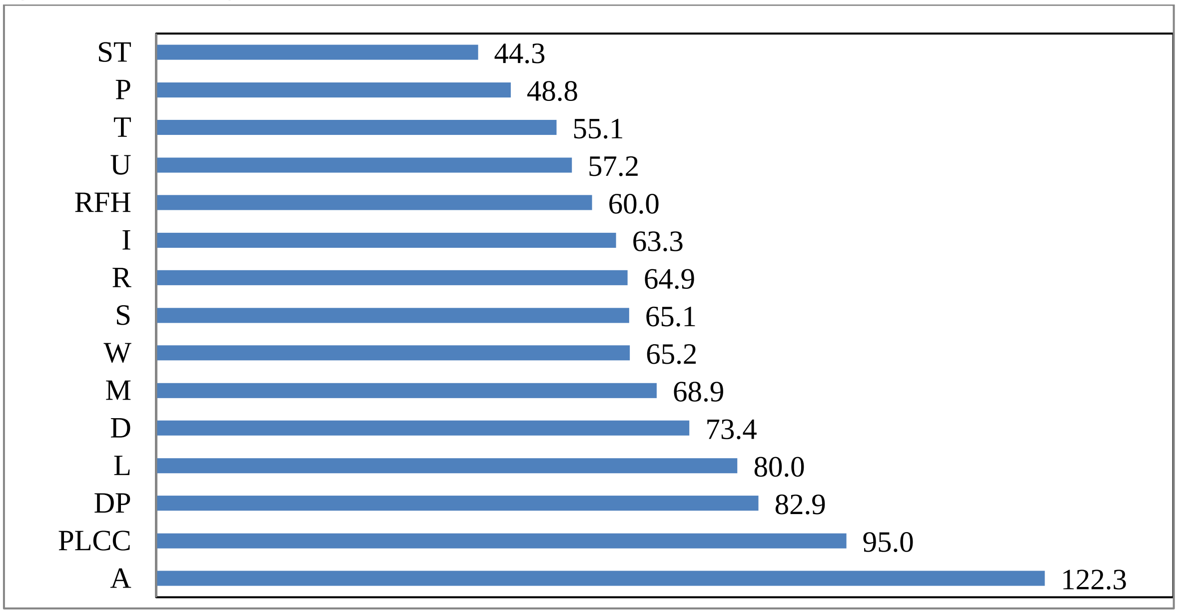
Figure 3: Percentage contribution of Banana EDSAT to productivity



KEY FOR BANANA EDSATs: *A: Apply manure, deep cultivate and mulch; PLCC: Planting leguminous cover crops; DP: Decomposition pits/basins; L: Liquid manure application; D: De-suckering and thinning; M: Mulching; W: Weeds removal before they bare seeds; S: Surface Manure application; R: Rabbit urine application for pest management and liquid manure; I: Irrigation; RFH: Ring fork hoeing/forking around the mat & deep ploughing; U: Uprooting rhizomes/corms from which other suckers grow; T: Trenches, water retention ditches & basins; P: Pruning*

Source: Own Field Survey (January 2023)

Contribution of Implemented Beans EDSATs to Productivity

From *Figure 4*, Manure application combined with burying weeds to decompose in the garden improves bean productivity by 238.3%. Spraying with Super Grow improves beans productivity by 151.9% compared to planting on virgin land and using the materials to mulch which contributes 130.6%. Irrigation and liquid manure improve beans' productivity equally at 125.0%. Banana-Bean intercropping improves beans productivity by 122.0%, and row planting with hoe weeding improves beans productivity by 94.0%. Dry Spell Adapted Climbing beans with Growing beans in wetlands each improved beans productivity by 90.0% and 80.0%, respectively. While spraying with selective weed killers and early planting, each contributes 79.0% and 68.4%, respectively. Lastly, comparing trenching and hand weeding as DSATs, each contributes 63.0% and 48.7% to bean productivity.

