Adoption of Advanced Vegetable Production Technologies and Practical Extension Methods promoted by ISSD Plus

Submitted by

Christopher Sebatta

Makerere University

College of Agricultural & Environmental Sciences

Department of Agribusiness & Natural Resource Economics

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Abbreviations and acronyms

GDP	Gross Domestic Product
LDC	Low Development Country
MoFPED	Ministry of Finance Planning and Economic Development
UBOS	Uganda Bureu of Statistics
NPA	National Planning Authority
ISSD	Integrated Seed Sector Development
WCDI	Wageningen Centre for Development Innovation
WUU	Wageningen UR Uganda
WEO	World Economic Outlook
IMF	International Monetary Fund
GOU	Government of Uganda
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
CAADP	Comprehensive Africa Agriculture Development Programme CAADP
EU	European Union
TE	Traditional Exports
UN	United Nations
UK	United Kingdom
UEPB	Uganda Export Promotion Board
UN/DESA	United Nations Department of Economic and Social Affairs

Executive summary

The vegetable sector in Uganda has always faced a number of bottlenecks including but not limited to limited access to and knowledge of improved varieties on the market; lack of knowledge and skills in recommended agronomic practices; predominant use of low quality seedlings from field nurseries; high pest and disease pressure; poor water and fertilizer use; lack of market information; inconsistency in vegetable product quality and supply and non-conformity to phytosanitary requirements. The Integrated Seed Sector Development (ISSD) under the 4-year ISSD Plus Project, coordinated by Wageningen Centre for Development Innovation (WCDI), Wageningen University & Research, implemented by Wageningen UR Uganda (WUU) and funded by the Embassy of the Kingdom of the Netherlands, Kampala intervened to solve some of these challenges from 2017 to 2020. The ISSDPlus programme sought to strengthen the development of a vibrant, pluralistic and market-oriented seed sector that is able to address the highlighted challenges that hamper seed sector development in Uganda.

The aim of the Vegetable component of the ISSD Plus project is to contribute to increased earnings and competitiveness of the vegetable sector, which would eventually contribute to improved food and nutrition security. This has been done through implementing five strategies including; the vegetable training of trainers (ToT) programme to improve extension services, partnering with seed companies to set up farmer training sites and variety demonstration sites in partnership with six Dutch seed companies, mass media campaigns through radio shows and organizing training events.

This report therefore provides findings of an adoption study commissioned by the Integrated Seed Sector Development (ISSD) in March 2020 aimed at assessing and establishing the levels of adoption of improved vegetable varieties and advanced vegetable production techniques which have been promoted by the vegetable component of the ISSD Plus project and its partners since 2017. The study findings were also meant to inform the final evaluation of project in terms of impact among the targeted key stakeholders within the vegetable value chain in Uganda.

The adoption study used a mixed-methods approach using both qualitative and quantitative data collected from the vegetable farmers through a survey, Focus Group Discussions (FGDs), key informant interviews and case studies from 15 out of 24 project districts. The quantitative and qualitative data were used to answer a number of adoption study evaluation questions such as to what extent have trained vegetable growers adopted the promoted technologies and varieties, to what extent were variety demonstrations sites effective in promoting variety awareness and uptake, what are the

reported/purported factors that enhanced or hindered adoption of advanced agronomic practices and quality seed of improved vegetable varieties and others. The quantitative methods involved using a pre-tested questionnaire on sampled farmers in the selected districts in Eastern, Northern, Central and Western Uganda where the project interventions were implemented while qualitative methods such as FGDs, key informant interviews and case studies for selected progressive farmers and seed companies were also conducted.

Key study findings

Results showed that tomato, onion and cabbages were the most important vegetable crops according to over 80 per cent of the sampled farmers. Over the project period between 2017 and 2020, tomato growers in the districts of implementation using the Dutch vegetable varieties increased by 19 percent, cabbage growers by 16 percent and onion growers by 9 percent. This is an indication that farmers who used not to grow these crops have taken them on. Awareness of new technologies precedes their adoption in many cases. Findings show a high level of awareness of improved varieties for the main vegetable crops promoted by ISSD Plus vegetable component. Results showed that 39 percent of tomato farmers were aware of the varieties, 82 percent and 95 percent of cabbage and onion farmers respectively were also aware of the Dutch improved vegetable varieties. Overall, the most adopted tomato varieties were Gammar F1 (19 percent) and Padma F1 (16 percent). Among cabbage growers, Gloria F1(62 percent) and Escazu F1(16 percent) were the most adopted. Red coach (33 percent) and Red pinnoy (17 percent) onion varieties were the most adopted. A gender disaggregation however indicated significant differences between men and women and between older farmers and youth with higher adoption levels found among youth while women tended to adopt different varieties from the men.

Findings also showed that onion, cabbage and tomato contributed over 90 percent of the total share of seed revenues for the Dutch seed companies between 2017 and 2020. An extrapolation of sample data on the entire targeted population for training sites, training events and demos that was about 41,778 farmers indicated that over the four year period of the ISSD Plus project, the adopted vegetable varieties generated over 235 billion Uganda shillings (US$63.4 million) as a contribution to the vegetable seed economy.

The results indicated that generally adoption of advanced agronomic practices in vegetable production was between 25 and 45 percent. The most adopted practice was trellising, modern seedling production, followed by improved crop fertilization. The Northern region registered a higher proportion of farmers adopting modern seedling production, while Eastern region had a higher proportion of farmers adopting

improved crop fertilization and crop protection practices. Adoption of trellising practice was more evident in Central Uganda. It is important to note that adoption of practice was related to the crop produced for instance the likelihood of adopting advanced agronomic practices significantly increased by 60 percent among tomato growers. Hence we conclude that adoption of practices is crop specific and is inclined to the relative importance of the crop to the farmer. The finding that increased acreage under vegetable production hinders adoption of advanced agronomic practices echoes the need for improvement in technology innovations to make them more cost efficient especially for medium to large vegetable farms.

Cost-benefit dynamics of vegetable production

Generally, all promoted vegetables were found to be economically viable and worthwhile enterprises for farmers to undertake except carrots. Tomato and cabbage variety adopters got about 2 Uganda shillings (US$0.001) per shilling invested per production cycle. The Northern region followed by Central regions were the most lucrative in as far as vegetable production viability was concerned. Except for the Eastern region who mainly grew crops such as onions and pepper that did not require a lot of materials for implementing agronomic practices unlike tomato that requires staking, other region advanced agronomic practices adopters got less returns compared to non-adopters. This is an indication that the cost of implementing the agronomic practices needs to be lowered to increase benefits for adopters or investment in agronomic practice is more valuable at a larger scale.

Adoption of ISSD Plus' and partners' extension methodology by ISSD trained extension service providers

Results showed that there was increased adoption and use of promoted extension approaches such as demonstrations, field visits and group meetings by trained vegetable brigadiers. In addition, there was an increase in the number of farmers reached after the vegetable brigadier training. Overall, an estimated 392,704 farmers were reached of whom 193,402 were youth. However, the numbers of youth farmers reached were low. Practical challenges such as the costs associated with establishing and maintenance of demonstrations, coupled with lower women participation on demo sites given their workloads and the effects of COVID-19 limited the use of demonstrations as an extension approach to some extent in 2020.

Impact of Radio shows on technology adoption

Radio can be an effective channel of creating awareness about improved vegetable varieties. Radio listenership was highest among Training Event participating farmers at about 54 percent followed by demonstration site farmers at 49 percent. By gender, a higher percentage of youth farmers attending

training events (55 percent) listened to radio programs organized by ISSD on vegetables followed by almost an equal proportion of male and female farmers. Among training site and demos, a higher percentage of males than females or youth listened to the vegetable-focused radio shows. Radio show listenership was higher in Eastern, Western and Central region in that order.

There was a significant and positive impact of radio programs on adoption of improved vegetable varieties among farmers who attended trainings on demonstration gardens, training sites and training events. The chances of a demonstration and training site participant adopting an improved variety promoted by a Dutch seed company increased by 44 percent if they listened to radio shows. The chance of adopting advanced agronomic practices increased by 50 percent. Although onion, and cabbage variety adoption chances increased significantly by about 60 percent if a farmer listened to radio. Tomato as a crop has a lot of good varieties on the market including non-Dutch varieties that are hybrids supplied by many other seed companies which creates a large variety pool from which farmers choose from.

Conclusions

Generally, we can conclude that the project led to increased adoption of improved vegetable varieties for cabbage, onion and tomato among vegetable growers across the project intervention areas within the country. However, it is important to note that significant differences were observed in the level of adoption across the four regions implying that future promotion campaigns should be region specific. In addition, the use of training sites and demonstration with field days as an extension approach of promoting improved vegetable varieties should be up scaled but efforts should be made to make them gender inclusive since findings show that more males than females benefited from these approaches especially the training sites. Training events were surprisingly effective in promoting adoption of varieties and practices among participants. However, field observations indicated that the participants need to be followed up as many of them dropped out of vegetable production because on first trial, the vegetables did not do well. The project also resulted into increased farmer outreach and adoption of ISSD PLUS extension methodology among the trained vegetable brigadiers. However, many of them suggested that there is need for a support package to enable them have wider coverage and outreach given that their organizations cannot fully facilitate them.

1. Introduction

1.1 Background to the study

This study was commissioned by the Integrated Seed Sector Development (ISSD) Plus project in March 2020. The study was aimed at; (i) assessing and establishing the adoption levels of improved vegetable varieties and advanced vegetable production techniques which have been promoted by ISSD Plus and its partners under the ISSD Plus project vegetable component since 2017 and (ii) generate findings which will be key in informing the final ISSD Plus project evaluation. ISSD has been promoting vegetable, cereal and legume seeds and making them accessible to farmers in Uganda and through the four-year ISSD Plus Project, implemented by Wageningen UR Uganda (WUU) in collaboration with the National Agricultural Research Organisation (NARO). The project is coordinated by Wageningen Centre for Development Innovation (WCDI), Wageningen University & Research, and funded by the Embassy of the Kingdom of the Netherlands in Uganda. In line with increased awareness on vegetables as well as increased adoption.

The aim of the ISSD Plus project is to strengthen the development of a vibrant, pluralistic and market-oriented seed sector that is able to address key challenges that hamper seed sector development in Uganda. The ISSD Plus project has four components including the vegetable component which aims to contribute to increased earnings and competitiveness of the vegetable sector, which would eventually contribute to improved food and nutrition security. For the vegetable component of the project, the entry point was to address a number of challenges and constraints in the vegetable sector, ranging from limited access to and knowledge of improved varieties that are available in the market; lack of knowledge and skills in recommended agronomic practices for vegetable production; predominant use of low quality seedlings from field nurseries; high pest and disease pressure; poor water and fertilizer use; lack of market information; inconsistency in vegetable product quality and supply and non-conformity to phytosanitary requirements etc. Since 2017, the ISSD Plus project used five strategies to intervene in the vegetable sector including; the vegetable training of trainers (ToT) programme to offer quality extension services within the horticulture sector; partnering with six Dutch seed companies to set up farmer training sites; variety demonstration sites ; mass media campaigns through radio shows; and organising training events for vegetable farmers.

This report is the result of the study done on the vegetable interventions rolled out by the project in the last four years across Uganda. The report first presents a country overview of the economy in general as well as discusses the Ugandan vegetable sector dynamics before scope of the study, methodology, findings, conclusions, recommendations and lessons learned are presented.

1.2 Uganda's microeconomic situation

Uganda's real GDP in 2020 is projected to be between 0.4 and 1.7% compared to 5.6% in 2019 (Table 1). Exports, tourism, remittances, foreign direct investment and portfolio flows shrunk during the second half of FY2019/2020 due to international trade disruptions and restrictions of movements. This created significant fiscal and external imbalances, and a deceleration in growth in services, primarily in real estate activities and ICT. It is estimated the medium-term outlook is also not favorable as the decline in real GDP growth and the corresponding loss of jobs could be even be larger if the country faces a more widespread pandemic in addition to the effects of the locust invasions, further deterring a rapid economic recovery.

Table 1: Summary of Uganda's Economy

Indicator	2015	2016	2017	2018	2019	2020
Population (million)	35.5	36.6	37.7	38.8	39.8	46.2[1]
GDP per capita (USD)	829	835	837	867	912	823
GDP (USD bn)	29.4	30.5	31.5	33.7	36.3	33.93
Economic Growth (GDP, annual variation in %)	6.0	0.6	7.2	6.0	5.6	-4.3[2]
Fiscal Balance (% of GDP)	-3.9	-4.1	-3.2	-3.8	-6.7	-39.8[3]
Public Debt (% of GDP)	34.3	37.1	39.7	41.4	43.6	40.2[4]
Money (annual variation in %)	5.6	13.5	15.4	6.3	16.2	-
Inflation Rate (CPI, annual variation in %, eop)	8.4	5.7	3.3	2.2	3.6	3.9
Inflation Rate (CPI, annual variation in %)	5.4	5.5	5.6	2.6	2.9	2.3
Policy Interest Rate (%)	17.00	12.00	9.50	10.00	9.00	7.00
Exchange Rate (vs USD)	3,372	3,610	3,645	3,715	3,670	3,773
Exchange Rate (vs USD, aop)	3,240	3,418	3,612	3,728	3,704	3723
Current Account (% of GDP)	-6.2	-2.8	-4.5	-7.2	-9.5	-9.7
Current Account Balance (USD bn)	-1.7	-0.8	-1.5	-2.3	-2.3	-3.6
Trade Balance (USD billion)	-2.3	-1.6	-1.7	-2.5	-2.7	-2.4[5]
Exports (USD billion)	2.7	2.9	3.4	3.6	4.1	2.7
Imports (USD billion)	5.0	4.5	5.2	6.1	6.8	5.1
Exports (annual variation in %)	-2.1	9.5	18.1	5.6	11.9	-34%
Imports (annual variation in %)	-2.8	-8.8	14.3	18.1	11.7	-25%
International Reserves (USD)	2.8	3.0	3.7	3.2	3.2	
External Debt (% of GDP)	32.5	33.0	37.1	36.6	-	

Source: Bank of Uganda[6], 2019 & 2020[7]

[1] Uganda's population as at 23rd October, 2020. Accessed at: https://www.worldometers.info/world-population/uganda-population

[2] https://tradingeconomics.com/uganda/indicators

[3] MoFPED, 2020. https://www.finance.go.ug/sites/default/files/Publications/March_2020_Performance_of_Economy_Report.pdf

[4] Uganda: Key conditions and challenges. Accessed at: http://pubdocs.worldbank.org/en/953081492188175553/mpo-uga.pdf

[5] Figures in green are calculated for January 2020 to August 2020. Accessed at: https://tradingeconomics.com/uganda/exports

[6] BOU. https://bou.or.ug/bou/bouwebsite/Statistics/Statistics.html

7 BOU(2019/2020). https://www.bou.or.ug/bou/bouwebsite/bouwebsitecontent/publications/StateofEconomy/publications/StateOfEconomyReports/2019/Dec/SOE_December_2019_Board_Final.pdf

1.3 Overview of Uganda's agricultural sector

Uganda's economy is highly dependent on the agriculture sector that employs about 64 % of all the working population and 72 percent of all youths in the country and provides about half of all exports (45 percent of all exports) and about one-quarter of GDP (World Bank, 2018;MoFPED, 2020)[8]. The economy's growth has slowed down with real GDP for the FY 2019/2020 recorded as 3.1% down from 6.1%, for the FY 2018/2019 and 3.9% in the FY 2016/2017, 24% of which is contributed by agriculture (World Bank, 2018; UBOS, 2020). In addition, the gross valued added for Agriculture, Forestry and Fishing activities grew by 4.2% in 2019/2020 compared to the growth of 5.3% registered in 2018/19[9]. The agriculture sector has contributed between 24.7% and 22.2% of Gross Domestic Product (GDP) between 2011/12 and 2015/16. This is a crucial macro-economic indicator for the agricultural sector, given the fact that this growth has been driven by growth in exports more than half of which are agricultural goods, credit to the private sector (some of which is invested in agriculture and agribusiness), good weather and recovery in crop production. The Government has positioned agriculture as a key economic sector in Uganda's transition into a middle-income country. In this regard, it has emphasized the importance of value addition, commercialization, and building resilience to climate change (GoU, 2013; MAAIF, 2019). The broader agri-food system also has the potential to provide significant employment opportunities for the country's predominantly young population.

The agriculture sector is dominated by smallholder farmers, 39.3 percent of whom are subsistence farmers although the entire sector employed 64.6% of the Uganda working population by FY2016/2017 (UBOS, 2018)[10]. Women dominate farm employment in a sector that has limited mechanization and which is heavily dependent on rain and relatively fertile soils. The agricultural sector is also declining due to over cultivation and low fertilizer application (UBOS, 2018a). Overall per capita agriculture production has been declining due to a high population growth rate of 3.26 % (in as much as it dropped from an average 3.2% to 3.0% per annum) leading to annual food production deficits (UBOS, 2017). This scenario falls short of the minimum 6% annual agricultural sector growth target agreed upon under the Comprehensive Africa Agriculture Development Programme (CAADP) protocol.

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[8] MoFPED, 2020. Budget Speech FY 2020/21

9 UBOS (2020). The economic performance of Uganda's economy in FY 2019/20. Accessed at: https://www.ubos.org/wp-content/uploads/publications/06_2020The_economic_Performance_of_Uganda's_economy_in_FY_2019_20.pdf

10 UBOS(2018). Statistical Abstract. Accessed at: https://www.ubos.org/wp-content/uploads/publications/05_2019STATISTICAL_ABSTRACT_2018.pdf

It is also worth noting that Uganda's economy has experienced a slowdown in growth due to the severe impact of the COVID-19 (coronavirus) pandemic crisis, locust invasion and flooding caused by heavy rains. Uganda's real gross domestic product (GDP) in 2020 is projected to be between 0.4 and 1.7% compared to 5.6% in 2019 (World Bank, 2020)[11].This may have dire consequences on general employment and particularly youth employment that was already in a crisis.

In the past, Government had maintained a zero-rated tax on agricultural inputs such as certified seeds, and fertilizers. The goal was to promote the widespread adoption and use of yield enhancing inputs for increased agricultural productivity and food security. However, in the 2014/2015 financial, the Government removed the zero rating on supply of these agricultural inputs and introduced the standard taxable rate of 18 percent Value Added Tax. This action inevitably became a barrier to access the required inputs to boast production and productivity (NPA, 2015).

Despite having a rich base of land and water resources and a favourable climate in most areas, the sector is hampered by low productivity and persistent poverty (MAAIF, 2019). There are significant crop yield gaps between on-farm yields and those attainable under irrigation. The low crop yield has negative implications for food security of Ugandans, especially those who mainly depend on their own food production for subsistence. The low agricultural productivity is mainly due to low access to extension services and adoption of agricultural-enhancing technologies (such as fertilisers, improved seeds, and irrigation), and uncertainties around land tenure system. With respect to agricultural incomes, the mean annual agricultural income per household/farmer was estimated at Uganda shillings (UGX) 1,130,000 in 2015/16 and this is significantly far off the government's target of ensuring that agricultural households earn on average of UGX 20 million per annum (GoU, 2017). Whereas the crop diversity is high in Uganda, majority of households engaged in the agricultural sector grow a limited number of food crops for subsistence. Despite the existing resource endowments, these households are vulnerable to food insecurity and economic shocks (UNICEF, 2018a).

[11] https://www.worldbank.org/en/country/uganda/overview

1.4 Uganda's vegetable situation, production and trade overview

Vegetables are important for Uganda as they can help to address micronutrient deficiencies, especially vitamin A and iron deficiency. "Limited data available in Uganda shows that among children younger than 5 years, 53% suffer from anemia, 29% from stunting, and 11% from underweight. Among women of reproductive age, 32% have anemia and 9% suffer from underweight, while 24% are overweight or have obesity (UBOS/UNDHS, 2016). These data suggest a high risk for vitamin and mineral deficiencies among vulnerable populations in Uganda"[12]. In terms of production, shown in Table 2, available information by 2015 showed that the country registered a surplus in production of plantain, pulses, roots and tubers and sugar (NPA, 2015).