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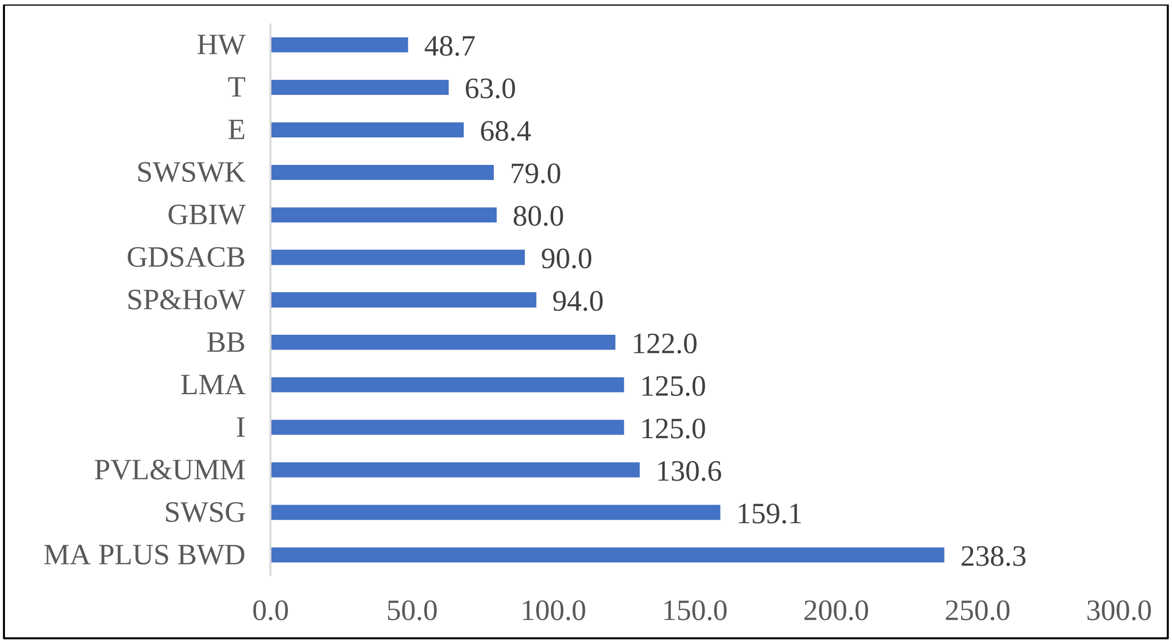
Figure 4: Percentage contribution of Beans EDSAT to productivity



***KEY BEANS EDSATs**: MA PLUS BWD: Manure Application plus burry weeds to decompose; SWSG: Spray with Super Grow; PVL&UMM: Plant on Virgin Land & Use Materials to Mulch; I: Irrigation; LMA: Liquid Manure Application; BB: Beans – Banana Intercropping; SP & HoW: Strip/Row Planting with Hoe Weeding; GDSACB: Grow Dry Spell Adapted Climbing Beans; GBIW: Growing Beans in Wetlands; SWSWK: Spray with Selective Weed Killer; E: Early Planting; T: Trenching for soil and water conservation; HW: Hand Weeding*

Source: Own Field Survey (January 2023)

Contribution of Maize EDSATs to Productivity

From *Figure 5*, Monoculture with manuring and appropriate spacing as a DSAT has been observed to produce an impressive improvement in maize productivity of 178.3%, while spraying with Super Grow which improves maize productivity by 155.8% compared to planting with solid manure, which contributes 120.0%. Growing maize in wetlands improves its productivity by 105.7%, and Irrigation with Tithonia liquid manure improves maize productivity by 90.0%. Appropriate spacing of 1M by 1M improves maize productivity by 89.0% compared to Row Planting with hoe weeding at 88.6%. Spraying against armyworms contributes to maize productivity by 85.0%, while growing maize with Bio slurry contributes 80% to maize productivity. Early planting and thinning follow each other at 69.8% and 61.7%, respectively, in contributing to maize productivity. Maize-banana intercropping contributes 57.1% to maize productivity, while Hand contributes 51.2% to maize productivity. Beans – Maize intercropping, which is mainly practised by farmers with small pieces of land contributes a 35.0% improvement in maize productivity.