[12] https://www.cdc.gov/nutrition/micronutrient-malnutrition/projects/uganda.html

Table 2: Status of food supply in Uganda

Category	Description	DR[13]	AR[14]	TNR[15]	Aggregate Production by category (2014)	Difference	Status
Cereals and millets	Maize, Rice, Millet, Sorghum, Wheat, Barley	375	136.9	4,244,557	3,227,415	-1,017,142	Shortage
Plantain /Matooke	Starchy banana cooked and consumed as staple	375	136.9	4,244,557	4,578,000	333,443	Surplus
Pulses	Beans, Peas, French, Beans, Soya Beans, Simsim, Chickpeas, Groundnuts	75	27.4	848,911	1,436,615	587,704	Surplus
Milk and Milk Products	Whole Milk, Skim Milk, Yoghurt, Cheese, Ice cream	300	109.5	3,395,646	1,939,540	-1,456,106	Shortage
Roots and tubers	Sweet Potatoes, Cassava, Irish Potatoes, Yams	200	73.0	2,263,764	4,811,600	2,547,836	Surplus
Green leafy vegetables	Dodo, Cabbage, Nakati, Jjobyo, Sukumawiki, Spinach	100	36.5	1,131,882	Data not available	Data not available	Data not available
Other vegetables	Tomatoes, Onions, Garlic, Green Beans, Green Pepper, Beet Greens,	200	73.0	2,263,764	Data not available	Data not available	Data not available
Fruits	Guava, Bananas, Oranges, Pineapples, Apples, Pears, Grapes, Lemon, Water,	100	36.5	1,131,882	279,359	-852,523	Shortage

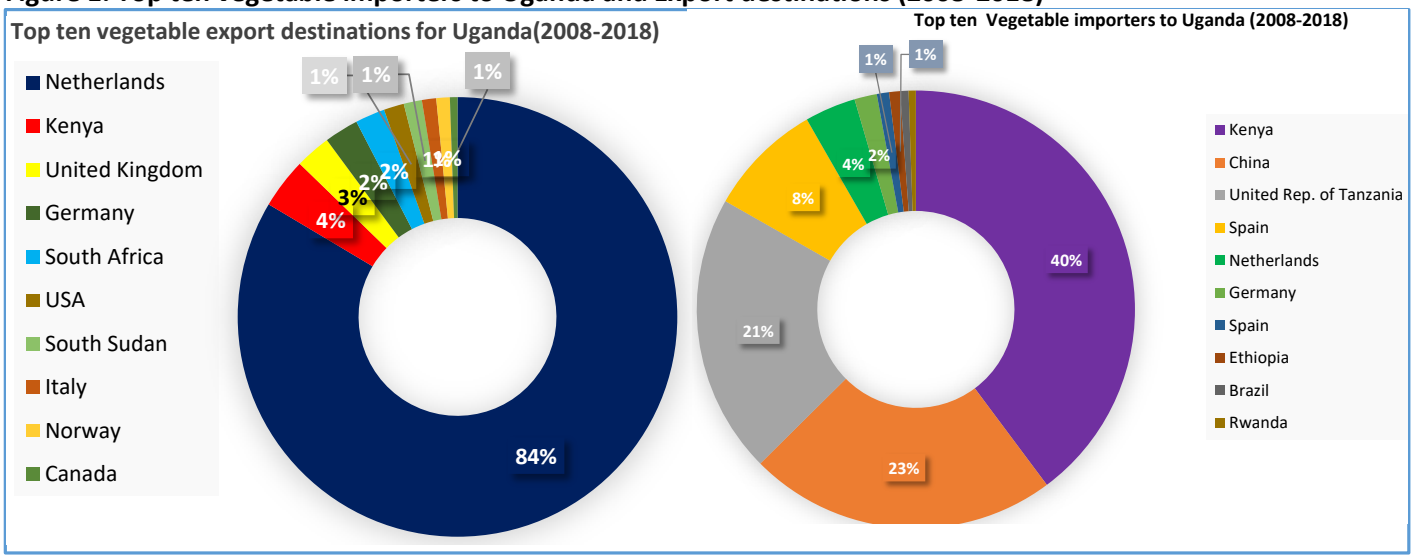
[13] DR = Daily Requirements per capita (in g)
[14] AR = Annual Requirement per capita (in kg)
[15] TNR = Total National Requirement (in tons)

Category	Description	DR[13]	AR[14]	TNR[15]	Aggregate Production by category (2014)	Difference	Status
	Melon, Mangos, Avocado, Papaya, Coconut, and Passion Fruits						
Sugar	Cane Sugar, Brown Sugar, Honey, Molasses	20	7.3	226,376	438,400	212,024	Surplus
Fat	Nuts, Fish, Eggs, Dark Chocolate, Cheese, Avocado	25	9.1	282,970	Data not available	Data not available	Data not available
Fish	All types	70	25.6	792,317	245,000	-547,317	Shortage
Meat	Beet, Goat meet, Mutton and Pork	70	25.6	792,317	247,813	-544,504	Shortage

Source: NPA (2015)

The Netherlands is a top destination for Uganda's vegetable exports accounting for over 80% of the value of vegetable exports for the top ten destinations in the last ten or so years. Kenya, United Kingdom, Germany and South Africa are the other four destinations (Figure 1). However, in terms of imports, Uganda gets much of its vegetable products from Kenya, China, Tanzania, Spain and the Netherlands (UN Comtrade, 2019). Between 2008 and 2018, Uganda exported vegetables worth US$ 492.9 million to the Netherlands (about 80% of all vegetable exports), US$21.9 million to Kenya and US$15.4 million to the UK (Table 3).

Figure 1: Top ten vegetable importers to Uganda and Export destinations (2008-2018)



Source: ***UN Comtrade data, 2019.***

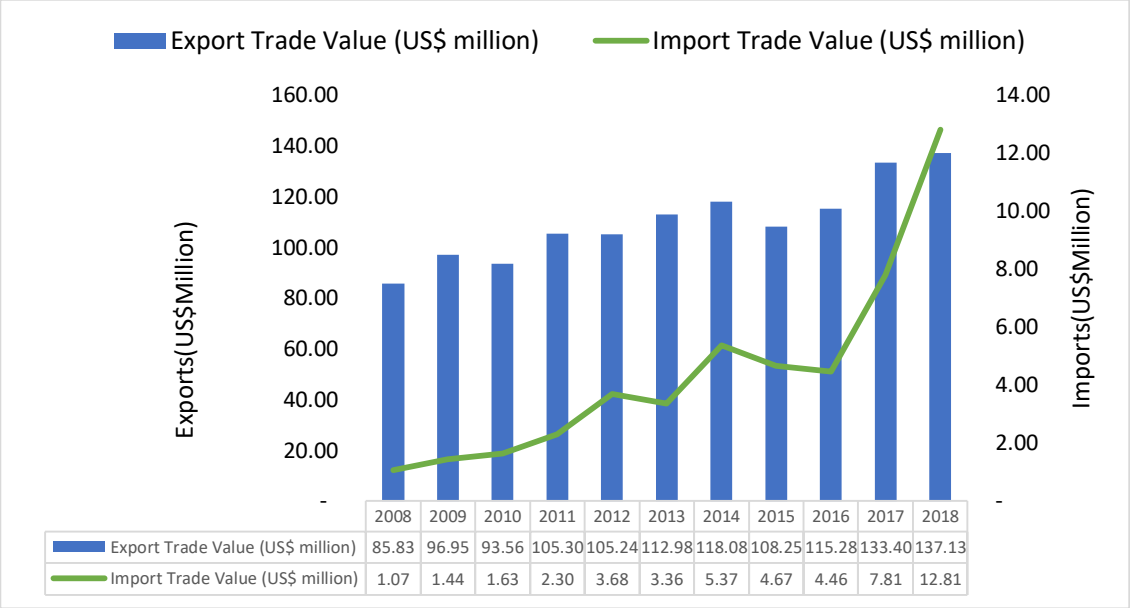
Table 3: Value of vegetable exports by top destinations to Uganda (2008-2018)

Export destination (country)	Value (US$, millions)
World	606.00
Netherlands	492.90
Kenya	21.87
United Kingdom	15.41
Germany	14.86
South Africa	12.89
USA	8.77
South Sudan	7.89
Italy	6.19
Norway	5.86
Canada	3.26

Source: UN Comtrade data, 2019. Note, Uganda exported to the UAE US$ 3.2million worth of vegetables in the same period

Uganda has been a net exporter of vegetables for the last ten years. The country's vegetable exports have grown from US$85.8 million in 2008 to US$137.1 million in 2018 while in the same span of time, the imports have equally been rising from US$1.1 million to US$12.8 million (Figure 2). The growing value of imports and exports is a sign that the country still has great potential an opportunity for domestic consumption as well as production and export of vegetables for job creation and foreign exchange earnings.

Figure 2: Value of Uganda's vegetable exports and imports (2008-2018)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Export Trade Value (US$ million)	85.83	96.95	93.56	105.30	105.24	112.98	118.08	108.25	115.28	133.40	137.13
Import Trade Value (US$ million)	1.07	1.44	1.63	2.30	3.68	3.36	5.37	4.67	4.46	7.81	12.81

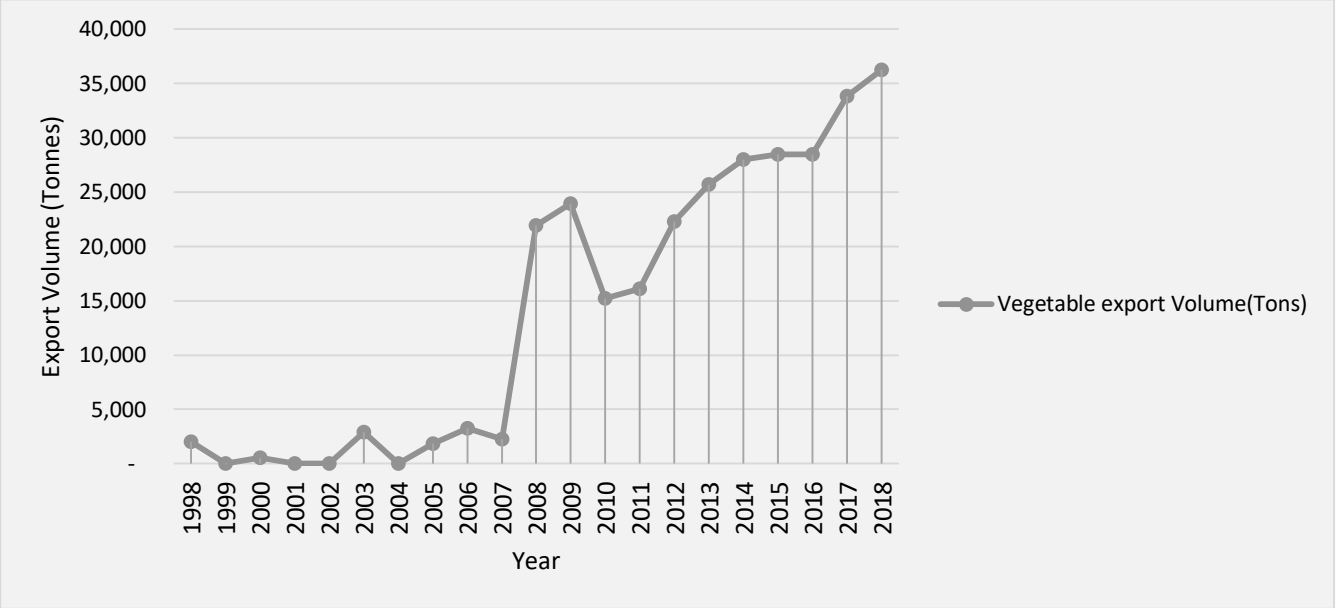
Source: UN Comtrade data, 2019.

There was an exponential growth in vegetable exports between 2007 and 2008[16] (Figure 3).[This is confirmed by an UNCTAD report of 2008[17] that Uganda was exporting US$11.5 million worth of vegetables by 2006, contributing about 2.3% of total agricultural exports. The report also noted that the major vegetable exports were beans, green chillies (cayenne), hot peppers (scotch bonnet), and other vegetables including okra.]. This growth in vegetable exports was followed with a steady growth in the export volumes from 2010 through 2018 (UEPB, 2019).

[16] This growth is partly attributed to the investment in Good Agricultural Practices promotion as a result of a USAID grant "Investment in Developing Export Agriculture (IDEA) project" that developed and promoted a National code of practice for the Fresh fruit vegetable and flower sector.

[17] UNCTAD (2008). Private-Sector Standards and National Schemes for Good Agricultural Practices: Implications for Exports of Fresh Fruit and Vegetables from sub-Saharan Africa Experiences of Ghana, Kenya, and Uganda. Accessed at: https://unctad.org/en/Docs/ditcted200713_en.pdf

Figure 3: Volume of Uganda's vegetable exports for the last 20-years (1998-2018)



Source: UEPB, Uganda Bureau of Statistics, URA, UCDA, CAA, UETCL data, 2019.

2 Methodology

2.1 Introduction

This adoption study was conducted between September 2020 and October 2020. The purpose of this study is to assess and establish the adoption levels of improved vegetable varieties and advanced vegetable production techniques which have been promoted by ISSD Plus and its partners. The study findings will inform the final evaluation of project in terms of impact among the targeted key stakeholders within the vegetable value chain.

The evaluation questions are described as follows in the ToR:

1. To what extent have trained vegetable growers (from company-led training sites and ISSD Plus training events) adopted the promoted technologies, including advanced agronomic practices and use of improved vegetable varieties, by: number of adopting farmers; promoted technology; crop; specific technique; and location, and what is the total area under adopted vegetable technologies?
2. To what extent have variety demonstrations sites been effective in promoting variety awareness and uptake, by number of farmers aware of new improved varieties and their providers, and farmers purchasing quality vegetable seed?
3. What is the relationship between spread/pattern of adoption farmers and the location of ISSD Plus' supported training and variety demonstration sites?
4. What are the reported/purported factors that enhanced or hindered adoption of advanced agronomic practices and quality seed of improved vegetable varieties?
5. What are the characteristics of adoption farmers (farmers that adopt most advanced agronomic practices and use quality seed of improved varieties)?
6. What are the costs and benefits of the advanced technologies versus previously used technologies for farmers involved in the ISSD Plus project?
7. What are examples of farmers with successful business cases?
8. To what extent have the Vegetable brigadiers contributed to the ISSDPlus vegetable extension program (farmer outreach)?
9. To what extent have the ISSD trained extension service providers adopted the ISSD Plus' and partners' extension methodology (use of practical training/ demonstration sites in their normal practices)? Any challenges in adopting the methodology?
10. What is the impact of radios shows on variety adoption?
11. What are the purported factors that positively or negatively influenced this adoption?

12. What lessons can be learned for future initiatives in the vegetable sector? What are the key stories of change for the vegetable component of the ISSD Plus project (at least 5): for selected adoption farmers and for selected extension service providers?

Given the number of questions to answer in this study, we used of a range of methods in collection of data and its subsequent analysis. This chapter, therefore delves into the methods used in data collection and analysis in relation to the various ISSD Plus project interventions implemented under the vegetable component. In addition to primary data, the study also involved review of secondary data from various sources to give context and perspective of the horticulture sub sector in Uganda.

In terms of scope, the study was national in nature targeting all vegetable farmers in the four regions for sampling, extension staff/Vegetable brigadiers (TOTs), seed companies and other stakeholders reached by ISSD Plus vegetable component since 2017. The sampling of the enumeration districts was done in such a way to ensure that all the four regions where the project was implemented are represented adequately.

2.2 Sampling design

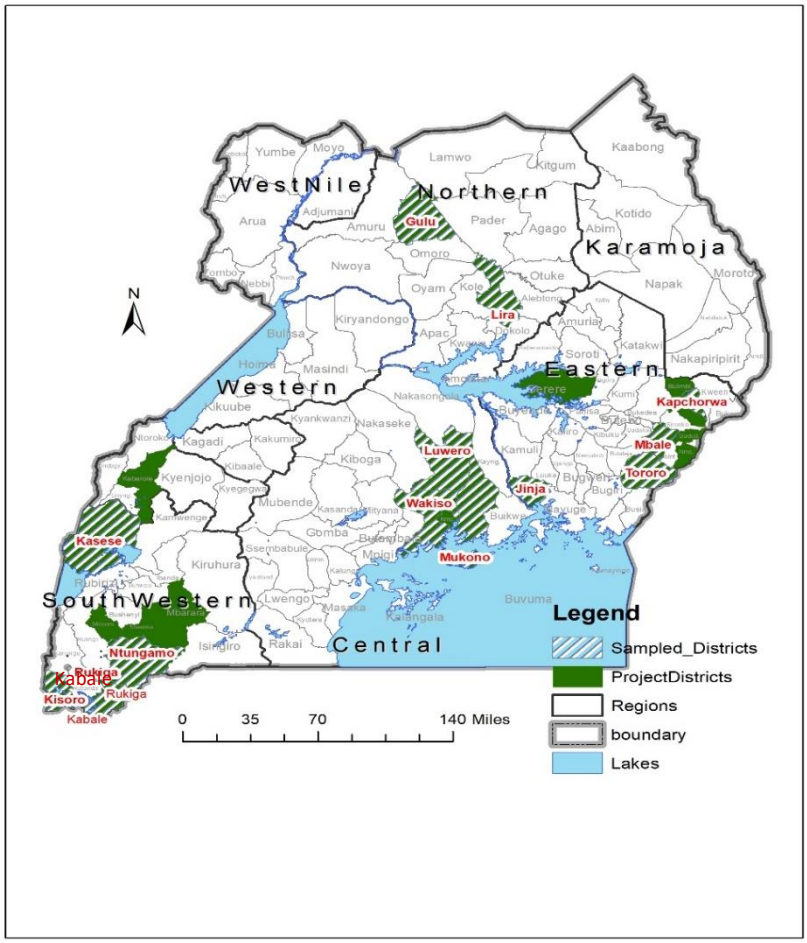
We used five levels of sampling based on five project interventions, i.e. training sites, demonstration sites, vegetable training of trainers (TOTs/vegetable brigadiers), and training events for vegetable farmers. Respondent selection was done by assigning them by proportionate distribution across regions/districts of project implementation. Radio talk shows (and DJ mentions and adverts) listeners were sampled by snowball method since they could only be accessed by referral from radio station and fellow listeners/farmers.

Table 4 shows how the total sample was distributed across the regions, districts, sub-county and parish/village by cluster of project interventions. The details of the sampling plan and distribution of the sample size within the selected 15 out of 24 project districts is given in Table 4 and mapped. The survey used a mixed methods design in which both quantitative and qualitative data were collected using surveys with beneficiary and spill over farmers and trained vegetable sector professionals (trained in ToTs). Qualitative data was collected using key informant interviews (with seed companies, agro-dealers, and vegetable vendors), Focus Group Discussions (FGDs) with farmers as well as case studies with farmers and seed companies.

Table 4: Sampling areas indicating the ISSD Plus vegetable component districts, interventions and selected districts for sampling

Region	North	East	West	Central
Districts covered by the vegetable component of ISSD Plus	– Lira – Gulu	– Mbale – Kapchorwa – Jinja – Bududda – Namisindwa – Tororo – Bulambuli – Serere – Luuka	– Mbarara – Mitoma – Sheema – Ntungamo – Kabaale – Kisoro – Rukiga – Kasesse – Kabalore	– Mukono – Wakiso – Kampala – Luwero
Purposively selected districts	– Lira – Gulu	– Mbale – Kapchorwa – Namisindwa – Tororo – Luuka	– Ntugamo – Rukiga – Kabale – Kisoro – Kasese	– Mukono – Wakiso – Luwero
Interventions rolled out	– Training sites – TOT – Radio shows	– Training sites – Demonstration sites – TOT – Radio shows	– Training sites – Demonstration sites – TOT – Radio shows – Training event	– Demonstration sites – TOT – Radio shows – Training event
Seed companies partnered with	– East West – Home harvest	– East West – Holland – Greentech – House of Seeds – Syngenta – Dutch Seed Centre (Cycas)	– East West – Holland – Greentech – House of Seeds – Syngenta – Dutch Seed Centre (Cycas)	– Holland – Greentech – House of Seeds – Syngenta – Dutch Seed Centre
Crops promoted in the region	– Tomato – Cabbage – Green pepper – Onions – Eggplant	– Tomato – Cabbage – Onions – Green pepper – Eggplant	– Tomato – Cabbage – Onions – Carrots – Green pepper – Eggplant	– Tomato – Cabbage – Onions – Green pepper – Eggplant

Figure 4: Map of Uganda showing the ISSD Plus Vegetable project and sampled districts



2.2.1 Sample size determination

ISSD Plus had indicated that the vegetable training of trainers (ToT) programme had benefitted 118 vegetable sector professionals through trainings; some 23,265 farmers were reached through seed company-led training sites; and some 17,218 farmers were reached through the variety demonstration sites established by seed companies. In addition, the number of listeners reached through the radio talk shows and adverts was estimated at over 5,000,000. The radio shows included live talk shows with partner seed companies and pre-recorded messages and spot adverts. Another 1,295 farmers had been reached through training events organized by ISSD Plus. These numbers formed the basis for sample size determination.

Therefore, the five categories of target respondents whose estimated populations are known from the above information were used in a formula by Cochran (1963:75), first assuming that the project participants were picked from populations that are large, in equation 1 to result into a representative

sample for proportions. We then used statistical tables to get the samples and then we adjusted these samples using the known populations as given by ISSD Plus following Yamane (1967)[18] in equation (2) and its adjustment as proposed by Glenn (1992) in equation (2).

Assuming a large population whose variability in proportion that will adopt the practices under project promotion is not known, we assumed p=0.5 (maximum variability) and q=1-p=(1-0.5)=0.5. Furthermore, we assumed a 95% confidence level and ±5% precision. The resulting sample size is demonstrated in Equation 1.

$$n_0 = \frac{Z^2 p(1-p)}{e^2} = \frac{1.96^2 * 0.5 * 0.5}{0.05^2} = 385 \quad (1)$$

We used this to calculate the final samples of each category of project participants using the finite population correction in Equation 2.

$$n = \frac{n_0}{1+\frac{n_0-1}{N}} \quad (2)$$

The population numbers for each project participant category was plugged into equation 2 and the samples are indicated in Table 5. However, since the N for the vegetable training of trainers (ToT) programme was less than 385, the sample was read off directly from the statistical tables[19]. Additionally, to cater for project spillover effects, we included a third category of respondents, the unintended beneficiaries mainly neighbors of the beneficiaries who were confirmed to have benefited from the interventions indirectly from the direct beneficiaries. We used 10% of the sample demo sites and training sites to get the spill overs (about 80 respondents).

[18] Yamane, T. (1967). *Statistics, An Introductory Analysis*, 2nd Ed., New York: Harper and Row.
[19] https://d3i71xaburhd42.cloudfront.net/ed039f87c11fc5b1e17dab7ab79c26b3cf1f9ebb/12-Table2-1.png

Table 5: Sampling frame and sample size by category of intervention

	Sample category by project intervention				
	A vegetable training of trainers (ToT) programme	**Seed company-led training sites**	**Seed company-led variety demonstrations**	**Training events which are organized by ISSD**	**Radio shows**
Category	Vegetable sector professionals reached through the ToT programme	Farmers reached through the training sites.	Farmers reached through the variety demonstration sites	Farmers reached through the ISSD training events	Listeners reached through the radio programmes
N	118	23,265	17,218	1,295	5,000,000
Selected Sample (n)	56	378	376	296	400
Actual sample (n)	52	221	539	116	397

2.2.2 Sampled respondents by location

The total number of sampled vegetable farmers was 1,367 of whom 748 were direct beneficiaries from training sites and demonstration sites, 116 were participants at training events while 54 were spillover farmers, 397 radio listeners and 52 vegetable brigadiers (Table 6). Training event and radio farmer numbers are lower than the planned numbers because the former were found to be “mobile farmers” who were ever on the move and not settled in the sampled districts, so the team resorted to phone interviews yet some of the phones could not be reached. In the case of the latter (Radio listeners), there was no database of farmers who listened into the talk shows either at seed company or radio station. So the research team resorted to referrals and snow balling to locate those who had listened to radio.

Table 6: Sampled farmers by region and category

	Frequency					
Region	**Direct beneficiaries (Training sites & Demos)**	**Training event**	**Spill overs**	**Radio**	**Extension workers(Brigadiers)**	**Overall**
Central	224	60	5	135		424
Northern	150	-	15	69		234
Eastern	216	2	24	88		330
Western	158	54	10	105		327
Total	748	116	54	397	52	1367

2.2.3 Vegetable brigadiers

The total number of 51 vegetable brigadiers, or vegetable sector professionals, sampled in the four regions was 43. Eastern region had the least number of vegetable brigadiers (8) while central and Western had the highest numbers (Table 7).

Table 7: Sampled vegetable brigadiers (extension/TOTs) by region

Region	Number of sampled vegetable brigadiers per region	Percentage of the total number of brigadiers per region
Central	19	38
Western	12	24
Eastern	8	16
Northern	12	22
Total	**51**	**100**

2.2.4 Sampling Plan

We sampled respondents from a total of 15 districts for the 5 project interventions. The sample was distributed proportionately across the districts. Sampling of training sites and demo participants was based on the one hand on lists provided by ISSD submitted by seed companies that indicated mainly the host farmers per districts. At the Host farmer level, individual farmers were randomly selected from a listing done with the host farmer subject to attending a field day on the demonstration/training site by the farmer. The TOT and training events participants' sampling was done randomly from lists provided by

ISSD of those who had attended the trainings and events though many of them were interviewed on phone[20].

2.1 Quantitative Data collection

Quantitative data were collected using two pre-tested survey questionnaires administered on vegetable farmers and sector professionals (Vegetable brigadiers). The vegetable farmer questionnaire was programmed and coded onto a cloud server using KoboCollect App and administered on a randomly sampled group of farmers. The digital questionnaire was administered by 4 regional teams of well-trained research assistants in face to face interviews. The tool for the sector professionals (Vegetable brigadiers) was paper-based and it was administered by research assistants in either face to face or phone interviews given that vegetable brigadiers are highly mobile people who could sometimes not be available for face to face interviews.

2.2 Qualitative Data collection procedures

2.2.1 Key informant interviews

The key stakeholders relevant to the implementation of the ISSD Plus vegetable interventions were interviewed to provide more insights and information. Interviews were held with key informants from ISSD Plus Implementation team; Radios that had participated in the project activities; seed company managers; agro-dealers and vegetable vendors. The purpose of the key informant interviews held with the ISSD Plus implementation team was to have a deeper understanding of the management, execution and activity implementation successes and challenges. The team conducted 35 key informant interviews overall using key informant interview guides.

2.2.2 Focus Group Discussions

Forty Focus Group Discussions (FGDs) (15 in Western, 10 in each of Central and Eastern regions and 5 in the Northern region) were carried out mainly with ISSD Plus vegetable intervention beneficiaries/farmers using an FGD checklist with relevant questions. This information was used for triangulation with data collected using other methods such as the survey. An average of 8 farmers who benefited from the ISSD promoted interventions participated in each of the discussion groups.

[20] Many of the TOTs and training event participants were no longer residing or working in their original districts, some had got other jobs while some had changed work stations, prompting the team to interview them via phones as one of the proposed methods of respondent capture and interviewing.

2.2.3 Case studies with farmers

A detailed data capture and documentation of progressive examples of farmers with successful business cases was also done. The consultant team used the Rapid Outcome Assessment (ROA) methodology to assess and map the contribution of a project's actions on a particular change in livelihoods of the case study farmers. The ROA's suitability was based on the fact that it draws significantly from Outcome Mapping as it focuses on key actors that the project is directly influencing and the progressive changes in those actors. The ROA methodology followed a three-stages approach starting with a preparation stage, during which a series of informal conversations were carried out to develop a draft picture of the project/business's history and the changes made in the life of the case study farmer, followed by a meeting/interview during which key change processes were identified and follow-up process where the researchers refined and verified with the told stories of change by consulting members of the groups or fellow farmers or an extension worker who closely worked with the case study farmer and understood their life's journey as far as the project is concerned.

2.2.4 Case studies with seed companies

A detailed capture of data was done of the experience of two seed companies in the marketing and promotion of the improved vegetable varieties and other technologies. The two seed companies were selected purposively in consultation with ISSD based on longevity in the business and coverage of operations. We investigated the relative contribution of the new improved vegetable varieties and technologies to the seed business of these companies in terms of seed sales, geographical outreach, supply networks in terms of source, and outlets through agro-dealers and also captured their perceptions with the project in terms of effectiveness, relevance, impact and sustainability. In addition, we also captured the contribution of the project to trade and hence foreign exchange earnings by documenting the seed road map of the six participating seed companies (the companies are; East West, Holland Green tech, House of Seeds, Syngenta, and Dutch Seed Centre (Cycas)) in terms of actual and potential vegetable seed / other input imports and vegetable exports.

2.3 Ethics and transparency

As part of ethical principles of research, the team in the field ensured that consent was sought after introducing themselves to the potential respondents. A consent statement was included in the Tablet form. In addition, for interviews done on phone, especially the TOT and training event interviews, the interviewers still sought consent of the respondent and respected their time schedules where a

respondent referred to a later appointment. Assurance of confidentiality of the data collected was also done prior to interviews or focus group discussions.

2.3.1 Tools Development, staffing and transparency

Tools for data collection to generate the required survey data for farmers as per the objectives specified in the Terms of References (TOR) was captured through a programmed tool using TAPI (Tablet Aided Personal Interviewing) approach. For the face to face TAPI farmer interviews, a programmed questionnaire was scripted and the scripts loaded onto the tablets. A team of 20 experienced Research Assistants were recruited and rigorously trained for two days and a day of pre-testing in Bwikwe district. Data were hosted online using Google's powerful hosting platform, Google AppEngine and was instantly relayed on the server after editing by research assistants.

An in-field quality control mechanism was set up to ensure robust and valid data was collected and analysed for reporting. The Research Assistants were monitored by the data Programmer via GPS coordinates configured on their Tablets. The four team Supervisors also monitored and oversaw Research Assistants in their respective regions to ensure that field data collection followed ethical standards and the data was of good quality. In addition, a team from the ISDD office worked closely with the field teams to ensure the right data was captured and they often gave feedback where needed. The overall responsibility of field data collection at all levels was however under the Lead consultant assisted by the two experts.

2.4 Data Processing and Analysis

2.4.1 Quantitative data analysis

Farmer survey data that was captured electronically using Tablets onto a cloud server by Research Assistants while in the field, was downloaded in excel and exported into SPSS 16.0 and STATA 15.0 for analysis. The other survey data from TOTs was captured on paper questionnaires, edited and entered directly into SPSS 16.0 and later analyzed using the same software and STATA 15.0. The data were analysed descriptively where means, frequencies, percentages and t-tests were generated to describe and analyze sampled farmers' and TOT's characteristics. In addition, the data were analysed econometrically using probit and regression models as well as propensity score matching to measure adoption and impact of the various interventions under study. Presentation of the results was done in tabular, graphical as well as narrative forms. All key estimates had levels of reliability, statistical test and confidence intervals run and stated. Estimates were also disaggregated for gender and location to see if there are any differences in these categorizations.

2.4.1.1 Analysis of the impact of radio shows on variety adoption

To answer the question of impact of radio shows on vegetable technology adoption (improved vegetable varieties and advanced low cost production techniques), we sought to understand how much of the adoption impact can be attributed to the radio shows and or the net effect of the radio shows on the project beneficiaries. An impact evaluation provides information about the impacts produced by an intervention - positive and negative, intended and unintended, direct and indirect. This means that an impact evaluation must establish what has been the cause of observed changes (in this case 'impacts') referred to as causal attribution (also referred to as causal inference) (Better Evaluation, 2020)[21].

Since the beneficiaries of the radio talk shows were not randomly assigned at the beginning of the intervention, a plausible approach was to use a quasi-experimental design which is an empirical interventional study used to estimate the causal impact of an intervention on target population without random assignment. To effectively measure impact however, there was need to use rigorous impact evaluation methods (Gertler et al., 2011) to measure attribution due to the intervention as recommended by the World Bank. A counterfactual was constructed for households with similar characteristics (e.g. age, sex, education level of household head). To do a rigorous impact evaluation we collected data from both those affected by the intervention (the treatment group) and a similar group who have not been treated (the comparison group) through randomization, matching areas on observables or propensity score matching (World Bank, 2007)[22]. The consultant applied a propensity score matching approach to measure attribution due to the intervention (Radio talks) (Mendola, 2007; Winters et al., 2010). In addition, we used the Doubly robust estimation that addresses the potential existence of selection bias to give robust results in the analysis of impact of radio messages on adoption. We estimated the causal effect of an exposure (radio messages and other interventions to an outcome (adoption). This analytical method builds on the propensity score approach and the inverse probability of weighting approach (Bang & Robins 2005; Robins et al. 2007; Mendola, 2006).

[21] https://www.betterevaluation.org/en/themes/impact_evaluation

[22] World Bank (2007). IMPACT EVALUATIONTHE EXPERIENCE OF THE INDEPENDENT EVALUATION GROUP OF THE WORLD BANK. http://www.oecd.org/dac/evaluation/dcdndep/37634791.pdf

2.4.1.2 Factors influencing adoption of improved vegetable varieties and agronomic practices by farmers

The Probit model was used to identify factors that influenced the adoption of technologies and methods by farmers. The Probit models was specified as:

Pr (Technology (Adopt=1, otherwise =0) = $\alpha+\beta_1$*Technology characteristics*$+ \beta_2$*Farmer characteristics*$+ \beta_3$Other characteristics$+ +\varepsilon_i$ (3)

Where Pr (Technology)= probability of adopting improved technologies (Technology =1 if a farmer adopts improved technologies and 0 otherwise.)

2.4.1.3 Factors purportedly influencing adoption of improved vegetable varieties and agronomic practices by extension service providers (vegetable brigadiers)

Similarly, the consultant used the binary probit model on the dataset of extension service providers ('Vegetable brigadiers'/TOTs) since a sizeable and statistically acceptable sample of 56 extension service providers was captured.

The Probit model was also used to identify factors that influence the adoption of **improved varieties and agronomic practices** by extension service. The Probit models was specified as:

Pr (Extension method adopted=1, Otherwise=o) = $\alpha+\beta_1$*Technology characteristics*$+ \beta_2$ *extension service providers characteristics*$+\beta_3$Other characteristics$+ +\varepsilon_i$ (4)

Where Pr (Technology)= probability of adopting an extension method technology (Extension method adopted =1 if a TOT adopts and 0 otherwise.)

In addition, the consultant contributed to the project existing Theory of Change (ToC) following project indicators in the Log frame to follow the planned activities and anticipated outcomes and impacts (See Annex 3 for the project indicators tracked).

2.4.1.4 Assessing spillover effects

Agricultural interventions such as those implemented under the ISSD Plus project vegetable component for four years (2017-2020) are likely to have spillover effects that in turn affect the reported impacts on adoption. Spillover issues in the study design were ensured to get reliable and robust findings (Winters et al., 2010). Spillover effects from project interventions among beneficiaries onto non-beneficiaries were captured through collecting data on a sample of neighbors of the beneficiaries especially those that seem

to have adopted the vegetable interventions. Identification and sampling of the spillover non-beneficiaries was done by eligibility criteria as suggested by (Angelucci and Di Maro (2010) through a snow ball sampling assisted by the beneficiaries to identify their peers.

2.4.2 Costs and benefits of advanced technologies versus originally used technologies

The study made use of the cost-benefit analysis approach to address costs and benefits of advanced technologies promoted by ISSD Plus in relation to originally used technologies. The idea behind the Cost-Benefit analysis (CBA) is to compare the economic performance of different alternatives (Bouyssou et al., 2000). Data were collected on the new and originally used (traditional) technologies to make comparisons.

Total Costs for each technology were calculated using the following formula (Lwasa & Mwanje, 2006);

$$C_i = F_i + V_i \quad (6)$$

Where F_i, are the fixed costs in period i which includes purchase of working tools, V_i, represents the variable costs in Uganda shillings in period *i*, say year1 or year2 which includes labour, materials, training, chemicals etc.

The benefits are represented by the positive gains from the technologies in terms of income. Costs and benefits were calculated over a one-year period depending on number of annual production cycles per farmer. The central bank discount rate of 14% was used to discount future costs and benefits to present values. The benefit-cost ratio (total Present Value (PV) benefits divided by total PV costs) were determined by comparing the costs incurred and the resultant benefits (revenues).

2.4.2.1 Net Benefits and BCR

Cost-Benefit analysis not only bases decisions on costs and benefits, it goes a bit farther to look at the value of net benefits after deducting costs from benefits. While benefits may be of different kinds and are put together—to the extent that they can be—through a selection of weights (or ranges of weights), costs are seen as forgone benefits, ultimately making benefits and costs to be defined in the same ‘‘space” (Sen, 2000).

We employed the formula in equation (2) to calculate the BCR;

$$BCR_i = \frac{[\sum B_i/(1+d)^i]}{[\sum C_i/(1+d)^i]} \quad (7)$$

Where:

B_i = the technology benefit in year *i*, where *i* = 0 to n years

C_i = the technology's costs in year *i*, where *i* = 0 to n years

i = the total number of years for the technology implementation's duration/ life span

d = the discount rate

The BCR is then interpreted as in Table 8.

Table 8: Interpretation of BCR results

BCR < 1.0	BCR = 1.0	BCR > 1.0
In economic terms, the costs exceed the benefits. Solely on this criterion, the technology should not proceed.	Costs equal the benefits, which means the technology should be allowed to proceed, but with little viability	The benefits exceed the costs, and the technology should be allowed to proceed.

Note: Sensitivity analysis was done on the outcomes of CBA

2.5 Qualitative data analysis

Analysis of qualitative data started immediately while in the field. The transcribed interviews were managed using Atlas Ti. Version 5.0. The coding was done using Atlas Ti environment. Open coding was used to code the data and analyse it using content analysis. Participants' responses were coded and typed in MS-word. Trend analysis of the KIIs and FGDs was useful in identifying the major issues for each assessment. Analysed quantitative and qualitative data were utilized in drafting this adoption study report.

3 Findings on adoption of technologies by farmers

This section presents the findings on farmers involved in ISSD Plus project. The findings are presented by intervention under the ISSD Plus vegetable component. It includes general findings as well as specific findings on adoption among farmers trained at demonstration and training sites and farmers trained in training events. It also describes awareness and adoption of farmers in the life time of the project as well as the impact of radio on the adoption of improved vegetable technologies (improved vegetable varieties as well as improved agronomic practices).

In all the four regions field days were organized on demonstration sites. Training sites were organized in the Northern, Eastern and Western regions, whilst the training events were organized only in Western and Central region[23]. This is also reflected in the responses, although the interviewed farmers seem not to distinguish between training events or training sites.

3.1 General information on demonstration and training sites farmers

3.1.1 Socio-economic and demographic characteristics of demonstration and training sites vegetable farmers

3.1.1.1 Occupation of household heads

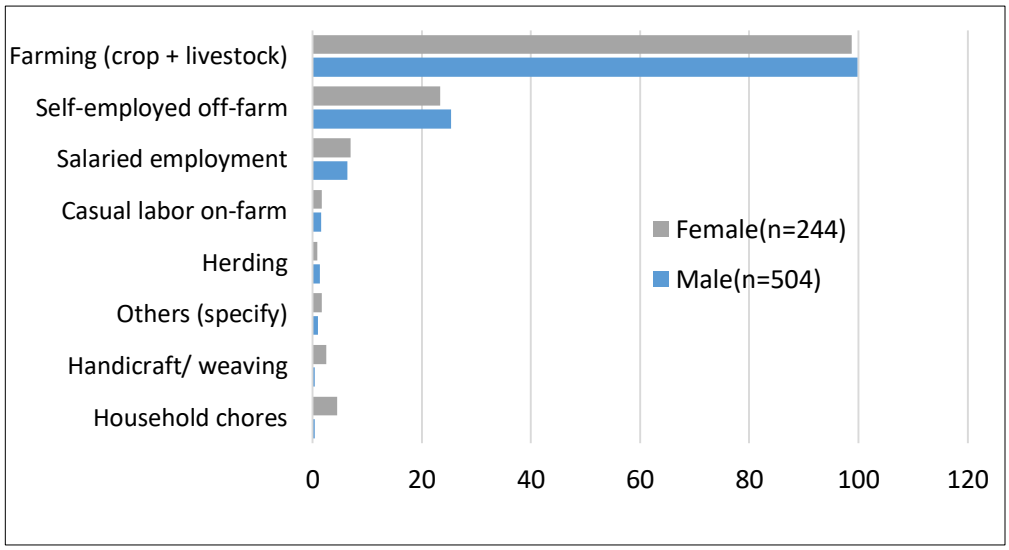
Majority of the household heads in the four regions are involved in crop and livestock farming (99 percent) while 25 percent are self-employed and only 7 percent of them have salaried employment. However, of the four regions, Northern Uganda has the lowest percentage (3 percent) of household heads who have salaried employment (Table 8). Although female and male farmers are equally highly employed in crop and livestock farming at levels of 99%, the male farmers have a narrow range of occupations in farming, off-farm self-employment and salaried work, the women have a wider range from farming, off-farm self-employment, salaried work, handcraft and household chores (Figure 5).

[23] Information from ISSD indicates that a total of 60 training sites were set up by Dutch seed center (Cycas) and House of seeds in Eastern and Western Uganda while 670 sites were set in the Northern region by East West

Table 8: Occupation of the household head by region

	Percentage of household heads				
Occupation	**Central (n= 224)**	**Northern (n= 150)**	**Eastern (n= 216)**	**Western (n= 158)**	**Overall (n= 748)**
Farming (crop + livestock)	99.11	100	99.07	100	99.47
Self-employed off-farm	36.61	10.67	25	20.89	24.73
Salaried employment	7.59	2.67	6.94	8.23	6.55
Household chores	0	1.33	2.78	3.16	1.74
Casual labor on-farm	1.34	0	1.85	3.16	1.6
Herding	0	1.33	2.78	0.63	1.2
Others (*Carpentry, garage, bar)*	1.79	1.33	0.93	0.63	1.2
Handicraft/ weaving	1.34	2	0.46	0.63	1.07

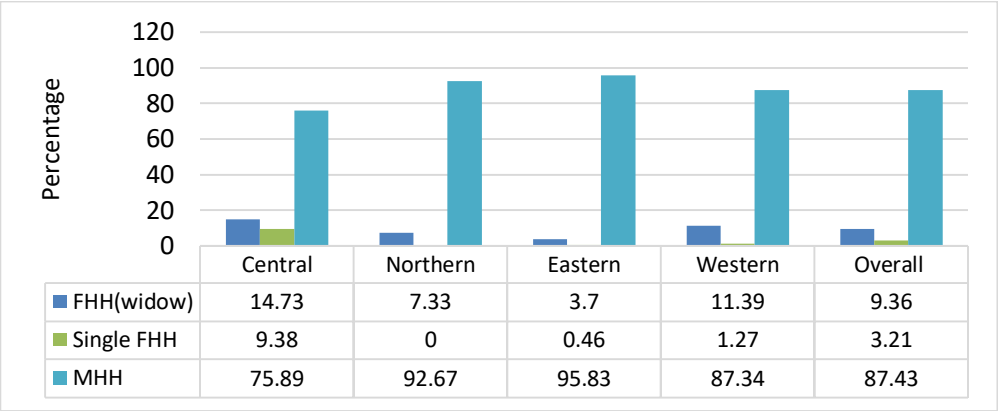
Figure 5: Occupation of the farmer by gender



3.1.1.2 Vegetable farming households

Majority of the vegetable growing households in the four regions are male headed. 87 percent of the sampled vegetable households in the four regions were male headed households, but the Eastern region had the highest percentage of male headed households (96 percent). The central region had the highest number of female widow headed households (15 percent) and single female headed households (9 percent) yet the Northern region didn't have a single female headed household (Figure 6).

Figure 6: Type of vegetable farming households by region



Of the sampled vegetable farmers in the four regions, 36 percent were youth farmers below 35 years and 64 percent were mature farmers above 35 years. However, the Northern region had the highest percentage of youths involved in vegetable growing (49 percent) and had the lowest percentage of mature farmers involved in vegetable growing (51 percent)(Table 9).

Table 9: Age group disaggregation by region

Region	Farmers by age disaggregation	
	Mature farmer(>35Yrs) (n=505)	Youth farmer(<=35yrs)(n=284)
Central	71.43	28.57
Northern	50.67	49.33
Eastern	63.43	36.57
Western	65.82	34.18
Overall	63.77	36.23

3.1.2 Vegetable production cycles

Majority of the vegetable farmers from the four regions have two vegetable production cycles in a year on average (Table 10).

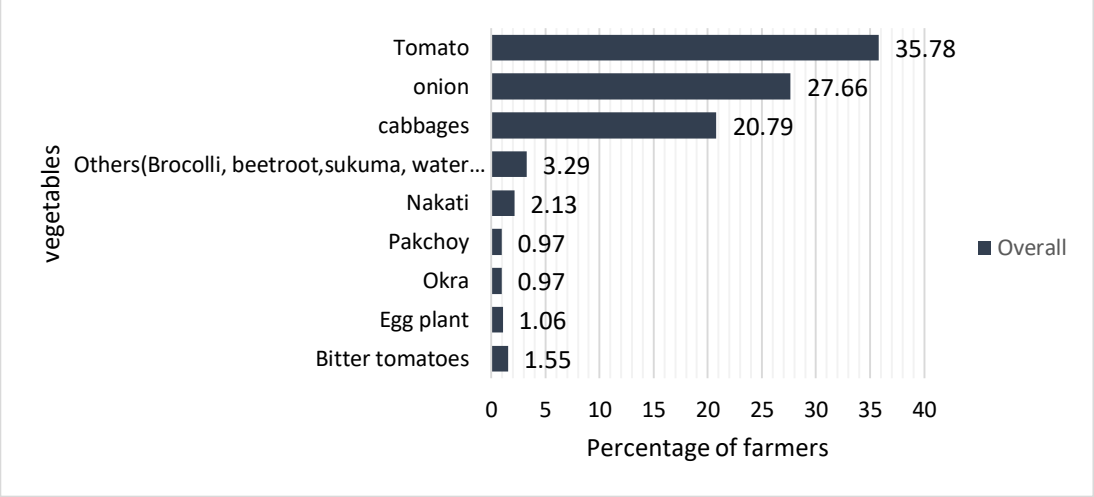
Table 10: Number of average annual vegetable production cycles by region

Region	Mean cycles
Central	1.88
Northern	1.86
Eastern	1.83
Western	2.08
Overall	1.90

3.1.3 Farmers' most important vegetable crop

Tomato is the most important vegetable crop grown by most farmers followed by onion and cabbages. 36 percent of the vegetable farmers grow tomatoes as their most important crop (Figure 7).