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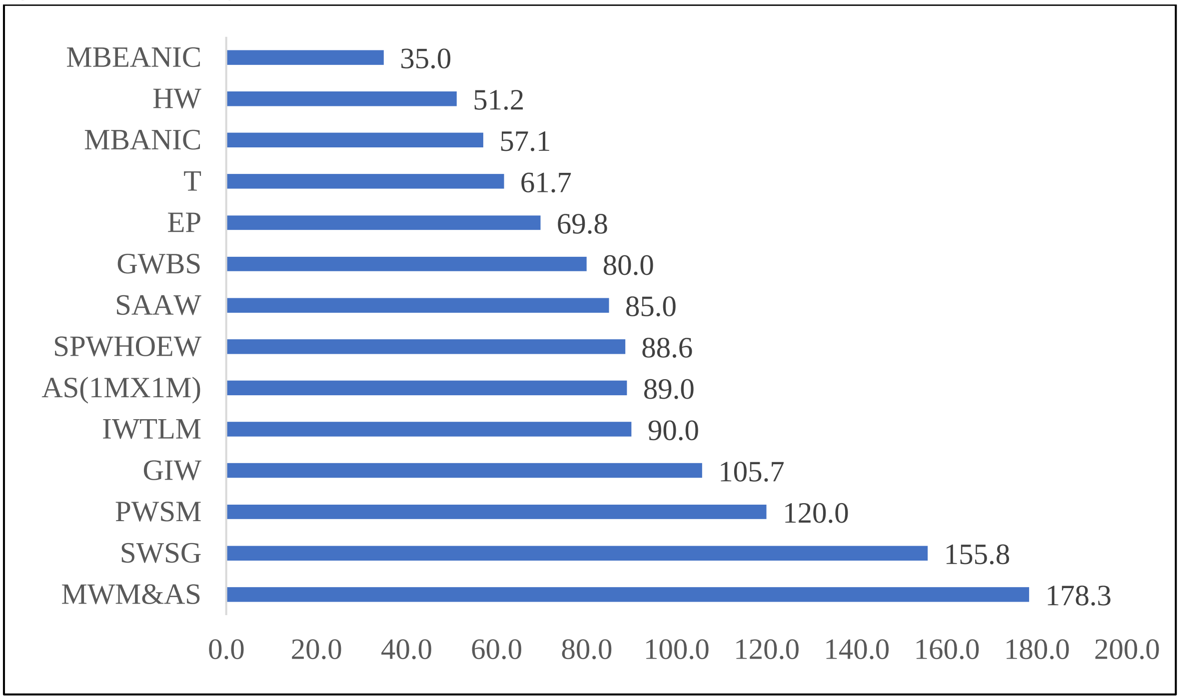
Figure 5: Percentage contribution of Maize EDSAT to productivity



KEY FOR THE MAIZE EDSATs: *MWM&AS: Monoculture with manuring & appropriate spacing; SWSG: Spray with Super Grow; PWSM: Plant with Solid Manure; GIW: Growing in Wetlands; IWTLM: Irrigation with Tithonia Liquid Manure; AS(1MX1M): Appropriate Spacing (1 m x 1 m); SPWHOEW: Strip/Row Planting with Hoe Weeding; SAAW: Spraying against Army Worm; GWBS: Grown with Bio-slurry; EP: Early Planting; T: Thinning; MBANIC: Maize-Banana Intercrop; HW: Hand Weeding; MBEANIC: Maize-Bean Intercrop*

Source: Own Field Survey (January 2023)

DISCUSSION

Family Size, Land Acreage and Years in Implementing DSATs

The mean family size of 7.56 members, mean farm size of 3.87 acres, and 10.448 years of implementing DSAT provide insights into Dry Spell Adaptation activities. The average family size of the sampled respondents was high, and this explains the fact that most of the DSATs are labour-intensive and require sizeable labour. This is in agreement with Mfitumukiza et al. (2020) conclusion that the size of a household determines the use of labour-intensive technologies.