Figure 7: Farmers' most important vegetable crops



Note: See annex 1 for a detailed table with all vegetables

3.1.4 Levels of farmer vegetable production

Before delving into variety adoption, we present the change in percentage of farmers growing the project promoted vegetable crops. This feeds directly into variety adoption dynamics since some farmers might shift from growing certain vegetables to growing others they see others growing and profiting from.

3.1.4.1. Change in proportion of vegetable growers by region

Tomato, cabbage and onion were promoted by the project in all the four regions. Results show that these three vegetables registered an increase in the number of growers. Tomato has the highest change of producers among all crops in all regions. Among tomato growers, the Northern region had a positive change where the number of growers increased by 38 percent between 2017 and 2020 followed by 20 percent for the Eastern region while the Western region had the lowest increase of 4 percent. Cabbage registered the highest change in growers in Eastern and central Uganda and an overall 16 percent increase in farmers producing the vegetable. Onion on the other hand had an overall 9 percent increase in growers with a 24 percent and 7 percent increase in Eastern and Western regions respectively (Table 11). FGD

responses confirmed the fact that tomato, cabbage, onion and pepper are the dominant vegetables across the targeted regions.

Table 11: Regional Vegetable crop production levels (% change) among beneficiaries

	Percentage change in growers between 2017 and 2020				
Vegetable	**Central (n=258)**	**Northern (n=150)**	**Eastern (n=223)**	**Western (n=158)**	**overall % change**
Tomato	15.87	37.59	20.19	3.94	19.1
Cabbage	21.63	8.05	27.59	2.63	16.43
Carrot	-0.96	0	-0.49	1.32	-0.14
Onion	2.4	0.67	24.14	6.58	9.13
Sweet/green pepper	2.89	2.02	-0.49	1.31	1.4
Cucumber	1.93	0	-1.48	0	0.14
Bitter Tomato/ African Eggplant	11.235	1.98	4.365	0.985	5.2
Beet root	0	0	0	6.84	2.03
Sukuma Wiki	3.85	0	31.03	0	9.97
Cauliflower	0	0	0	7.49	2.22
Others(beet root, brocolli, water melon)	-37.9	-29.76	-49.92	-19.17	-34.19

3.1.4.2. Production of other promoted vegetables

Production of the other vegetables such as pumpkin and spinach among farmers generally was low. Only a few vegetable farmers in the Western region grew spinach with the number increasing from 2 to 3. Eastern region has the highest number of farmers who were growing Pakchoy (Chinese cabbage) although the number remained at 8 between 2017 and 2020 (Table 12).

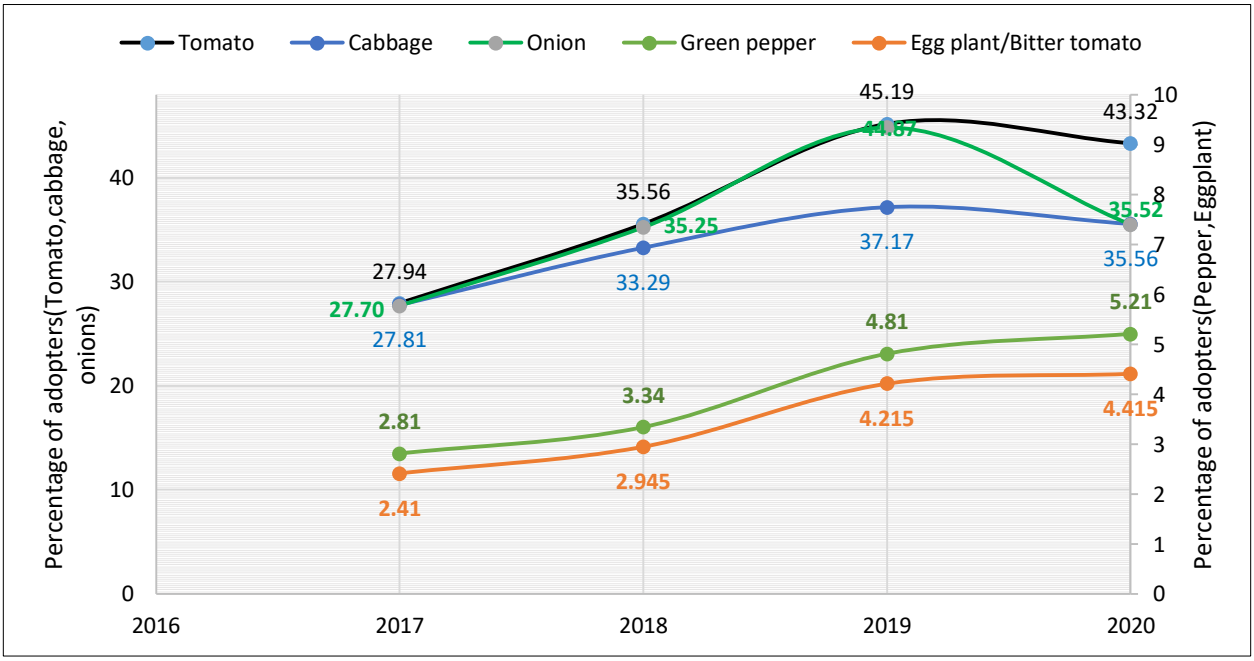
Table 12: Regional production of "minor" Vegetables

	Number of farmers growing the vegetables between 2017 and 2020					
Region	**Spinach**		**Pakchoy(Chinese cabbage)**		**Pumpkin**	
	2017	**2020**	**2017**	**2020**	**2017**	**2020**
Central	0	0	1	3	0	1
Northern	0	0	0	3	0	0
Eastern	0	0	8	8	1	1
Western	2	3	0	0	0	0
Overall	**2**	**3**	**9**	**14**	**1**	**2**

3.2.4.3. Growth in percentage of farmers growing the promoted vegetable crops using the improved varieties during the ISSD Plus project time

Among the vegetable crops promoted under the ISSD Plus project, tomato and onion had the highest positive growth in proportion of farmers growing them using the improved varieties (adopters) while eggplant and green pepper had the least increase in farmers growing the improved varieties over the project period (2017-2020). By 2020, at the time of data collection, about 5 percent) have taken up growing the eggplant and green pepper using the improved varieties promoted by ISSD Plus in partnership with Dutch seed companies compared to 43 percent for tomato and 36 per cent for cabbage and onion (Figure 8). Information from the seed companies and the vegetable team at ISSD indicated that some Dutch seed companies such as House of Seeds, East West and Dutch Seed Centre (Cycas) were already operating in Uganda before the ISSD Plus vegetable component started in 2017. However, by then their seeds were being imported by agro-dealers.

Figure 8: Percentage of farmers growing vegetable crops using improved varieties promoted by ISSD Plus between 2017 and 2020



3.2 Awareness and adoption of improved vegetable varieties under ISSD Plus project

3.2.1 Levels of Vegetable Variety awareness

Of all the crops promoted among farmers involved in demonstration and training sites, onions were the single most crop whose improved varieties were known to many farmers in the four regions. On the other hand, very few farmers were aware of the egg plant varieties promoted by the Dutch seed companies. For instance, 95 percent of the farmers were aware of at least one of the onion varieties promoted by the

Dutch companies. The other crops with a high proportion of farmer awareness for improved varieties promoted by the project were cabbages, sweet pepper and tomato. This makes sense as onion, tomato and cabbage varieties were promoted by the project in all the four regions. Only 6 percent of the vegetable farmers were aware of the eggplant varieties promoted, whilst in the Western and Eastern regions, vegetable farmers were not aware of the eggplant varieties that were promoted by the six Dutch companies, since this crop was not promoted in these regions. Majority of the vegetable famers that were sampled in all regions were aware of the onion varieties promoted by the Dutch companies (Table 13).For other crops promoted but not highly adopted yet, see annex 2.

Table 13: Regional awareness levels of main vegetable varieties by crop promoted under ISSD Plus vegetable component

	Percentage of farmers aware				
Vegetable whose varieties are known	**Central (n=258)**	**Northern (n=150)**	**Eastern (n=223)**	**Western (n=158)**	**Overall (n=789)**
Tomatoes	52.43	33.64	31.25	36.96	38.54
Cabbages	97.89	81.08	69.18	89.66	82.14
Sweet Pepper	66.67	85.71	54.55	75	67.39
Eggplant	4.17	33.33	0.00	0.00	5.56
Onion	100	100	93.10	97.53	95.41
Carrot	33.33	-	-	28	28.57
Other promoted crops[24]					

Source: ISSD Plus adoption study survey, 2020:

3.2.2 Adopted vegetable varieties by region

This section presents the varieties of the key vegetables that were promoted by ISSD Plus project in partnership with Dutch seed companies by region and farmer gender.

3.2.2.1 Tomato varieties adoption by region

Among the tomato varieties promoted, overall Gammar F1, Uwezo F1, Anjah F1 and Padma F1 were the most adopted by farmers. Across regions however, about 21 percent of the tomato farmers reached by the seed companies through demonstration gardens and training sites were growing Padma F1 with northern Uganda having 88 percent of the farmers growing Padma F1. In the central region, Gammar F1, Uwezo F1, Jarrah F1 and Padma were popular varieties adopted. The Western region equally adopted Padma F1, Jarrah F1, Gammar, Anjah F1 and Kuber F1 (Table 14). It should be noted here that some

[24] One farmer in central region was aware of MYDAS F1 cucumber variety, while only 3 farmers knew about the Okra varieties Pusa, safari and Tisa F1 in Northern Uganda. 2/8 of the Vegetable brigadiers working directly with seed companies indicated they promote pumpkins (Pujita F1 & Arjuna varieties), 4/8 indicated they promote water melon (Aromance & Sukali varieties).

varieties were either specifically promoted in certain regions or among a given producer segment. For instance, while Padma F1 was promoted in Northern Uganda, Jarrah F1 was promoted in Central and Western Uganda and Anjah F1 was promoted in the Eastern, Central and Western regions. Uwezo F1 on the other hand, was promoted only among greenhouse producers.

Table 14: Tomato varieties adopted among demonstration and training site farmers by region

	Percentage of adopters by region				
Adopted tomato variety	**Central (n= 95)**	**Northern (n=8)**	**Eastern (n=4)**	**Western (n=9)**	**Overall (n=116)**
Gammar F1	29.47	0.00	0.00	11.11	25.00
Padma F1	13.68	87.50	50.00	22.22	20.69
Uwezo F1	21.05	0.00	0.00	11.11	18.10
Jarrah F1	17.89	0.00	0.00	22.22	16.38
Anja F1	12.63	12.50	50	11.11	13.79
Kuber F1[25]	5.26	0.00	0.00	22.22	6.03
Total	100	100	100	100	100

NB: Padma was promoted only in North, Anjah in West

3.2.2.2 Cabbage varieties adoption by region

Among cabbage farmers, Gloria was the most highly adopted variety followed by Escazu F1 and Tacoma F1. Gloria F1 was popularly adopted across the regions followed by Escazu F1 in central and Eastern Uganda. In Northern Uganda however, the farmers equally adopted Gloria F1, Indica F1 and Bavero F1 (Table 15). Some of these cabbage varieties were either not promoted by ISSD Plus project or promoted in some regions. For instance, Tacoma F1 was promoted in Central and Western regions, BowieF1 was promoted in Western Uganda while Bavero F1, Fanaka F1 and Karibo F1 were never promoted by the project but they were being promoted by the seed companies.

[25] This was an East west seed company variety that was promoted long before the project. It was never promoted by the project

Table 15: Cabbage varieties adopted among demonstration and training site farmers by region

	Percentage of adopters by region				
Adopted cabbage varieties	**Central (n= 112)**	**Northern (n=5)**	**Eastern (n=20)**	**Western (n=101)**	**Overall (n=238)**
Gloria F1[26]	56.25	20	77.78	15.69	39.66
Tacoma F1	18.75	0	0	24.51	19.41
Escazu F1	8.93	0	16.67	11.76	10.55
BowieF1	6.25	20	0	15.69	10.13
Bavero F1	4.46	20	5.56	12.75	8.44
Indica F1	5.36	20	0	3.92	4.64
Karibo F1	0	0	0	7.84	3.38
Nuzaka F1	0	0	0	7.84	3.38
Fanaka F1	0	20	0	0	0.42
Total	100	100	100	100	100

NB: Escazu and Bowie were promoted only in West, Indica and Karibo in East, indica in North and Central Uganda

3.2.2.3 Onion variety adoption by region

Overall, Red coach, and Super Yale were the most adopted onion varieties. Given that the regions have different terrain, some of the varieties were specifically meant for highlands while others for lowlands. Therefore highland varieties were more in the Eastern and Western regions as shown in Table 16 and these included Red coach. Super Yale on the other hand, was promoted mainly in the North but also in the low lands of Fort portal district.

Table 16: Onion varieties adopted among demonstration and training site farmers by region

	Percentage of adopters by region			
Onion varieties adopted	**Northern (n=1)**	**Eastern (n=19)**	**Western (n=47)**	**Overall (n=67)**
Red coach	0.00	100	69.84	71.43
Red passion	0.00	0	7.94	6.49
Super Yale	100	0	22.22	22.08
Total	100	100	100	100

NB: Red coach was promoted only in East, central, and West, while Super Yale was promoted in North & East, Red passion was in West.

[26] This was an old variety of Syngenta Seed Company that has been on the market long before the project started. It was not promoted by ISSD Plus.

3.2.2.4 Gendered adoption of tomato, cabbage and onion varieties

There was a clear gender disaggregation in terms of adoption of tomato varieties. Male farmers mainly adopted Garma F1, Padma F1 and Anja F1 while females mainly adopted Uwezo F1, Garmar F1 and JarrahF1. Youth on the other hand adopted mainly Padma F1, and to some extent Anja and Gammar F1. The results show that women had adopted a wider range of varieties than men. Some of the reasons for adoption of the various varieties during FGDs that could explain these differences such as: "they yield highly, they fetch a higher price[27] and they don't need a lot of chemicals for spraying". The youth on the other hand adopted more of Gammar F1, Anja F1 and Padma F1 in that order (Table 17).

Table 17: Gendered adoption levels of main Dutch seed company tomato varieties

	Percentage of adopters by gender and youth		
Adopted tomato varieties	**Male (n=103)**	**Female (n=49)**	**Youth (n=49)**
Padma F1	52.94	8.33	71.43
Anja F1	11.76	0.00	14.29
Gammar F1	23.53	25.00	14.29
Jarrah F1	5.88	25.00	0.00
Kuber F1	0.00	8.33	0.00
Uwezo F1	5.88	33.33	0.00
Total	100	100	100
	Pearsonchi2(9) =11.83 Pr=0.04		Pearsonchi2(9) =7.94 Pr=0.16

Among the cabbage farmers, females mainly adopted Gloria F1,Tacoma F1 and Escazu while 44 percent of the men adopted Gloria F1 and the other 20 percent adopted Tacoma F1, 7 percent Indica F1 and 9 percent Escazu F1. The youth cabbage farmers widely adopted Gloria F1 (63 percent) and Tacoma F1 only (Table 18). During FGDs, farmers indicated that the reasons for adoption of these varieties of cabbage were that cabbage seed is available and that cabbages get ready at once and they sell them at once and the land is used for other purposes. Female farmers indicated that their main reasons for adoption of the vegetable varieties were because of a ready market. The youth and many other males and females indicated that they adopted the cabbage varieties because of poor performance of the previous varieties.

[27] Some farmers indicated that they are able to sell a basinful of tomato at UGX 8,000, which they considered higher than the prices for other varieties.

Table 18: Gendered adoption levels of main Dutch seed company cabbage varieties

	Percentage of adopters by gender and youth		
Adopted cabbage varieties	**Male (n=259)**	**Female (n=111)**	**Youth (n=129)**
Gloria F1	44.44	55.17	62.50
Tacoma F1	20.00	10.34	25.00
Bavero F1	4.44	6.90	6.25
Karibo F1	2.22	0.00	6.25
BowieF1	11.11	3.45	0.00
Escazu F1	8.89	20.69	0.00
Indica F1	6.67	3.45	0.00
Nuzaka F1	2.22	0.00	0.00
Total	100	100	100
	Pearson chi2(9) = 6.34, Pr = 0.50		Pearson chi2(9) 11.22, Pr = 0.129

Men adopted a wider range of onion varieties compared to women and youth. Well as females adopted only Red coach variety, men adopted all the other varieties three varieties promoted by Dutch seed companies. Youth adopted mainly Red coach and then Super Yale (Table 19). During FGDs with farmers they indicated that the reasons for adoption of the varieties were because they were resistant to prolonged dry spells while others are marketable. Youths said they got interested in improved Dutch onion varieties because they are high yielding since they plant a small size of land and get considerably good output and income.

Table 19: Gendered adoption levels of main Dutch seed company onion varieties

	Percentage of onion variety adopters by gender and youth		
Adopted onion varieties	**Male(n=152)**	**Female(n=81)**	**Youth(n=86)**
Red coach	45.45	100	71.43
Super Yali	27.27	0.00	28.57
Red passion	27.27	0.00	0.00
Total	100	100	100
	Pearson chi2(7) = 3.64, Pr = 0.16		Pearsonchi2(7) =3.39, Pr=0.18

3.2.2.5 Relationship between awareness and adoption

Exploring the relationship between adoption and awareness, results showed that except for pepper, there was a significant and strong relationship between awareness and adoption of a variety. The highest relationship was seen with cabbage, tomato and bitter tomato varieties and the lowest but significant was with onion varieties (Table 20)

Table 20: Correlation between awareness of vegetable varieties and adoption

Region	Spearman's correlation	p-value
Cabbage	0.95	0.000
Bitter tomato	0.70	0.000
Tomato	0.65	0.000
Onion	0.24	0.0004
Pepper	0.17	0.241

3.2.3 Acreage of all the plots cropped under vegetable production in main season of 2019

Vegetable farmers who adopted Dutch varieties were planting between about half to one and half acre of vegetable garden per growing cycle. The non-adopters cultivated bigger gardens of about two acres per cycle. Tomato, cabbage, and onion had the biggest areas allocated to them by vegetable growers per cycle by both adopters and non-adopters (Table 21). Overall, adopters are estimated to have 116,792 acres of vegetables under Dutch varieties in 2019 while the non-adopters had about 8 times as much area under vegetables as adopters.

Table 21: Land planted to Dutch improved and "Other" vegetable varieties (acres) in 2019 by crop

	Dutch improved varieties		Non-Dutch varieties	
Crops by Dutch seed varieties	**Area per cycle**	**Total area planted (acres) in 2019 (Adopters)**	**Area per cycle**	**Total area planted (acres) in 2019 (Non-adopters)**
Tomato	0.66	20,270	1.916	313,194.32
Cabbage	1.14	32,760	1.783	301,980.36
Onion	1.52	48,349	1.83	187,350.83
Carrot	1.25	9,630	2.309	47,549.14
Sweet Pepper	0.68	4,673	1.968	35,917.55
Bitter tomato/ Eggplant	0.44	1,110	2.106	7,442.69
Overall		**116,792**		**893,434.90**

Source: ISSD Plus adoption study survey, 2020

3.2.4 Level of input use in vegetable production

Majority of the sampled farmers use fertilizer, manure and pesticides. Although use of fertilizer and pesticides is spread almost equally across regions, manure application is more dominant in Central and Western Uganda (Table 22). These and other input related practices[28] that farmers were trained in and

[28] Input related practices meant that farmers were able to apply the right quantities of specific fertilizers at different crop stages to ensure that the required nutrients are applied as and when needed. In addition, as long as a farmer

which were adopted are shown in Table 22. Focus Group Discussions indicated that input related practices that farmers were trained in by the project and they were using them in vegetable production included; Proper use of fertilizers, Integrated pest management, Soil and water conservation and proper use of chemicals. Table 23 shows that farmers applied an average of 2,341 Kg of manure and 55Kg of inorganic fertilizer per acre per season.

Table 22: Farmers using inputs in vegetable production in 2018/2019

	Percentage of farmers				
	Central n=241	**Northern n=148**	**Eastern n=210**	**Western n=152**	**Overall** n=571
Improved vegetable seed(All crops)	74.27	97.97	97.62	69.08	84.42
Pesticides	80.91	64.86	81.43	71.05	75.90
Fertilizer	45.64	61.49	65.71	32.24	51.66
Fungicide	21.16	50.00	39.52	44.08	36.62
Manure	53.94	9.46	20.48	36.84	32.36
Plant booster	21.99	8.78	8.10	21.71	15.45
Local vegetable seed	18.26	2.03	2.38	30.92	13.18

Source: ISSD Plus adoption study survey, 2020

Table 23: Level of inputs use in vegetable production in 2018/2019

	Quantity of input per unit area (Kg/acre)							
Farmer region	**Local seed**		**Improved seed**		**Manure**		**Fertilizer**	
	Mean	**Std.Dev**	**Mean**	**Std.Dev**	**Mean**	**Std.Dev**	**Mean**	**Std.De**
Central	0.06	0.27	0.63	2.51	751.49	4,957.44	23.35	197.03
Northern	0.00001	0.00012	0.21	1.09	18.60	127.65	9.34	14.82
Eastern	0.01	0.07	0.60	0.83	2,227.92	31,025.22	140.31	797.76
Western	1.12	8.21	0.94	1.88	7,258.40	50,014.75	29.01	98.27
Overall	0.25	3.72	0.60	1.79	2,341.12	28,081.01	54.52	441.68

indicated sense of alternating fertilizers based on vegetable crop stage, they were considered an adopter. However, the common practice is to apply any fertilizer and many farmers applied UREA only.

3.3 Technology adoption among farmers that attended training events

This section presents the results of the interviews done with vegetable farmers from around the country who attended training events Organised by ISSD Plus. Although these farmers came to training events in certain regional venues, it was found that they do their vegetable production and business throughout the country.