Farmers reported that small land-owners collect lower returns on investment due to the limited harvests and as a result do not implement many EDSATs on their crop enterprises. In a similar way, land ownership determines whether EDSATs are implemented because it influences the level of decision-making power a farmer has over land use. Farmers who hire land or possess small pieces of land shun long-term EDSATs due to either uncertainty of the period of land usage or alternative multiple uses the small pocket of land ownership has to offer to a family at any given time. The availability of relatively more land presents an opportunity for uptake and use of EDSATs as was expressed during interviews and group discussions. This is in agreement with Byenkya et al. (2014) who affirm that land size and ownership influence the crop types that can be grown and the diversity of farming practices, which may either be long-term DSATs or short-term agricultural practices.

The average of 10.45 years provides a hit into the time the farmers have been aware of the certainty and impact of EDSs in the area and have intentionally been in the practice of implementing EDSATs.

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Farmers' Understanding of Dry Spell Adaptation

121 (96.8%) of HHs have an understanding of what Dry Spell Adaptation is all about. This has influenced the types of DSA technologies implemented by HHs. They are mainly those aimed at increasing soil moisture and nutrient availability to food crops during Extended Dry Spells for sustained food productivity.

Contribution of Banana Dry Spell Adaptation Technologies (DSATs) to Productivity

This study confirmed that the impacts of dry spells on banana plants include; reduced bunch weight 91.2% (114), Wilting of young leaves 74.4% (93), Reduced leaf numbers/size 63.2% (79), Reduced finger size 60.8% (76), Reduced sucker production 52.8% (66), Reduced, drying & disintegration of pseudo-stem 44.8% (56), Delayed flowering & bunch formation 27.2% (34), Stunted growth 22.4% (28) and Prolonged bunch filling time 15.2% (19) all of which negatively impact on the productivity of bananas. Sabiiti et al. (2018) also noted that "expected increases in temperature and depressed rainfall are likely to retard banana growth and negatively impact productivity due to high moisture deficits" (Page 10).

From this study, farmers have been able to sustain the productivity of food crops amidst Dry Spell Associated stresses by implementing various specific crops DSATs.

Linkage of the Banana, Beans and Maize DSATs to Dry Spell Adaptation

Deep manure application improves soil stricture, leads to deeper root establishment, vigorous and stable banana stools improving banana yields by 122.3%. Small HHs practice Surface Manure Application, which leads to superficial root growth that exposes roots to the impacts of dry spells leading to banana yield improvement of only 65.1%. Velvet beans grow as leguminous cover crops, control the growth of weeds, conserve soil moisture, increase soil-carbon content and improve soil organisms' activity, thus improving soil structure and leading to a 95% improvement in banana productivity.

Decomposition pits filled with banana and other plant remains are covered thinly and left to decompose to form a basin-like depression which becomes a water catchment when it rains. As the water percolates, it facilitates the supply of nutrients to the surrounding banana mats and leads to 82.9% improved banana productivity. Undiluted liquid manure from rabbit urine and bio-slurry kills nematodes, cures Banana Bacterial Wilt (BBW) and repels insects. Irrigation with a mixture of 1 part of fermented livestock urine in 3 parts of water increases crop vigour against diseases and dry spells. The solution is rich in nitrogen and also increases soil moisture content providing an 80% improvement in banana yields.

De-suckering leaving mother in fruit, teenage shoot, and young shoot on a mat at any one moment reduces competition for moisture, light and soil nutrients causing strong and healthier banana stands to improve banana productivity by 73.4%. Mulching helps to sustain soil moisture, increases manure at decomposition and there are increases soil organisms' activity, all of which work together to improve soil structure for improved productivity of 68.9%. Weeds removal before seed-bearing breaks the next cycle of weed growth. This practice of weed removal before seeding improves banana yields by 65.2%.

Ring fork hoeing around the mat facilitates water percolation, nutrient availability and improved soil organisms' activity leading to deeper root growth and banana stability for improved banana productivity of 60%. Banana corms for harvested stands have roots and suckers, which are parasitic. Up-rooting corms eliminate this competition behaviour between the bananas and unwanted suckers; banana weevils are controlled, and corms provide mulch when up-rooted and are converted to manure when they decompose, causing a 57.2% improved banana yield. According to (Stella, 2021), Isingiro District is 100% exposed to windstorms due to dry spell high temperatures, which causes low atmospheric pressure leading to estimated losses of 6.9% of the national yields of

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bananas annually. Staking minimises losses from premature falls of dry spell stressed and weak banana stands due to hot strong winds sustaining food availability by 44.3%.