3.3.1 Training event farmer characteristics

Of the sampled 108 vegetable farmers that attended Training Events (TE), 59 were mature farmers aged above 35 years and 49 farmers were youth farmers of 35 years and below. Out of 49 youth vegetable farmers, 71 percent were youth male farmers while 67 percent of the 59 mature farmers were male (Table 24).

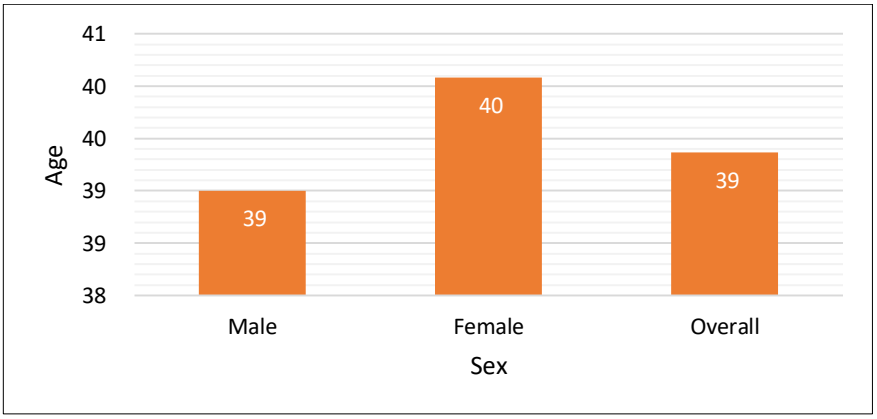
Table 24: Gender and age group of TE vegetable farmers

	Youth(<=35 years)		Old(>35 years)		Overall	
Farmer	Freq.	Percent	Freq.	Percent	Freq.	Percent
Male	35	71.43	37	62.71	72	66.67
Female	14	28.57	22	37.29	36	33.33
Total	49	100	59	100	108	100

Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

The average age of the farmers that attended training events was 39 years (Figure 9). However, female farmers were slightly older that the males.

Figure 9: Average age of TE farmers



Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.2 Occupation of TE farmers

Of the 108 vegetable farmers that attended training events and were sampled, 57 percent practice farming (Crop and Livestock) and only 0.1 percent are involved in handcraft /weaving and these are females only (3 percent). The percent of female and male farmers practicing farming (Crop &Livestock) was the same (57 percent) (Table 25).

Table 25: Main occupation of TE vegetable farmers by gender

Occupation	Male(n=72)	Female(n=36)	Overall(108)
Farming(Crop &Livestock)	57.14	57.14	57.14
Salaried Employment	15.71	20	17.14
Self-Employed Off-Farm	24.29	11.43	20
Handcraft /Weaving	0.00	2.86	0.95
Student	2.86	8.57	4.76
Total	**100**	**100**	**100**

Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.3 Membership of TE farmers to groups

The highest number of the vegetable farmers that attended training events had no group membership (63 percent). Of the 108 vegetable farmers that were sampled from attendance of training events, 70 percent were females (Table 26).

Table 26: TE vegetable farmers' level of group membership by gender

Are you a member of a farmer group/association? (%)	Male (n=72)	Female (n=36)	Overall (108)
No	59.72	69.44	62.96
Yes	40.28	30.56	37.04
Total	100	100	100

Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.4 How TE farmers accessed information about the events

Of the 108 farmers that were sampled from attendance of training events, 39 percent go the information about the events from fellow farmers (Table 27).

Table 27: TE vegetable farmers' source of information about training events

	Frequency	Percent
Source of information about TE		
Fellow Farmer	42	38.89
Extension Officer	19	17.59
Radio	18	16.67
ISSD	6	5.56
MMU Management	5	4.63
Neighbor	4	3.7
Lecturer	4	3.7
LCI Chairman	2	1.85
Counselor	2	1.85
Posters	2	1.85
NARO (Research Institute)	1	0.93
Seed Company	1	0.93
News Papers	1	0.93
District Production Officer	1	0.93
Total	108	100

Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.5 Land allocated to vegetables (acres)

On average, male farmers allocate significantly ($p< 0.05$) more land to vegetable production compared to female farmers. The males allocate about 1 acre to vegetables while the females allocate about half an acre of land to vegetables (Table 28).

Table 28: TE vegetable farmers' vegetable land sizes operated

	Mean	Std. Dev.
Sex of TE farmer		
Male	1.12	1.28
Female	0.57	0.44
Overall sample	**0.94**	**1.11**
P-value	Pr(|T| > |t|) = 0.0327	

Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.6 Use of inputs among TE farmers

Pesticides were the agricultural input most used by farmers that attended training events (82 percent), followed by manure (72 percent) and fertilizer (44 percent). However, results show that the percentage of male TE attendees using fertilizer in vegetable production is significantly ($p<0.10$) higher that the percentage of females. Quite a number of TE farmers use irrigation technology in the vegetable production with about 60 percent of the sampled farmers found to use the technology (Table 29). Findings also show that a significant difference exists between male and female farmers who do intercropping of vegetables with other crops. Off all female farmers, 19 percent intercrop while only 8 percent do intercropping. The main crops intercropped with vegetables were leafy amaranth, cassava, bananas. This scenario might be driven by women's lack of access to bigger parcels of land.

Table 29: Improved input use among TE vegetable farmers

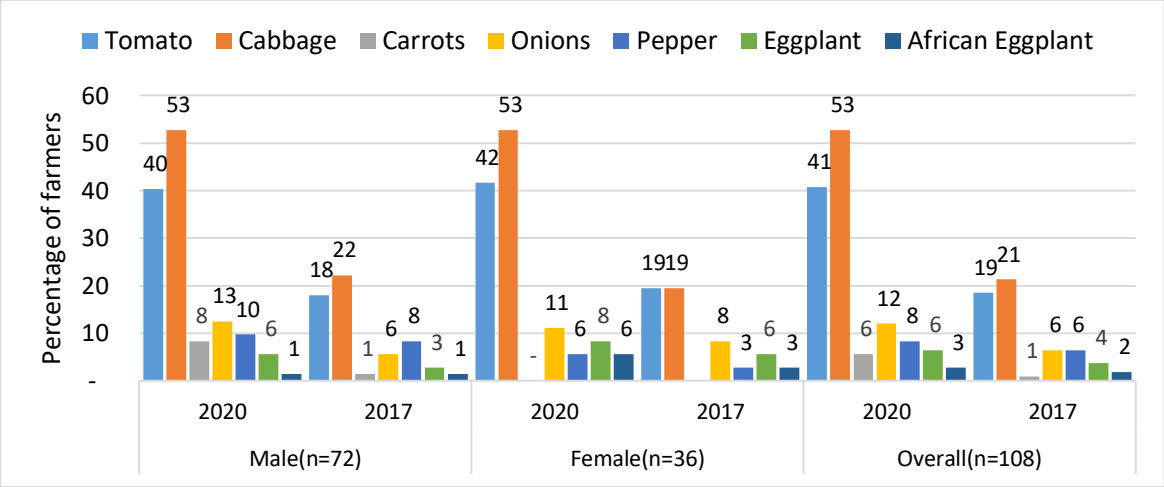
Percent				
Input used	**Male**	**Female**	**Overall**	**Chi2 & p-value**
Fertilizer	50.00	33.33	44.44	chi2(1) = 2.700 Pr = 0.100
Manure	73.61	69.44	72.22	chi2(1) =0.208 Pr=0.649
Pesticides	83.33	80.56	82.41	chi2(1) = 0.128 Pr = 0.721
Irrigation	59.72	58.33	59.26	chi2(1) = 0.0192 Pr = 0.890
Intercrop vegetables	8.33	19.44	12.04	chi2(1) = 2.7984 Pr = 0.094

Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.7 Vegetable crops grown before and after training events

Of the 108 farmers that were sampled from attendance of training events, 53 percent grew cabbages in 2020, and only 6 percent grew carrots in 2020. There was a higher level of adoption since 2017 where 21 percent farmers grew cabbages and only 1 percent grew carrots. The percentage of male and female vegetable farmers that grew cabbage in 2020 was the same (53 percent) (Figure 10).

Figure 10: Vegetable crops grown by TE farmers before and after attending the event

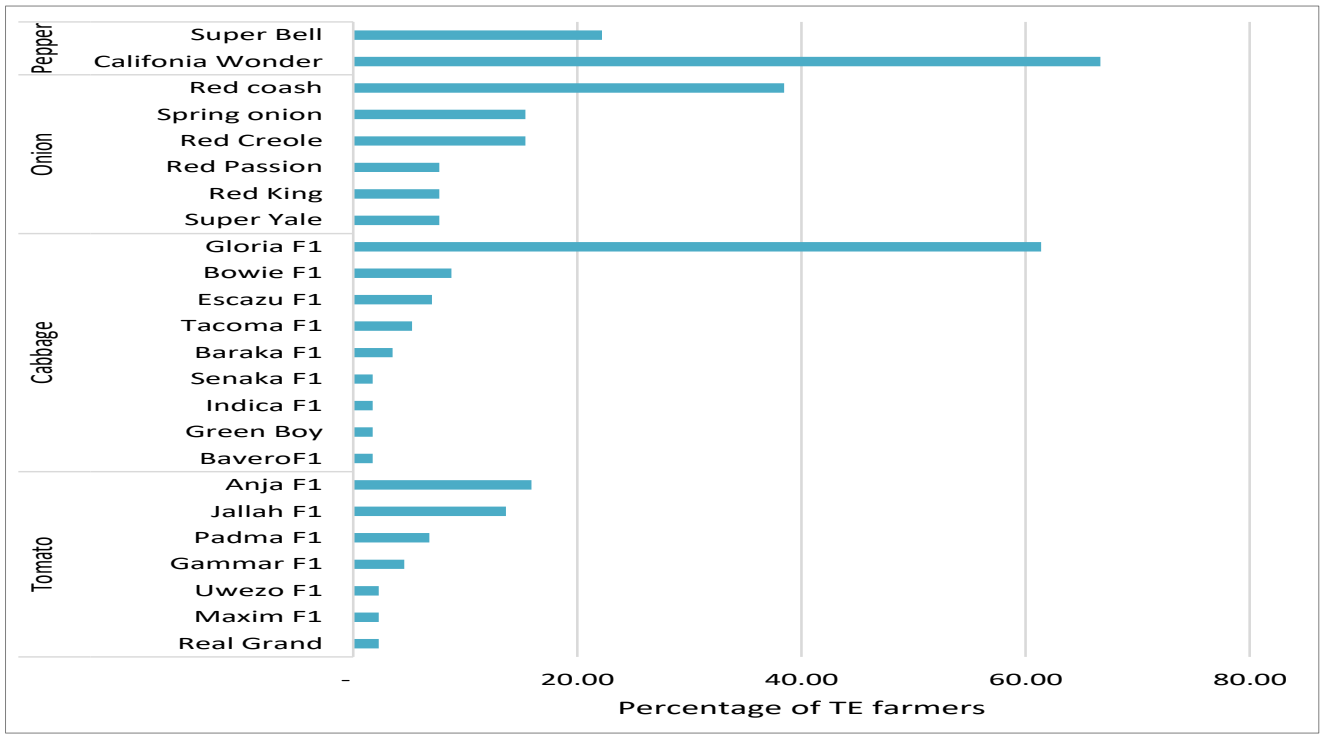


Source: ISSD Plus-vegetable component farmer adoption survey data, 2020

3.3.8 Vegetable crop variety adoption among TE participants

There seemed to be clear leaning of adopters towards certain varieties of particular vegetables. For instance, among tomato growers, Anja F1, Jarrah F1 and Padma F1 were adopted by TE farmers. For the cabbage growers, many of them went for Gloria F1, Bowie F1 and Escazu F1 while among onion farmers, Red coach was popularly adopted (Figure).

Figure 11: Vegetable crop variety adoption among TE farmers (percent)



Note: A few other farmers grew other improved varieties for crops such as Sukuma wiki(4),African eggplant(2),eggplant(7) and cucumber(2).

3.3.9 Overall adoption of improved varieties and agronomic practices by training event farmers

More female than males adopted the varieties promoted by the Dutch seed companies. Among the advanced practices, trellising and nursery management were the most adopted among TE farmers (Table 30). Preference of vegetable variety traits among TE farmers mainly leaned towards pest and disease resistance, level of yields attained and germination capacity. Among tomato varieties, Gammar F1 commanded preference for the mentioned three traits. However, Jarrah F1 and Anja F1 had a more balanced distribution of range of traits preferred. Among cabbage farmers, Indica F1, Baraka F1, Escazu F1 and Bowie F1 were liked by farmers for yielding high, germinating well and resistance to pests and diseases. On the other hand, among onion farmers, Super Yali and Red Coach were also preferred (Table 31).

Table 30: Vegetable variety and agronomic practice adoption among training event farmers

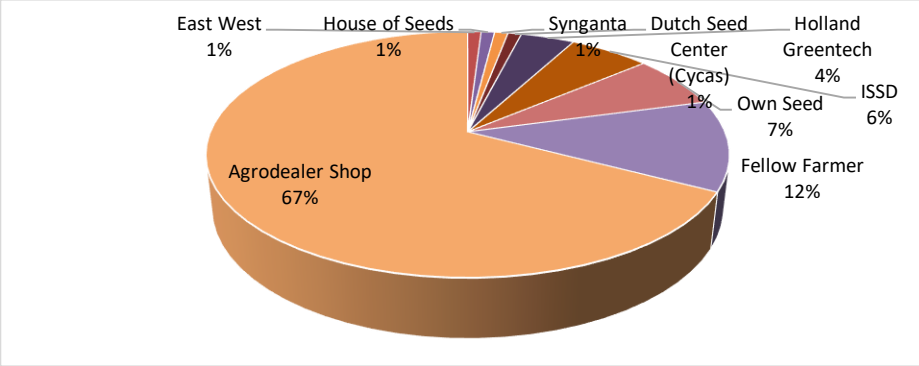
Percent				
	Male	**Female**	**Overall**	**Chi2/p-value**
Varieties	54.17	77.78	62.04	Pearson chi2(1) = 5.681 Pr = 0.017
Agronomic practices				
Nursery management	23.61	36.11	27.78	Pearson chi2(1) = 1.869 Pr = 0.172
Crop fertilisation	16.67	16.67	16.67	Pearson chi2(1) = 0.000 Pr = 1.000
Soil and water conservation	27.78	19.44	25	Pearson chi2(1) = 0.889 Pr = 0.346
Trellising	48.61	41.67	46.3	Pearson chi2(1) = 0.465 Pr = 0.495

Table 31: Vegetable variety preferences for Dutch seed company varieties among TE farmers

Farmer preference of vegetable variety traits(percent)					
	Resistant to pests & diseases	**High yielding**	**High germination %**	**Size of seedling**	**Long shelf life of product(less perishable)**
Tomato					
Uwezo F1	0	100	0	100	100
Gammar F1	100	50	50	50	0
Padma F1	33.33	100	33.33	0	33.33
Jallah F1	66.67	100	66.67	16.67	16.67
Anja F1	57.14	71.43	14.29	42.86	14.29
Cabbage					
BaveroF1	100	0	0	0	0
Indica F1	100	100	0	0	100
Tacoma F1	33.33	100	0	33.33	0
Escazu F1	66.67	66.7	66.67	0	33.33
Bowie F1	100	100	40	20	20
Gloria F1	66.67	75.76	18.18	24.24	24.24
Onion					
Super Yale	100	100	0	0	100
Red King	0	100	0	0	0
Red coach	80	100	40	0	40

Training event farmers mainly source their vegetable seed from agro dealers (67 percent), fellow farmers (12 percent), own saved seed (7 percent), ISSD events (6 percent) and Holland Green Tech Company (4 percent). Although other Dutch seed companies are mentioned by a few farmer, their share of seed purchases by TE farmers is only a combined 8% (Figure 12).

Figure 12: Main sources of improved vegetable variety seed for TE farmers



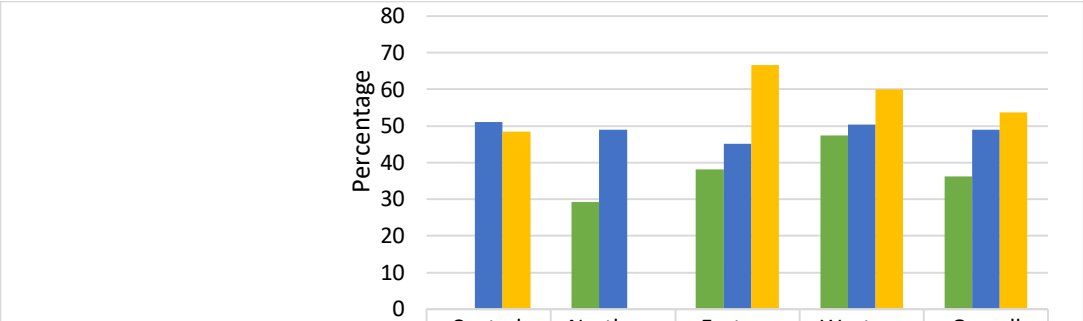
3.4 Impact of radio on vegetable adoption of improved vegetable varieties and agronomic practices

Radio was used as one of the ISSD Plus interventions in promoting improved vegetable varieties and advanced agronomic practices among farmers across Uganda. The radios, many of them located in the ISSD Plus project regions of implementation, relayed information in form of radio talk shows and call in programmes on which extension workers and other vegetable sector professionals and stakeholders were hosted, DJ mentions, that happened in between programmes and radio adverts for trainings, events and availability and location of improved vegetable seed varieties. In this section, using econometric models and descriptives, we explore the impact of radio as a medium in advancing technology adoption among vegetable farmers.

3.4.1 Radio listening farmer characteristics by intervention

Overall, training events had the highest proportion of farmers that listened to radio shows sponsored by ISSD Plus on vegetable production (54 percent) followed by filed days on demonstration sites (49 percent). Farmers in Eastern and Western regions benefited from all the three interventions and generally the latter has the higher percentage of farmers attending demonstration field days and training sites while the former(Eastern) has the higher percentage of radio listeners(Figure 13).

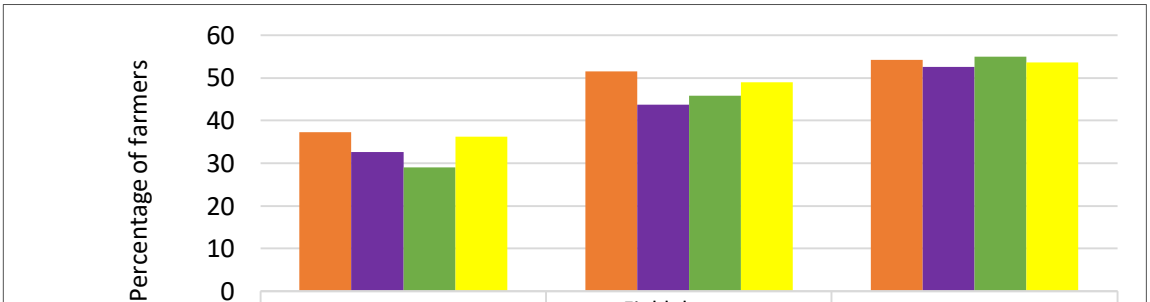
Figure 13: Percentage of farmers listening to radio shows by intervention



	Central	Northern	Eastern	Western	Overall
Training site		29.21	38.2	47.5	36.24
Field days on Demonstration sites	51.08	48.98	45.11	50.37	48.91
Training Event	48.39		66.67	60	53.64

Majority of the male, female and youth farmers listening to radio were those involved in the field days on demonstration sites and those attending training events. More males than females benefiting from training sites were listening to radio. Results indicated that only 29 percent of the youth learning from training sites were listening to radio shows compared to 55 percent of the same category of farmers attending training events (Figure 14). Analysis of Focus Group discussions data revealed radio facilitated access to variety and seed source information, market information also created awareness about the advanced agronomic practices (Figure 14).

Figure 14: Percentage of farmers by gender listening to radio shows by intervention



	Training site	Field days on Demonstration sites	Training Event
Male	37.28	51.48	54.17
Female	32.65	43.71	52.63
Youth(<=35 years)	29.07	45.88	54.9
Overall	36.24	48.91	53.64

3.4.2 Radio listening among Training Event farmers

Results indicated that about 55% of TE farmers actually listened to radio shows airing vegetable farming and advanced agronomic practices messages. Of these, about 56 percent were female farmers. We found no difference about listening to vegetable radio shows among females and males even though a higher percentage of the former gender listened compared to the males (Figure 15).Figure 16 shows that over 25% of the TE farmers adopted soil and water conservation practices, nursery management and fertilizer application via radio.

Figure 15: Percentage of TE farmers that have listened to vegetable radio shows promoted by ISSD

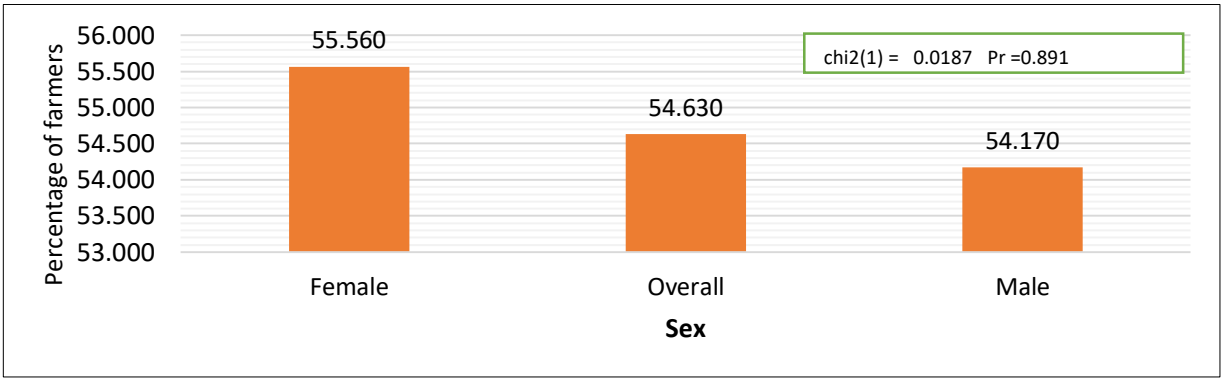
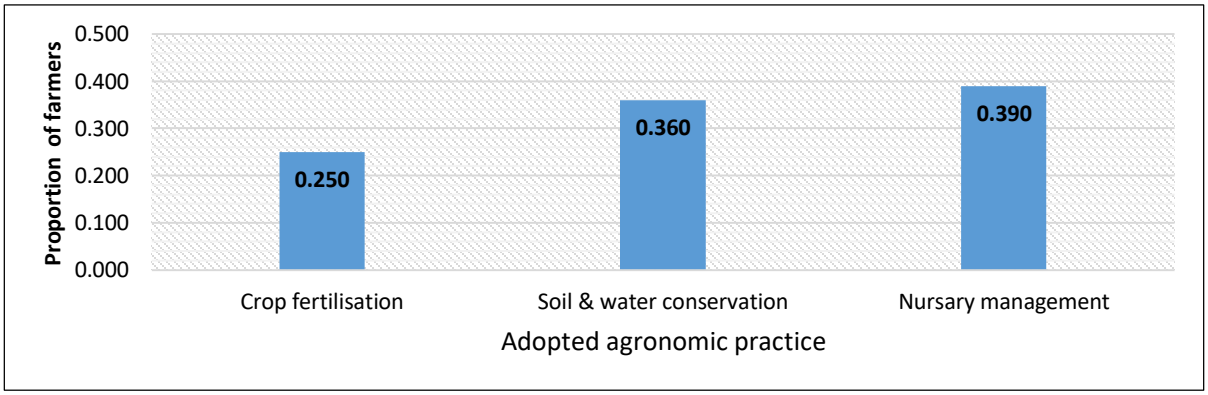


Figure 16: Proportion of TE farmers by agronomic practices adopted on radio



3.4.3 Impact of radio

In terms of impact of the radio shows and messages on improved vegetable variety and advanced agronomic technology adoption by farmers who benefited from demonstration and training sites, the doubly robust model results indicated that radio shows had a positive impact on adoption. If a farmer listened to a radio show, the odds of adopting an improved Dutch vegetable variety was 44 percent higher compared to one who did not listen in. In addition, the odds of adopting an advanced agronomic practice

increased by about 50 percent if a farmer listened to radio. However, the adoption of both a variety and technology, though positive, was not significantly (p=0.131) impacted by radio (Table 32).

Analyzing radio show impacts on the specific vegetables promoted indicated that the shows had more significant impacts on adoption of onion and cabbage varieties as compared to other vegetable crops such as tomato. The odds of adopting an onion variety increased by 58 percent while for cabbage, the increase was 71 percent. For tomato however, the odds reduced by 64 percent which could be explained by the more practical nature of trainings needed in tomato production, from nursery to trellising which cannot be effectively delivered in audio messages on radio. The other reason given by farmers in FGDs was that after listening to radio, they got to be aware of new and better performing varieties, hence they adopted the new varieties because of poor performance of the previous varieties. This would explain why the odds would reduce for a tomato variety. However, the results also indicated farmers dropping certain crops and growing others, this is also another cause for dropping a variety when for instance a tomato farmer switches to growing cabbage.

Table 32: Impact of radio messages on both variety and advanced agronomic practices promoted by ISSD Plus vegetable component among demonstration and training site farmers

Radio Listener(1=Yes, 0=No)	Odds ratio exp(b)	Std. Err.	z	P>z
Improved variety adoption	1.444	0.226	2.350	0.019
Advanced agronomic practice adoption	1.497	0.248	2.430	0.015
Variety + Advanced practice adoption	1.332	0.253	1.510	0.131
Onion variety adoption	1.578	0.326	2.210	0.027
Tomato variety adoption	0.642	0.163	-1.750	0.080
Cabbage variety adoption	1.714	0.272	3.390	0.001
Eggplant variety adoption	1.602	1.534	0.490	0.623
Pepper variety adoption	0.470	0.256	-1.380	0.167

For the training event participants, radio had more impacts on adoption of advanced agronomic practices, a combination of variety and agronomic practices as well as onion varieties. The chances of a training event farmer adopting an onion variety promoted by a Dutch seed company increased significantly by 79% percent if they listened to radio (Table 33). FGD participants indicated that the main information got while listening and learning on radio was information about available vegetable varieties, location of input sellers, and market linkages. They indicated that the advantage of radio as a learning media for farmers is that it reaches many people, repetitive programs and messages help slow learners and clear location of input sellers helps to avoid fake inputs.

Table 33: Impact of radio messages on both variety and advanced agronomic practices promoted by ISSD Plus vegetable component among Training Event (TE) farmers

Radio Listener(1=Yes, 0=No)	Odds ratio exp(b)	Std. Err.	z	P>z
Improved variety adoption	0.939	0.447	-0.130	0.895
Advanced agronomic practice adoption	16.811	11.159	4.250	0.000
Variety + Advanced practice adoption	4.450	3.265	2.030	0.042
Onion variety adoption	17.966	15.736	3.300	0.001
Tomato variety adoption	2.089	1.180	1.300	0.192
Cabbage variety adoption	0.794	0.327	-0.560	0.574

3.4.4 Correlation of radio and variety and technology adoption among TE farmers

Radio shows were highly and significantly associated with nursery practice adoption, fertilizer adoption and soil and water conservation practice adoption. The reason for this is partly because these were emphasized topics on radio shows as indicated by interviews with radio stations that hosted the vegetable programs. It was surprising that radio shows were weakly correlated with improved vegetable adoption as shown in Table 34.

Table 34: Relationship between vegetable radio program listening and adoption among TE farmers

	Radio listener	Variety adopter	Sex	Age	Male headed household	Education> primary 7
Radio Shows	1.000					
Variety adopter	0.002	1.000				
Sex	0.013	0.229	1.000			
Age	0.034	0.046	0.042	1.000		
Male headed household	0.094	-0.250	-0.316*	0.060	1.000	
Education>primary 7	0.091	-0.111	0.018	-0.267	-0.043	1.000

3.5 Factors influencing adoption of technologies and improved vegetables varieties

This section presents the results of the probit model that predict the factors that influence adoption of varieties and promoted technologies under the ISSD Plus project.

3.5.1 Factors affecting adoption of technologies among TE farmers

Using a probit model, the factors which influence adoption of advanced agronomic practices, improved crop varieties and a combination of improved crop varieties and advanced crop management practices (hereby referred to as 'technology') among vegetable farmers who attended training events organized by ISSD Plus were estimated.

The results indicate that male vegetable farmers are more likely to adopt improved crop varieties promoted at training events. In addition, farmers who engage in the production of tomatoes, cabbage, onion and sweet pepper and use advanced crop management practices such as proper use of fertilizers and pesticides are more likely to adopt improved crop varieties that are being promoted during training events. However, vegetable farmers who are commercially oriented, belong to a male headed household and have attained a secondary level of education and above are less likely to adopt improved crop varieties promoted at training events.

On the other hand elderly farmers who listen to radio programs and are engaged in the production of tomatoes and sweet pepper and use fertilizers and pesticides are more likely to adopt advanced crop management practices that are being promoted during training events. However, farmers who came from households with an increased number of males are less likely to adopt advanced agronomic practices that are promoted at training events (Table 45).

More still, vegetable farmers who come from households with an increased number of females, listen to the radio and are engaged in production of vegetable crops such as tomatoes and cabbages and use organic manure are more likely to adopt a combination of advanced vegetable practices and improved varieties promoted during training events. In addition, vegetable farmers who come from male headed households and have attained a secondary level of education and above and are commercially oriented are less likely to technology combinations of improved crop varieties and advanced agronomic practices promoted during training events organized by ISSD.

The results in both the technology model and variety model show that vegetable farmers who come from male headed households are less likely to adopt improved technologies by 72% and improved quality seed

by 26%. This may be due to limited focus on vegetable crops as income crops by the male gender. Similar, the probability of adopting technology and quality seed of improved varieties decreases by 28% following an increase in the level of education contrary to prior expectations. However, an increase in the age of the farmer by one year increases the likelihood of adopting advanced agronomic practices by 0.6% probably due to ability to experiment with new technologies as farmers mature.

The results show that listening to radio increases the likelihood of adopting advanced agronomic practices and advanced technology by 53% and 72% respectively. This is probably due to the fact that radio programs act as an important source for additional information on a number of aspects related to vegetable production after the events given the fact that training events are conducted for a limited period of time. The technology model shows that an increase in the number of females by one member increases the probability of adopting a combination of advanced agronomic practices and quality seed by 2%. This is probably due to the increased contribution of vegetables for food and nutrition security of the household. On the other hand the results show that an increase in the number of males in the household by one member reduces the likelihood of adopting improved agronomic practices by 3% this is may be due to limited focus on vegetable crops as income crops. More results reveal that the likelihood of adopting quality seed increases by 14% with the use of fertilizers and 17% with the use of pesticides an indicator that fertilizers and pesticides are critical inputs for increased productivity among vegetable farmers.

The likelihood of adopting quality seed is more evidenced in farmers that are currently engaged in the production of tomato, cabbage, onion and sweet pepper. The probability increases by (20%, 47%, 56% and 13%) among tomato, cabbage, onion and sweet pepper farmers respectively this may be due to the fact that farmers adopt technologies for the crops that exist in their farming system. Further still, the results for the technology model indicate that cabbage and tomato producers are (92% and 78%) more likely to adopt a combination of quality seed and advanced agronomic practices compared to other vegetable producers (Table 35). However, results for the agronomic practice model indicate that the likelihood of adopting promoted agronomic practices only increases by 21% among tomato producers and decreases by 37% among sweet pepper producers an indication of limited focus of training event activities on some crops.

In addition, farmers who use formal information sources to get knowledge about training events are 16% more likely to adopt improved technologies and advanced agronomic practices this is due to increased access to critical information after the training. Farmers who were affiliated to Holland green tech are more likely to adopt quality seed and advanced agronomic practices by 23% and 40% this may probably be due to increased interaction with Seed Company after the training event.

Lastly, an increase in the area under vegetable production by one acre reduces the likelihood of adopting improved technology and quality seeds by 1% and 2% respectively. This may be due to the increased cost of production that may result from adopting an increased number of technologies which discourages farmers from taking on new technologies.

Table 35: Probit model indicating factors that influence adoption of improved technologies among TE vegetable farmers

	Technology (Advanced agronomic practices & Use of improved seed)		Adoption of Improved seed		Adoption of Advanced agronomic practices	
	dy/dx (marginal effects)	P>z	dy/dx (marginal effects)	P>z	dy/dx (marginal effects)	P>z
Household type(1=Male HHH, 0=FHHH)	-0.717	0.000	-0.262	0.008	0.109	0.338
Higher education(Secondary level & above)	-0.283	0.000	-0.140	0.078	-0.040	0.683
Listened to radio	0.719	0.000	0.007	0.901	0.527	0.000
Sex of farmer(Male=1, female=2)	0.201	0.004	0.261	0.000	-0.040	0.546
Age	0.004	0.117	-0.003	0.209	0.006	0.047
Number of males in household	-0.033	0.126	-0.021	0.312	-0.033	0.069
Number of females in household	0.020	0.000	-0.009	0.483	0.007	0.538
Membership in farmer group(1=Yes,0=No)	0.027	0.466	-0.003	0.955	0.053	0.434
Acreage of vegetables cultivated(acres)	-0.010	0.000	-0.026	0.001	0.002	0.794
Number of production cycles	0.024	0.159	0.087	0.110	0.172	0.000
Uses fertilizer(1=Yes,0=No)	0.047	0.235	0.138	0.034	0.054	0.340
Uses manure(1=Yes,0=No)	0.173	0.006	0.053	0.502	0.030	0.634
Uses pesticide(1=Yes,0=No)	0.065	0.371	0.179	0.047	0.185	0.007
Grows tomato (1=Yes,0=No)	0.778	0.000	0.198	0.011	0.213	0.000
Grows cabbage(1=Yes,0=No)	0.922	0.000	0.470	0.000	0.023	0.757
Grows onions(1=Yes,0=No)	0.015	0.818	0.559	0.000	-0.112	0.299
Grows pepper(1=Yes,0=No)	-0.028	0.614	0.132	0.046	-0.370	0.000
Affiliated to Holland Genentech	-0.012	0.697	0.236	0.032	0.400	0.014
Information source about Training Event (1=Formal e.g. radio, news,MMU,extension, NARO, 0=Informal fellow farmers)	0.161	0.001	-0.147	0.048	0.169	0.011

3.5.2 Vegetable seed supply by agro-dealers

The results from key informant interviews with agro-dealers show that out of the 27 tomato varieties stocked by agents, 3 (11%) which include Kilele, Anja F1, and Padma F1, are currently being promoted by seed companies under the ISSD Plus project. More results of the information from KIIs with agro-dealers show that 13 varieties out of the 27 varieties are high yielding and resistant to pests and diseases, and out of these, 3 varieties (27%) are promoted by ISSD Plus partner seed companies. Given the fact that most of the varieties that were being promoted under the project are new, only 1 variety (12.5%) (Padma F1) has gained popularity out of the total 8 varieties which were found to be popular. The main reason for its popularity among farmers is that Padma F1 is the cheapest of the Dutch tomato varieties introduced on the market (Table 36).

More results indicate that out of the 16 cabbage varieties stocked by agents, six (38%) which include Indica, Gloria F1, Tamisa, Escazu, Tacoma, Karibu and Bowie F1 are currently being promoted by seed companies under ISSD Plus project. A further analysis of the variety attributes from the key informant interviews with agro dealers show that a total of three varieties currently under promotion are Bowie F1, Gloria F1 and Escazu F1, which are high yielding. Further still, three cabbage varieties (Bowie, Indica and Gloria F1) currently under promotion by seed companies are resistant to pests and diseases.

Table 36: Main vegetable varieties on the market and their traits

		Vegetable Seed variety traits					
Vegetable	**Vegetable seed varieties stocked (n=27)**	**Highest yielding (n=13)**	**Drought tolerant (n=12)**	**Pest resistant (n=13)**	**Disease resistant (n=11)**	**Cheapest (n=7)**	**Most popular (n=8)**
Tomato	• Padma F1 • Nouvelle F1 • Safa F1 • Prosper F1 • Shanty F1 • Tengeru 97 • Riogrand • Cal-J. • Roma VF • Bawito, Commando • Safa • Nuru • Rambo F1 • Terminator FI • Kilele • Real marks • Oxly- royal seed • Ansal • Assila, • Safa F1 • Randa • Rodade • real neck • Real make • Sultan F1 • Money maker • Anja F1	• Nouvelle F1 • Padma F1 • Riogrand • Terminator F1 • Rambo F1 • Kilele • Tengeru • Faulu • Anja f1 • Rambo • Assila F1 • Ansal F1 • Money maker	• Nouvelle F1 • Padma F1 • Riogrand • Terminator F1 • Rambo F1 • Kilele • Anja FI • Assila • Ansal • Rio grand • Tengeru 97 • Money maker	• Padma F1 • REAL (Top harvest- Red) • Tengeru 97 • Komando • Terminator F1 • Rambo F1 • Riogrand • Nouvelle F1 • Kilele • Anja F1 • Ansal • Money maker • Assila	• Tengeru 97 • Padma F1 • Komando • Terminator F1 • Rambo F1 • Faulu • Anja • Assila • Ansal • Commando F1 • Money maker	• Tengeru 97 • Roma VF • Riogrand • Cal J • Real marks • Padma • Ansal	• Tengeru 97 • Riogrand • Padma F1 • Riogrand • Cal J • Ansal • Money maker • Assila
Cabbage	(n=16) • Blue dynasty • Baraka F1 • Gloria F1 • Queen F1 • Mila F1 • Fanaka F1 • Green Boy	(n=5) • Gloria F1 • Baraka F1 • Bowie F1 • Blue dynasty • Escazu F1	(n=7) • Baraka F1 • Kilimo F1 • Gloria F1 • Bowie F1 • Blue dinnesty • Green ball • Escazu F1	(n=6) • Baraka F1 • Indica f1 • Gloria F1 • Bowie F1 • Blue dinnesty • Green boy	(n=6) • Baraka F1 • Indica f1 • Gloria F1 • Bowie F1 • Blue dinnesty • green boy	(n=3) • Copenhagen • Baraka • Gloria	(n=4) • Gloria F1 • Baraka F1 • Bowie F1 • Green boy

		Vegetable Seed variety traits					
	• Oxyilus • Indica F1 • Drum head • Copenhagen • Kelimott, Star 3316 • Bowie F1 • Karibo F1 • Escazu F1 • Tacoma F1						
Onions	(n=9) • Super Yale[29] • Russet F1 • Red magic F1 • Red creole • Red Bombey • Red pinnoy • Early red max • Afri seeds • Jamber	(n=8) • Red pinnoy • Red coach • Red creole • Bombey Red • Super yale • Early red max • Russet • Afri seeds	(n=8) • Red creole • Bombey red • Red Creole • Super yale • Red pinnoy • Red coach • Russet • Early red max	(n=7) • Red creole • Bombey red • Red pinnoy • Early red max • Red coach • Russet • Super yale	(n=6) • Red creole • Bombey Red • Red pinnoy • Early red max • Russet • Super yale	(n=5) • Red creole • Bombey red • Super yale • C.5 • Early red max	(n=4) • Red creole • Red pinnoy • Russet • Early red max
Pepper	(n=8) • California wonder • Yolo wonder • Kaveri F1 • Gaga • Crusader • super bell • Mildred F1 • Nemalite F1	(n=3) • California wonder • Kaveri F1 • Gaga	(n=2) • California Wonder • Kaveri F1	(n=1) • California Wonder	(n=2) • Kaveri F1 • California Wonder	(n=1) • California Wonder	(n=1) • California wonder

[29] "But this didn't pick up because farmers thought it was expensive yet they had alternative varieties like Red creole". Source: Interview with an agro-dealers in Gulu district.

3.5.3 Factors influencing adoption of improved vegetable varieties among farmers that attended demonstrations and training sites.

3.5.4 Farmer characteristics

Results indicated that the older a farmer is the less likely they were to adopt improved vegetable varieties promoted by Dutch seed companies. More results indicate that farmers with larger land sizes were significantly more likely to adopt promoted improved vegetable varieties with an additional acre of land managed under vegetable, increasing the probability of adoption by 5 percent. In addition, targeted farmers who were located in Central Uganda were more likely to adopt promoted improved vegetable varieties by 11 percent.

However, targeted farmers in Northern and Eastern Uganda were less likely to adopt the promoted vegetable varieties by 36%. Although learning from a training site increased chances of adoption by 6%, learning from a demonstration reduced the chances by 0.1%. This is due to the fact that training sites offer a more rigorous and practical learning about the introduced technology over a long period of time hence facilitating the adoption process. This can partly be explained by the fact that exposure of farmers to new varieties using only the demonstration approach, since the time period of interaction is much shorter compared to interaction at training sites. Lastly, farmers who listened to radio programs on vegetable production were more likely to adopt improved vegetable varieties with the likelihood of adoption increasing by 23%.

3.5.5 Technology and location related factors

The main improved vegetable varieties considered here were those adopted by tomato, cabbage, onion and pepper farmers and promoted by the Dutch seed companies given the higher proportion of farmers that were engaged in their production. We also explored the effect of the seed company promoting the vegetable variety on adoption.

Although interacting with any of the seed companies promoted adoption positively, significant adoption effects were seen with farmers who interacted with East West Seed, Dutch seed center, Holland Green tech, Cycas and House of Seeds. The results show that with East West Seed and Dutch seed center (Cycas) farmers were 27 percent more likely to adopt improved vegetable varieties while those from Holland Greentech and House of Seeds were 10 percent and 16 percent likely to adopt respectively. Syngenta and Home Harvest seed companies had a positive but non-significant effect on adoption probability (Table 37). The difference in adoption effects resulting from seed company interaction could be attributed to the

variations in the entry into the market for example the engagements of Syngenta and Home Harvest were initiated later in 2019 compared to Holland Green Tech, House of Seeds and Dutch Seed center whose activities started in 2017.

In addition farmers that grew cabbage, pepper and onion vegetable crops were more likely to grow improved varieties that were being promoted under the ISSD Plus project with the likelihood of adoption increasing by 18 percent, 1 percent and 20 percent respectively. However, no significant adoption effects were observed for tomatoes growers. The reason here is that tomato has a lot many competing varieties from other non-Dutch seed companies unlike other crops. Cost of improved variety seed had a negative though highly negligible effect on adoption of improved varieties. This means that cost of seed though important cannot be a deterrent to adoption of an improved variety.