Linkage of the Beans and Maize DSATs to Dry Spell Adaptation

The farmers' practice of incorporating organic manure into beans and maize fields is in agreement with Adekiya et al. (2020), who affirms that the use of organic manure to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture since organic manures generally improve the soil physical, chemical and biological properties. Manure application has led to 238.3% and 120% improved yields for beans and maize, respectively.

Super grow application in beans and maize enables the leaves to become thicker and reduces the rate of evapotranspiration. It makes water to be wetter; it helps to retain water under the soil much longer, even in dry, warm weather, which also makes the crops maintain their evergreen outlook and growth during dry spells. Super Grow makes other agricultural treatments a farmer uses (like fertiliser, insecticides, and pesticides) perform better by helping them penetrate deeper, stick better, stay longer and work more effectively (User farmers' own testimony). In this study, the application of Super grows improves beans and maize productivity by 159.1% and 155.8%, respectively.

Land that has been under fallow is more fertile, has good soil structure, has materials available for mulch and is less co-host pest and disease infested. Fallowed soils enable vigorous crop performance giving 130.6% improved bean productivity. Rwangire (2019) affirms that planting on fallow land adds green manure to the soil, which in turn conserves moisture. According to Saleh et al. (2018), irrigation treatment can increase green bean productivity and improve pod quality due to increased moisture availability during EDSs. Irrigation improves beans' and bananas' productivity by 150% and 63.3%, respectively.

The use of a composite of tithonia leaves, animal droppings and wood ash as liquid manure yield improved productivity by 125% and 90%, respectively for beans and maize. Bio-slurry improves maize yields by 80%. Rabbit urine application on bananas provided an improved yield of 64.9%. Gambart et al. (2020) confirm that due to decreasing land sizes and needs for food security, intercropping is a very common cropping system among most farmers planting beans, bananas, and maize. In the study area, maize intercropped with beans led to 35% improved maize productivity, beans with bananas led to 122% improved beans productivity and maize with bananas led to 57.1% improved maize productivity.

The respondents revealed that when two crops are grown together, you are assured of at least a harvest. In addition; due to the scarcity of land; inter-cropping enables a homestead to have a variety of food crops hence ensuring food availability, stability, and utilisation. Row planting and appropriate spacing provide a workspace for weeding, mulching, spraying, softening, and providing sufficient soil around the bean's root system. Planting in lines reduces competition for light, moisture and nutrients and enables effective management of pests and diseases securing a 94% and 88.6% improved beans and maize productivity, respectively.

Farmers confirmed that Climbing beans are drought tolerant and yield more harvest and even during dry spells, they continue seeding. According to Rose et al. (2018), Climbing beans are drought-tolerant to low soil fertility. Climbing beans are 90% more productive than indigenous beans during dry spells. Wetlands areas are virgin areas, have more moisture and are more fertile because they are catchment drainage areas; they are protected by the laws of the land and can yield a crop harvest even during dry spells. Wetlands farming secures 80% and 105.7% increased yield for beans and maize, respectively. According to Bamanya (2017), farmers are gradually

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encroaching on the wetlands to grow beans, among other crops during dry spells.

Weed killers help reduce the parasitic tendency of weeds against the beneficial elements of the beans. Pests and diseases that are likely to be shared between weeds and beans are managed, thus protecting beans from attack. The use of weed killers has secured farmers a 79% beans productivity improvement. Early planting is a product of the reception of early warning information, conducting pre-season planning and review of early warning systems, and agreeing on timelines for various operations. Early planting is often done under the beans-banana inter-cropping. Banana plantations provide shade, mulch, and fertile soils for beans during dry spells. Early planting builds crop resilience to dry spells assuring farmers of 68.4% and 69.8% improved beans and maize yields.