Table 37: Probit model results showing factors that influence adoption of improved vegetable varieties promoted by Dutch seed companies

Overall Dutch seed Variety adoption	Coef.	dy/dx	Std.err	P>z
Farmer age	-0.006	-0.002	0.001	0.132
Farmer sex(Male=1, Female=2)	-0.015	-0.008	0.031	0.805
Household size	0.002	0.001	0.005	0.902
Total cycle cost of hired labor (UGX)	0.000	0.000	0.000	0.637
Training site participant(Yes=1,No=0)	0.019	0.064	0.036	0.076
Field days on demonstration sites participant(Yes=1,No=0)	-0.055	-0.001	414.000	0.973
Interaction of training site and demo sites	-0.623			
Farmer attended Training event (Yes=1,No=0)	0.002	-0.001	0.041	0.973
Farmer listened to radio	0.235	0.053	0.028	0.057
Land size allocated to vegetables(acres)	0.182	0.050	0.021	0.015
Total cost of improved vegetable seed per cycle	-0.00000017	-0.00000005	0.00000002	0.034
Region_central	0.473	0.114	0.050	0.023
Region_North	-1.584	-0.362	0.087	0.000
Region_East	-1.529	-0.358	0.050	0.000
Region_West	-0.274	-0.091	0.058	0.115
Education of household head is higher than primary	0.174	0.032	0.028	0.255
Member of a farmer group or association? [1 =Yes,0 = No]	-0.114	-0.025	0.030	0.399
Family Labor days used in vegetable garden per production cycle	0.004	0.001	0.000	0.003
Fresh Vegetable selling point				
Village market	0.162	0.035	0.042	0.401
Main/district market	-0.298	-0.067	0.046	0.149
Other market	-0.312	-0.072	0.058	0.218
Crop grown				
Tomato grower	-0.003	-0.003	0.032	0.916
Cabbage grower	0.703	0.175	0.028	0.000
Onion grower	0.394	0.097	0.039	0.012

Overall Dutch seed Variety adoption	Coef.	dy/dx	Std.err	P>z
Pepper Grower	1.012	0.249	0.050	0.000
Seed company of affiliation				
East West	1.262	0.266	0.073	0.000
Holland Greentech	0.394	0.088	0.041	0.032
Dutch Seed center Cycas	1.231	0.279	0.061	0.000
Home harvest	0.467	0.096	0.060	0.109
Syngenta	0.336	0.069	0.080	0.386
House of Seeds	0.818	0.164	0.051	0.001
Constant	-0.751			

Model summary: LR chi2(36) = 414.28 ; Prob > chi2 = 0.0000 ; Pseudo R^2 = 0.361 n= 712

3.5.6 Advanced agronomic practice use in vegetable production

Adoption of improved varieties has greater impacts if it is accompanied with advanced production (agronomic) practices. The ISSD Plus project promoted both variety and advanced practices concurrently. Here were present results that link variety and advanced practice use. Results indicated that generally adoption of advanced agronomic practices in vegetable production, as promoted by the project, was between 20 percent and 30 percent. The most adopted practice was Seedling production (raising seedlings using different media on trays, pots) followed by Fertilization (fertilizer application following a specific regime) and trellising (raising tomato plants off the ground using sticks or any other method). However, Soil & water conservation techniques (ridges , blanket mulch) was more adopted in Northern region and Western region while crop protection (use of traps and proper use of chemicals) was more adopted in the Eastern region. The vegetable farmers in the Northern region had the highest adoption rate of Seedling production (Raising seedlings using different media on trays, pots) practice (46 percent) compared to other farmers in the other regions yet they had the lowest adoption rate (8 percent) of Soil & water conservation techniques (ridges, blanket mulch) and Crop protection (use of traps and proper use of chemicals. Spillover effects were more observed in Western, Eastern and Northern regions with more spill over farmers adopting the practices to almost the level of beneficiaries (Table 48).

Table 38: Percentage of farmers adopting the advanced agronomic practices in vegetables

	Percentage of vegetable farmers				
	Central n=258	**Northern n=150**	**Eastern n=223**	**Western n=158**	**Overall n=789**
Seedling production (Raising seedlings using different media on trays, pots)	26.85	46.15	30.3	28.57	29.08
Fertilization (fertilizer application following a specific regime)	12.04	30.77	48.48	28.57	22.96
Trellising (Raising tomato plants off the ground using sticks or any other method)	33.33	15.38	9.09	7.14	22.45
Soil & water conservation techniques (ridges, blanket mulch)	17.59	7.69	27.27	33.33	21.94
Crop protection (use of traps and proper use of chemicals)	17.59	7.69	30.3	9.52	17.35

3.5.7 Factors influencing advanced agronomic practice adoption for vegetable production

There are five main agronomic practices/technologies that were the focus of the ISSD Plus project. They include Seedling production (Raising seedlings using different media on trays, pots etc.), Crop protection (use of traps and proper use of chemicals), fertilisation (fertilizer application following a specific regime), Soil & water conservation techniques (ridges, blanket mulch), and Trellising (Raising tomato plants off the ground using sticks or any other method).

Adoption of these advanced vegetable agronomic practices was influenced by the size of the vegetable garden cultivated, regional location, selling vegetables into a district/main market, longevity of the seed company promoting the technology in the region, and tomato growing among others. Results show that adoption of these practices favours smallholders given that an increase in acreage results in about 19 percent chance of non-adoption (Table 39). Although selling fresh vegetables to a district market disfavours adoption significantly, even selling to a village market does the same though not significantly.

Results showed a significant increase in chances of adoption of promoted practices if a farmer is affiliated to Dutch seed center (Cycas) or House of seeds seed companies. Dutch seed center (Cycas) affiliated farmers were 42 percent more likely to adopt one of these practices while House of seeds' affiliated farmers were 41 percent more likely to adopt. Key informant information indicated that House of Seeds and Dutch seed center had started operations way back before ISSD Plus project started. This longevity in the market could be one of the explanations for their high performance. It is worth noting that the other seed companies also had positive chances of influencing adoption of practices (Table 39).

Table 39: Probit model results showing factors that influence adoption of advanced agronomic practice adoption in vegetables

Adopted at least one of the agronomic practices	Coef.	dy/dx	Std.err	P>z
Farmer age	-0.007	-0.001	0.002	0.335
Farmer sex (male=1, female=2)	0.120	0.028	0.043	0.523
Education level of household head is higher than primary(yes=1,No=0)	0.134	0.031	0.039	0.432
Household size	0.033	0.008	0.006	0.235
Total cycle cost of hired labor(UGX)	0.000	0.000	0.000	0.955
Farmer is ISSD Plus beneficiary(Yes=1,No=0)	0.332	0.076	0.139	0.582
Farmer attended Training site(Yes=1,No=0)	0.194	0.045	0.051	0.379
Farmer benefited from a demo site(Yes=1,No=0)	-0.361	-0.083	0.059	0.157
Farmer attended Training event (Yes=1,No=0)	-0.326	-0.075	0.065	0.249
Vegetable plot size(ha)	-0.824	-0.190	0.084	0.024
Farmer region (Central=reference)				
Northern	-1.900	-0.543	0.200	0.007
Eastern	-2.161	-0.589	0.108	0.000
Western	-1.480	-0.448	0.105	0.000
Member of a farmer group or association? [1 =Yes,0 = No]	-0.120	-0.028	0.042	0.509
Use any fertilizer on vegetable plots in 2018/2019[1 =Yes,0 = No]	-0.048	-0.011	0.044	0.804
Use manure on vegetable plots in 2018/2019[1 =Yes,0 = No]	0.021	0.005	0.050	0.923
Family Labor days used in vegetable garden per production cycle	0.001	0.000	0.000	0.428
Vegetable selling point				
Village	-0.026	-0.007	0.065	0.92
Main/district	-0.463	-0.103	0.059	0.08
Other	0.666	0.185	0.145	0.203
Seed Company				
Holland Green tech	0.271	0.042	0.098	0.670
Dutch seed center (Cycas)	1.708	0.417	0.162	0.010

Adopted at least one of the agronomic practices	Coef.	dy/dx	Std.err	P>z
Home Harvest	0.955	0.191	0.120	0.112
Syngenta	0.825	0.158	0.135	0.244
House of seeds	1.698	0.414	0.145	0.004
East West	-0.963	-0.240	0.074	0.001
Type of vegetable grown				
Cabbage grower	0.172	0.040	0.043	0.363
Tomato grower	0.654	0.150	0.045	0.001
Onion grower	-0.082	-0.019	0.055	0.732
Pepper grower	0.385	0.089	0.072	0.221
Eggplant grower	0.111	0.026	0.124	0.836
Constant	0.250		1.051	0.812

3.5.8 Costs and benefits of the advanced technologies versus previously used technologies

Results indicated that generally vegetable growers who had benefited from the ISSD Plus vegetable interventions incurred about 0.4-0.6 million shilling per acre per production cycle in costs. Adopters of Dutch vegetable varieties incurred significantly ($p<0.05$) higher costs than non-adopters. However, adopters in Western region incurred more costs of about 1.1 million Uganda shillings per acre per cycle compared to other regions. A vegetable adopter earned about 0.69 million/acre in revenues slightly than for a non-adopters with 0.7 million shillings. Adopters in Northern, Eastern and Central Uganda earned higher revenues per acre per cycle than non-adopters. In all regions except the Western region, Dutch vegetable variety adopters earned higher gross margins than non-adopters (Table 40).

The higher performance of the Northern region is corroborated by evidence from key informant interviews held with the Seed company personnel, ISSD and agro-dealers who confirmed these facts. The main explanation given is that Northern Uganda farmers had more contact time with agronomists and brigadiers in addition to East West seed company making partnerships with agro-dealers who massively promoted the Dutch improved varieties. The southern Sudan market and the fast urbanizing cities of Gulu and Lira have created opportunities for vegetable production to boom.

Table 40: Costs, revenues and margins per acre by adopters and non-adopters of improved vegetable varieties

	Costs(UGX)/acre		Revenues(UGX)/acre		Gross margins(UGX)/acre	
Region	**Adopter**	**Non -Adopter**	**Adopter**	**Non -Adopter**	**Adopter**	**Non -Adopter**
Central	284,328.70	239,302.80	474,044.70*	206,023.70	189,716.00	-33,279.10
Northern	118,321.80	108,422.40	1,055,012.00	883,479.30	936,690.20	775,056.90
Eastern	770,447.10	616,591.60	835,677.60	488,575.60	65,230.50	-12,8016.00
Western	1,106,052.00	945,323.50	812,594.10*	1,734,285.00	-293,457.90	788,961.50
Total	**565,549.20****	**425,589.70**	**693,772.30**	**705,357.00**	128,223.10	279,767.30

Significance:***1%,**5%,*10%

All improved vegetable varieties were found to be worth the investment given that their Benefit Cost Ratio (BCR) value was more than one except for carrot among adopters and onion among non-adopters. A tomato variety adopter gets about 2 Uganda shillings (Approx. US$0.001) per shilling invested per production cycle. Cabbage and eggplant adopters however get the highest returns of about 3 Uganda shillings (Approx. US$0.001) per shilling invested per production cycle (Table 41).

Table 41: Benefit cost ratio by adopter and non-adopter of improved vegetable variety among growers

Vegetable	Variety only adopter	Variety only non-adopter	Overall
Egg plant[30]	3.18	2.54	2.57
Cabbage	2.57	1.3	2.34
Tomato	1.92	2.15	2.11
Pepper	2.36	1.6	1.86
Onion	1.5	0.76	1.17
Carrot	0.06	1	0.43

Source: ISSD Plus vegetable variety and technology adoption survey, 2020

Among variety adopters, Northern Uganda farmers get the highest return per shilling invested in vegetable production. Variety adopters in this region get 10 Uganda shillings (Approx. US$0.003) per shilling invested per production cycle followed by central region. Table 43 still indicated the same trend among advanced agronomic practice adopters with Northern and Eastern regions leading.

Table 42: BCR among adopters and non-adopters of vegetable varieties promoted by Dutch seed companies

Location	Variety adopter	Variety Non-adopter	Overall
Central	2.57	2.17	2.67
Northern	8.22***	2.82*[E]	4.42***
Eastern	2.43	1.14	2.24
Western	1.72	1.82	1.75
Total	2.65	2.33	3.08

*ttest for adopter Vs Non-adopter Pr(T >t)=0.7684, Difference in BCR= -248.457, sig:***1%,*10%*

[30] There was only one eggplant variety adopter, hence standard deviation could not be calculated

Table 43: BCR among adopters and non-adopters of advanced agronomic practices promoted by ISSD Plus vegetable component

Region	Advanced agronomic practices adopter	Advanced agronomic practices Non-adopter
Central	2.23	2.60
Northern	1.66	5.19
Eastern	3.30***	1.67
Western	1.01***	2.11
Total	**2.16**	**2.72**

Significance:***1%

When the effect of variety and agronomic practice adoption were combined, the Eastern region farmers were found to earn more returns per unit of investment. The adopters get about 4 Uganda shillings (Approx. US$0.001) per shilling invested per production cycle followed by Central region (Table 44).

Table 44: BCR among adopters and non-adopters of both variety and advanced agronomic practices promoted by ISSD Plus vegetable component

Region	Variety & advanced agronomic practices adopter	Variety & Advanced agronomic practices Non-adopter
Central	1.91	2.66
Northern	1.05	4.65
Eastern	4.14***	1.61
Western	1.34**	1.90
Total	2.13	2.64

Significance:1%,**5%***

4 Findings on adoption of ISSD extension methods among sector professionals/vegetable brigadiers

In order to understand the extent of adoption of the ISSD Plus extension approaches, key informant interviews were conducted with selected trained sector professionals in four regions of Uganda. Table 45 presents results for the proportions and number of trained professions across the project implementation areas. The results show that a total of 50 sector professionals were interviewed of these 16 were operating in Central Uganda, 10 in Western Uganda, 11 in Eastern Uganda and 13 in Northern Uganda. The results further show, that the studied professionals were further grouped into five categories based on the field of operation and these included; researchers, agro input dealers, government extension workers, private extension service provider, NGO extension worker, Seed Company.

Table 45: Categories of studied vegetable brigadiers

Category	Central (n=16)	Western(n=10)	Eastern (n=11)	Northern(n=13)	Total(n=50)
Researchers (n=2)	12.5	-	-	7.7	6.0
Agro input dealers	6.3	10.0	18.2	30.8	16.0
Government extension worker	12.5	30.0	54.5	7.7	24
Private extension service provider	37.5	20.0	18.2	7.7	22
NGO extension worker	25.0	30.0	-	7.7	16.0
Seed company extension worker	6.3	10.0	9.1	38.5	16.0

4.1 Topics and methods taught at sector professional trainings by ISSD

Sector professionals interviewed indicated that they had been taught a wide range of topics related to vegetable production and extension work. Over 80 percent of them had been taught the seven topics and over 70 percent of these were applying the skills gained during trainings in their daily sector extension work (Table 46).

Table 46: Extent of applicability of knowledge on vegetable production by ISSD trained sector professionals

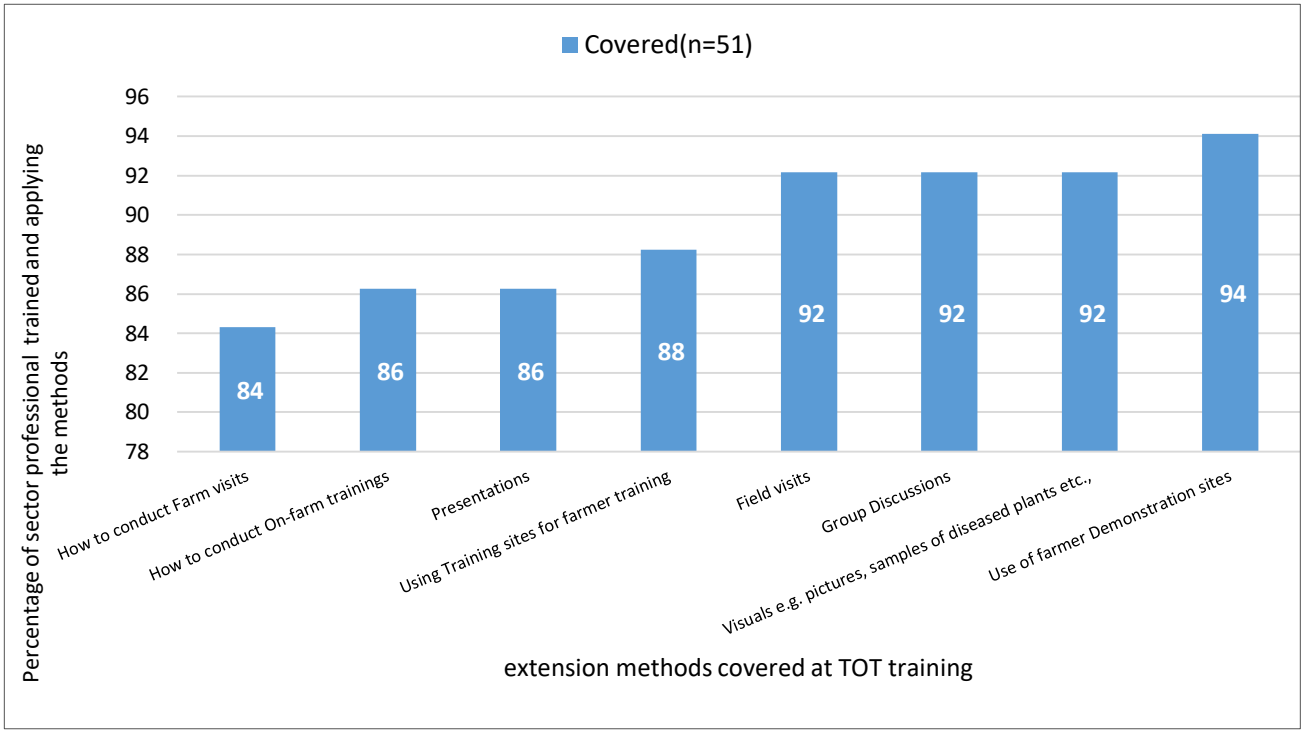
	Percentage of vegetable brigadiers	
Topic	**Covered (n=50)**	**Applied (n=50)**
Improved Nursery Systems & Management	100	96.07
Crop protection (disease & pest identification, diagnosis, recommended remedies etc.)	98.04	94.12
Vegetable agronomy	96.08	88.24
Practical Crop Protection(OSH)	94.12	92.15
Fertilization	94.12	94.12
Vegetable growing as Business	82.35	80.39
Water Conservation techniques(Soil & irrigation)	80.39	70.59

Source: ISSD Sector professional/vegetable brigadier survey, 2020

Under extension methods, sector professionals mainly covered use of demonstration sites, visuals for disease identification, group discussions and field visits. However, over 80 percent of the professionals indicated that they also learned about training farmers using training sites, presentations, and on-farm training and farm visits (

Figure ***17***).

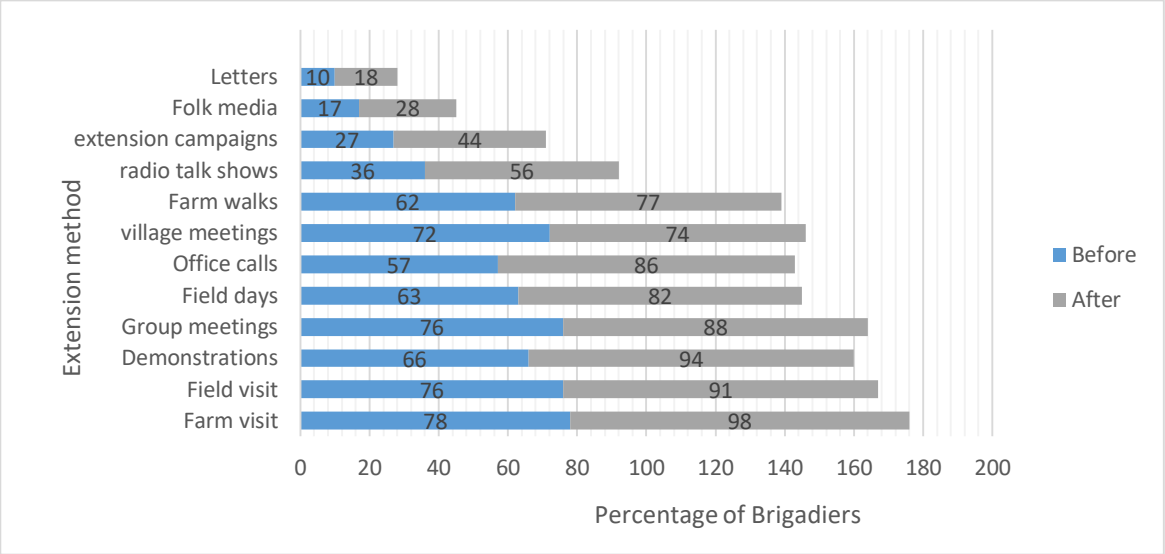
Figure 17 : Extension methodology covered at vegetable sector professional trainings by ISSD



4.2 Adoption of ISSD Plus project Extension methodology through dissemination of methods and topics covered during the sector professional/extension program training

As displayed in figure 18, the most frequently adopted extension methods include farm visits, field visits, demonstrations and group meetings. Farm visits is the dominant extension approach used by vegetable brigadiers, followed by demonstration, field visits and group meetings after the training. More results indicate that the level of adoption and use of demonstrations as a practical extension method increased by 42% following the training. It is important to note that generally, there was an increased adoption of other extension methods for instance the adoption of farm visits increased by 25% while that of field visits increased by 19% and that of group meetings increased by 15%. However, it is important to note that constraints such as the increased costs associated with establishing and managing a demonstration limit the use of demonstrations as a practical extension approach for disseminating advanced vegetable technologies.

Figure 18 Adoption of ISSD Plus project extension methodology by vegetable brigadiers



Source: ISSD Sector professional/vegetable brigadier survey, 2020

4.3 Extent of farmer outreach by trained vegetable brigadiers

The results in Table 47 show that an estimated 392,704 vegetable farmers were reached by trained vegetable brigadiers, 58 percent of whom were males. Each vegetable brigadier reached an average of 3,328 farmers. In addition, the total number of youth reached was 193,402 of whom female youth constituted 41 percent (Table 48). Key informant information from ISSD indicated that these outreach numbers were a result of synergies built by seed companies such as East West in Northern Uganda and agronomists from seed companies.

Table 47: Extent of overall farmer outreach by vegetable brigadiers following the ISSD training

Farmers gender	Mean farmers reached per Vegetable Brigadier	Estimated total program outreach*	Percentage
Male	1,924	227,032	58%
Female	1,331	157,058	40%
Overall	**3,328**	**392,704**	**100%**

**Estimated total is from the 118 sector professional (brigadiers) so far trained and who are active in the field*
Source: ISSD Sector professional/vegetable brigadier survey, 2020

Table 48: Extent of youth farmer outreach by vegetable brigadiers

Farmers gender	Mean youth reached per Vegetable Brigadier	Estimated total program outreach*	Percentage
Male youth	969	114,342	59%
Female youth	670	79,060	41%
Total	1,639	193,402	100%

****Estimated total is from the 118 Brigadiers so far trained and who are active in the field***

Source: ISSD Sector professional/vegetable brigadier survey, 2020

Aggregated estimates show that female brigadiers significantly outperformed the male brigadiers in establishing demonstration gardens. By the time of the survey, a female brigadier had established an average of 107 demonstrations compared to 29 for males since completion of the ISSD sector professional training. Overall, the brigadiers have established an estimated total of 6,532 demonstration sites and conducted 33,373 farm visits (**Table 49**).