Trenches, cut-off drains, retention ditches and stabilised road embankments help to harvest water, conserve the water, and manage the possibility of soil erosion in a crop garden. At the onset of the extended dry spell, there is moisture in the soil. Soil and water conservation structures have yielded a 63% and a 55.1% beans and bananas improved productivity in the study area. Hand weeding is practiced in both beans and maize growing and yields 47.8% and 51.2% improved yields, respectively. Hand weeding is cheaper for small-scale farmers, and the weeds are appropriately mulched by hands around the crop root area, conserving moisture and providing nutrients at decomposition. According to Davis et al., 2015, weeds have many attributes undesirable to crop producers that reduce crop yields through competition for resources such as sunlight, water, nutrients, and space. Weeds also may harbour insects and provide a host for certain plant pathogens.

The severity and extent of outbreaks of Army Warms are increased by extended dry spells in natural habitats followed by early-season rainstorms that facilitate the growth of vegetation in the neighbourhoods leading to migration of the moths (Nurzannah et al., 2020). The management of army warms reduces levels of devastation to maize production and secures 85% increased yield from maize. Thinning in maize is aimed at the elimination of the weaker maize stands, leaving excellent performers to maximise the productivity of the maize crop. The adaptation of the maize crop as a result of thinning is a result of improved performance due to optimal resource utilisation. Delayed thinning increases plant competition and reduces grain yields. Maintaining 5 plants/sq m after thinning gives optimum yield (Manjulatha et al., 2023). This study indicates a 61.7% increase in maize yield as a result of thinning.

In agreement with the main objective of sustaining soil moisture and nutrients for crop adaptation during dry spells, Rwangire (2019) affirms that "One aspect of cultivation involves ploughing when burying crop remains, weeds or bush when the area has been under fallow. The practice is very important in that it adds moisture-holding green manure to the soil". This is usually done when preparing a garden or planting maize and beans, among other crops. Another aspect of ploughing involves the practice where crop remains are cut into small pieces, mixed into the soil, and decomposed adding manure to the soil. These two aspects of ploughing are important for adding green manure and nutrients to the soil including holding moisture that is important for proper growth of plants. Interventions for shade and wind safety contribute to the management of premature losses of food through heat stress and dry spell winds.

CONCLUSION

This study was aimed at investigating the contribution of extended dry spell adaptation technologies (EDSATs) implemented at the HH level to crop productivity among farmers of Isingiro Town Council, Isingiro District. All technologies confirm Rwangire's (2019) assertion that dry spell adaptation that leads to improved agricultural productivity involves making the best use of nature's goods and services as functional inputs. This involves optimal utilisation of rains, water harvesting, irrigation, conservation agriculture and organic farming, which are

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enshrined within the farmers' definitions of Extended Dry Spell Adaptation. This study concludes that the Extended Dry Spell Adaptation Technologies (EDSATs) implemented have contributed to varying increased agricultural productivity in the study area as per the details of this report.

Recommendations

Government should provide agriculture insurance packages to cushion against intense dry spells that defeat DSATs contribution. Government should ensure that agricultural extension officers are capacitated to effectively offer extension service, intense education, and training of farmers on how to technically implement the DSATs on their farms. Exploit the strength of youths by intentionally interesting and engaging youths in farming activities within their homes for commercial farming as a livelihood option.

Train farmers on how to compute the cost-benefit analysis for each EDSAT so that knowledgeable decisions are taken. Carry out soil tests to determine the actual best treatments required by the soils for the best results. Formulate byelaws aimed at maintaining the implementation of proven EDSATs in terms of forming and sustaining community groups that can effectively implement DSATs that are Labour Intensive and require Public Works (LIPWs). Extension workers at the local level must ensure that farmers have access to all vital information regarding weather forecasts so that they can have an informed decision about which DSAT to implement when. Sensitize HHs about the dangers of GBV in hindering crop growth and implementation of associated technologies for family welfare and development. 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 agricultural inputs like organic manure, fertilisers, agrochemicals, equipment, and tools, which can facilitate the boosting of crop productivity. These also need to be availed in a timely manner.

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