Table 49: Extent of vegetable brigadiers outreach by demonstrations established and farm visits

Brigadier gender	Mean number of demonstrations	Estimated total number of demonstrations	Mean number of farm visits	Estimated total number of farm visits
Male	29	2,325.29	222	17,532.72
Female	107**	4,175.74	405	15,768.41
Overall	55	6,531.65	283	33,373.17

Note: Male brigadiers were 67%, and females were 33%. Significance:**5%

Source: ISSD Sector professional/vegetable brigadier survey, 2020

4.4 Types of ISSD PLUS project improved vegetable varieties promoted by varieties vegetable sector professionals)

The results (Table 32) indicate that there has been an increase in the number of seed company vegetable crop varieties promoted by trained vegetable sector professionals. For instance before the training only three tomato varieties (Anja F1, Kilele and Volos) were being promoted but following the training five new varieties including (Jarrah F1, UWEZO, Gammar F1, Padma F1 and Vilani F1) are currently being promoted. More results indicate that after the training there was an increase in the proportion of trained vegetable brigadiers promoting Padma F1 and Anja F1 by 32% and 14% respectively.

Similarly, following the training there was an increase in the number of trained sector professionals promoting cabbage varieties from three to six. Gloria F1 was the major cabbage variety promoted by 38% of the trained sector professionals before the training and the reported proportion increased by 4% after the training. More results indicate an increase in the proportion of trained sector professionals promoting Tacoma and Escazu F1 cabbage varieties by 10% while that of Indica increased by 28% respectively.

The results for the onion varieties being promoted show that Super Yali, Red coach, Red wave and Red king were the major varieties promoted by the trained vegetable brigadiers. More results show that the training resulted into increased promotion of Super Yali by 22% and Red coach by 9.3%. The training also resulted into an increased promotion of Kaveri a sweet pepper variety by 14% and Norma carrot varieties by 4% and 4.8%.

Table 50: Farmer adoption of Dutch Seed Company vegetable varieties according to trained sector professionals

Key: BP=Before ISSD Plus & AP=After ISSD Plus

Tomato			Cabbage			Onion			Carrots					
Tomato variety	**BP % (n=28)**	**AP% (n=42)**	**Cabbage variety**	**BP % (n=28)**	**AP% (n=42)**	**Onion variety**	**BP % (n=28)**	**AP% (n=42)**	**Carrots variety**	**BP % (n=28)**	**AP% (n=42)**	**Sweet pepper variety**	**BP % (n=28)**	**AP% (n=42)**
Padma F1	2.4	35.7	Tacoma F1	-	9.5	Super Yale	4.8	28.	Norma	-	4.8	Crusader F1	2.4	-
Anja F1	7.1	19.1	Indica F1	2.4	28.6	Red coach	11.9	19.1	Nantes	16.7	14.3	Kaveri	-	16.7
Kilele	7.1	11.9	Bowie F1	2.4	4.8	Red wave	2.4	7.1	Tripoli	4.7	11.9			
Jallah F1	-	2.4	Gloria F1	30.9	38.1	Red King	2.4	7.1						
Garma F1	-	7.1	Escazu F1	2.4	14.3	Red Passion	-	2.4						
UWEZO	-	3.6	Karibo F1	-	2.4									
Volos F1	2.4	2.4												
Vilani F1	-	2.4												

4.5 Level of satisfaction with the training program

The level of satisfaction with the ISSD Plus vegetable brigadier training as displayed in Figure 19 ranged from being very high, moderately high, low satisfaction and very low satisfaction. Generally the training course was perceived very useful by majority of the trained sectors professionals this is because the training led to increased knowledge on vegetable production and increased awareness about improved varieties

Figure 19: Level of satisfaction of the ISSD Plus vegetable brigadier training

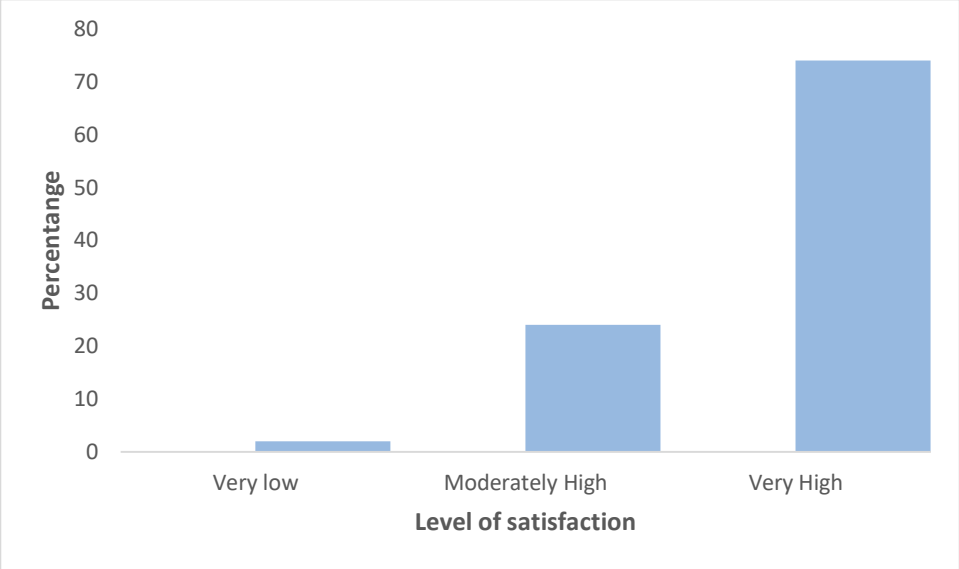


Table 51: Suggested reasons for level of satisfaction

	Level of satisfaction (n=47)		
	Low	**Moderately satisfied**	**Very satisfied**
Reason			
Low visibility of the project	2.1		
Sustainability of the project	-	4.3	4.3
Increased knowledge on vegetable production	-	14.9	63.8
Increased awareness about improved vegetable varieties	-	10.6	23.4
Increased adoption by farmers	-	4.3	8.5
Visibility of project in various parts of the country	-	4.3	2.1

5. Findings on seed companies case studies and their contribution to trade

5.1 Seed company experiences with training sites and demonstrations as approaches for business development

Demonstrations and training sites have proved to be an approach of demonstrating to the farmers the advanced agronomic practices and the performance of the new high quality improved varieties.

Key informant interviews done with four seed companies indicated that during the partnership period each seed company was meant to establish 40 demonstrations[31] within the 18 months and through these approaches farmers were skilled in proper nursery management practices where most of them are now in position to raise high quality seedlings and also improve on the seedling rate. Similarly other agronomic practices such as pests and disease control which involves pests and disease identification and proper use of chemicals have been demonstrated to the farmers which has also contributed to the adoption of the practices. Other agronomic practices which have been demonstrated include trellising where farmers have been encouraged to be innovative enough to use cheap locally available materials such as threads and old clothes to carry out the activity.

However, from their experiences there is still limited participation of the youth in activities organised at demonstrations and training events. In addition, gender issues related to women participation still exist. For example, a key informant from East West Seed Company intimated that demonstration and training sites hosted by female farmers attract more females than those hosted by males. This corroborates well with findings from the survey that indicated that female participation was limited. The main reason here is that the men own much of the land on which demonstration sites are located, hence they end up controlling much of what goes on and women are hindered in their participation.

In conclusion, the seed companies noted that they will continue to use these approaches in their future promotion activities and also lobby for additional budget to increase on the number of demonstrations being established by 25%.

[31] Note: Number of demos to be established per season differed from company to company based on their commitments made in the partnership agreement

5.2 Contribution of the ISSD Plus project to Ugandan trade with Netherlands through the Dutch seed companies

Interviews with Dutch seed companies revealed that at the point of entry to start importing seed to Uganda, the companies faced licensing huddles because of a legal framework that does not allow foreign entities to directly import seed or that makes licensing very expensive. To overcome this challenge, the Dutch seed companies resorted to importing and selling seed through other locally registered seed companies. For example, East West imports and sells through Nalweyo Seed Company Ltd (NASECO) while Syngenta sells through Simlaw Seed Company.

Estimates using the total outreach of the extension system with about 400,000 farmers reached and the levels of adoption by crop of Dutch seed company varieties showed that the seed trade alone generated about 234.9 billion Uganda shillings(US$63.44 million) in revenues from sales of seed to adopting farmers by Dutch seed companies between 2017 and 2020 (Table 52). Onion, cabbage and tomato varieties contributed over 90 percent of the share of total seed revenues to Dutch seed companies (Figure 20). Details of the estimates can be accessed in Annex 4 of the report.

Table 52: Estimated contribution of Dutch seed companies to Ugandan trade with Netherlands

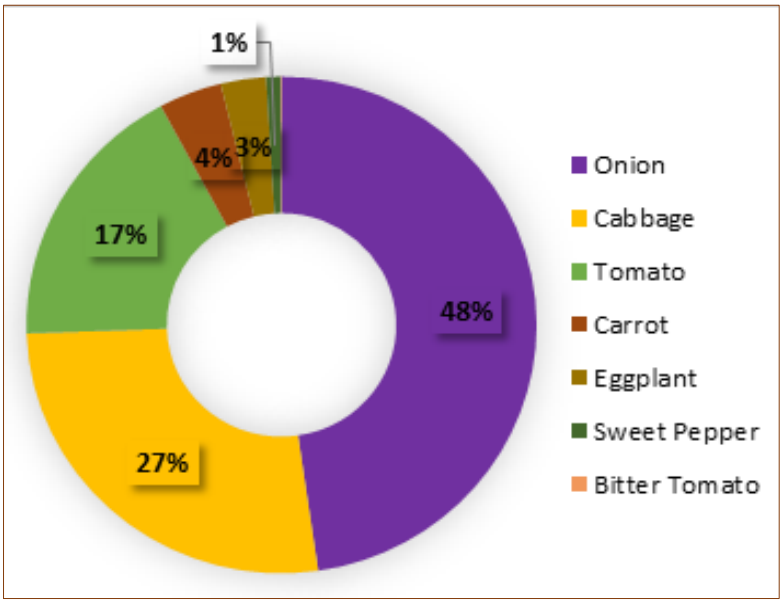
Crops by DUTCH varieties	Mean annual seed cost per farmer (UGX)	Total seed revenue by DUTCH companies (Million UGX)					Revenue seeds (Million US$)				
		2017	2018	2019	2020	4 year grand Total (UGX)	2017	2018	2019	2020	4 year grand Total (million US$)
Tomato	275,949	7,049.22	14,446.62	11,629.08	8,458.00	41,582.93	1.92	3.88	3.17	2.26	11.23
Cabbage	346,909	7,053.03	21,152.20	24,678.71	9,988.35	62,872.29	1.92	5.68	6.72	2.67	16.99
Onion	967,750	11,369.35	29,235.47	40,604.82	30,859.67	112,069.31	3.10	7.85	11.05	8.26	30.26
Carrot	332,000	854.48	4,272.41	1,708.96	2,563.44	9,399.29	0.23	1.15	0.47	0.69	2.53
Sweet Pepper	85,909	195.96	587.88	783.84	587.88	2,155.57	0.05	0.16	0.21	0.16	0.58
Bitter Tomato	68,333	-	-	107.34	-	107.34	-	-	-	-	-
Eggplant	362,500	-	3,373.82	1,686.91	1,686.91	6,747.64	-	0.91	0.46	0.45	1.82
Total	-	-	-	-	-	234,934.37	-	-	-	-	63.44

Note: Exchange rates used[32][33]. Source: Consultant's calculations from survey data, 2020.

[32] Source: https://www.poundsterlinglive.com/best-exchange-rates/us-dollar-to-ugandan-shilling-exchange-rate-on-2018-10-31

[33] https://www.exchangerates.org.uk/USD-UGX-spot-exchange-rates-history-2017.html

Figure 20: Seed revenue contribution by crop



Source: ISSD adoption study data, 2020

6. Findings on spill over effects of vegetable technologies based on training sites and demonstration activities

This section presents results that show the level of spillover effects of the ISSD Plus project vegetable component interventions on non-intended beneficiaries.

The demo and training sites had more spill over farmers in the Eastern and northern regions. The training sites were promoted in North, Western and Eastern Uganda while demos were all over the four regions. Central had 21% of the sampled spill over farmers learning from demos (Figure 19). However, majority of the spill over farmers were males although women spill over farmers were more concentrated on demos than training sites (**Figure 21**).

Figure 21: Spill over levels by region and intervention

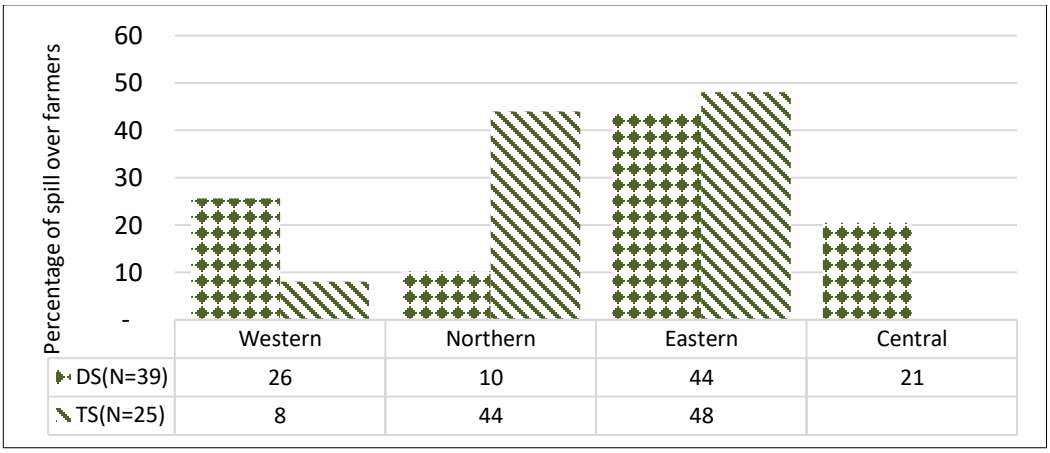
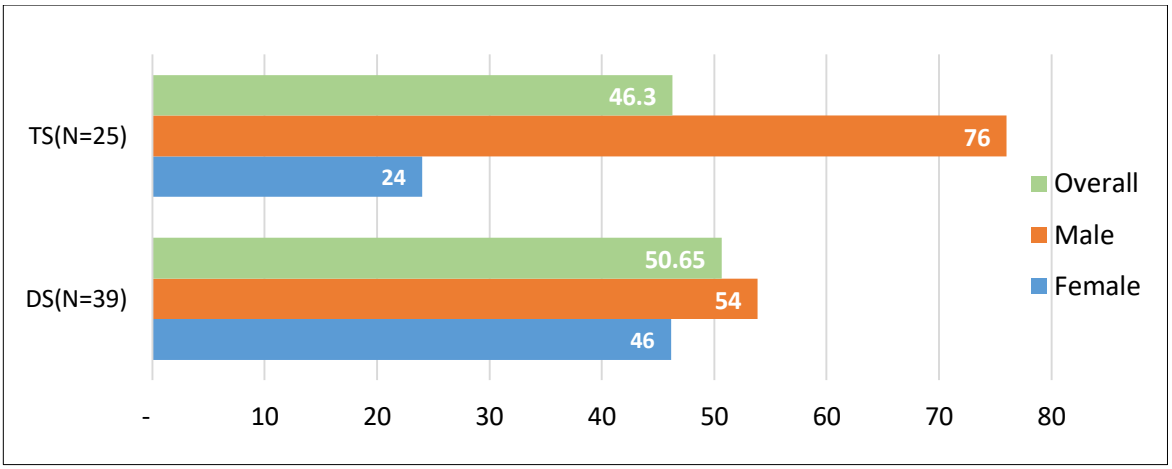


Figure 22:Sex of the spill over vegetable farmers by intervention



Many of the spill over farmers had taken up growing tomato, cabbage and onions. Table 53 shows that between 2017 and 2020, the number of spill over farmers growing tomato and cabbage increased by about 30 percent and 26 percent respectively.

Table 53: Spillover farmers' uptake of new vegetable crops

	Percentage of spill over farmers (n=54)		
	By 2020	**Before 2017**	**% change**
Tomato	55.56	25.93	29.63
Cabbage	35.19	9.26	25.93
Carrot	1.85	0.00	1.85
Onion	33.33	27.78	5.55
Sweet/green pepper	9.26	5.56	3.70
Cucumber	3.70	1.85	1.85
Eggplants	7.41	3.70	3.71
Bitter Tomato	9.26	5.56	3.70

Source: ISSD farmer adoption survey data, 2020

5 Conclusions, recommendations and lessons learned

This section highlights the key conclusions drawn from the results presented, field observations done, field experiences of the consultant and the entire team and interactions with stakeholders through interviews. The conclusions are made following evaluation questions that answered by the study. In addition, recommendations for the future are also made and lessons learned are elaborated.

5.1 Conclusions

5.1.1 To what extent have trained vegetable growers (from company-led training sites and ISSD Plus training events) adopted the promoted technologies, including advanced agronomic practices and use of improved vegetable varieties and what is the total area under adopted vegetable technologies?

The ISSD Plus project vegetable component led to increased adoption of improved vegetable varieties for cabbage, onion and tomato among vegetable growers across the regions within Uganda, many of which were resistant to pests and diseases and could withstand prolonged dry conditions. The levels of adoption of improved varieties varied by approach. Overall 33 percent of the training site farmers adopted Dutch vegetable varieties while 23 percent adopted use of advanced agronomic practices. For the farmers that benefited from training events, 62 percent adopted improved Dutch vegetable varieties and 23 percent adopted agronomic practices. Estimates of land coverage of Dutch vegetables shows that in 2019, about 50,000 hectares were under these vegetable varieties adopted by vegetable growers. This was only 12 percent of the total land coverage by about 20,000 vegetable farmers reached by the ISSD Plus project under the vegetable component. It is worth noting that tomato, cabbage and onion account for about 85 percent of the total land coverage of adopted varieties.

5.1.2 To what extent have variety demonstrations sites been effective in promoting variety awareness and uptake?

Demonstration sites were instrumental in driving variety awareness and uptake. The use of training sites and demonstration with field days and training events as extension approaches of promoting improved vegetable varieties were generally effective although they seemed not gender inclusive with more males than females benefiting. Many of the farmers indicated that they adopted after getting in contact with the varieties by viewing their performance on demonstration gardens. Dutch vegetable variety awareness levels for demonstration site farmers ranged between 30 percent and 95 percent. Farmers were more aware of onion, cabbage, and sweet pepper varieties. Tomato varieties were not well recognized by farmers because of a saturated input market with over 30 tomato varieties from other seed companies.

5.1.3 What is the relationship between spread/pattern of adoption farmers and the location of ISSD Plus' supported training and variety demonstration sites?

Generally adopting farmers were those in proximity with demonstration sites. The short project period could not allow a wide spread of adoption. Even spill over farmers were in most cases the neighbors of beneficiaries or who closely came in contact with demonstration or training sites. We can categorically say that the spread is still within a kilometer radius from the demonstration sites.

5.1.4 What are the reported/purported factors that enhanced or hindered adoption of advanced agronomic practices and quality seed of improved vegetable varieties?

Adoption of technologies and varieties have been known to be influenced by structural, economic, social and gender factors. Among the promoting factors for variety adoption were size of land where farmers with more land were more likely to adopt. Regional location also played a role. A farmer in Central Uganda was more likely to adopt a variety given the market access dynamics. Learning from a training site facilitated adoption more than just a demonstration site and farmers recommended combining the two approaches for better results. Affiliation to a particular Dutch seed company also promoted adoption of varieties given that this facilitated access to seed information and seed itself.

5.1.5 What are the characteristics of adoption farmers?

The average age of an adopter is 42 years though 36 percent of the adopters are youth aged below 35 years, 34 percent are women while the average household size has about 7 persons per household. Adopting farmers were generally smallholder vegetable growers operating about 0.8ha of vegetable gardens per season. About 78 percent of the adopters of improved vegetable varieties hire labour in their vegetable production activities. About 99 percent of the adopters earn a living from farming although 26 percent of them also have off-farm work. In addition, an adopter earns about 7 million Uganda shillings per season from growing vegetables.

5.1.6 What are the costs and benefits of the advanced technologies versus previously used technologies for farmers involved in the ISSD Plus project?

Farmers generally incur low costs in vegetable production across the regions. An average farmer with 1-2 acres of vegetable garden spends about 1 million Uganda shillings per cycle. In return, they earn about 7 million shillings in revenue and benefit from a gross margin of about 6 million shillings. Net benefits are however higher among eggplant, cabbage and tomato growers.

5.1.7 To what extent have the Vegetable brigadiers contributed to the ISSD Plus vegetable extension program (farmer outreach)?

The 118 trained vegetable brigadiers across the country trained and rolled out by ISSD Plus have so far reached out to about 392,700 farmers of whom 157,100 are females and 193,400 are youth vegetable farmers (See Annex 5)[34]. In terms outreach of approaches and methodologies used to train farmers, vegetable brigadiers have so far established about 6,530 demonstration sites and made 33,370 farm visits.

5.1.8 To what extent have the ISSD trained extension service providers adopted the ISSD Plus' and partners' extension methodology?

Findings showed that a high percentage of vegetable brigadiers that are applying the skills and approached that were trained by ISSD. Over 70 percent of the brigadiers indicated that they apply and train farmers in improved nursery systems and management, crop protection, vegetable growing as Business and other topics and areas trained under the program. Although many of the brigadiers were applying some of the methods before they joined the ISSD sector professionals program, the percentage using the trained methods have gone up. For example, only 66 percent were using demonstration gardens before and today 94 percent use the methodology. While only 78 percent used to visit farms before, today, 98 percent use the method.

5.1.9 What is the impact of radios shows on variety adoption?

The highest percentage of farmers that listened to radio were those benefiting from training events and demonstration sites. Radio shows increased the chances of adopting improved Dutch vegetable varieties by about 44 percent and adoption of advanced agronomic practices by 50 percent. More than among any other vegetable growers, radio shows had a higher impact on adoption of onion and cabbage varieties as compared to other vegetable crops.

[34] We sampled 51 out of 118 (43%) brigadiers and results indicated that the 51 had reached 125,710 farmers. We extrapolated this to get the total estimated number reached.

5.2 Recommendations

Therefore, we recommend that to advance the agenda of building a vibrant vegetable sector in Uganda, findings from this adoption study can form a bench mark for future sector interventions. The recommendations for improvement include;

1. Seed companies are encouraged to adopt the village/SC agent model to deliver seed to farmers at lower cost but increase/ease seed access.
2. Greater efforts that focus on subsidising seeds and critical inputs used in vegetable production can reduce the current high seed cost.
3. Marketing of the final produce is still a problem. Though exacerbated by COVID-19, market access has been a problem due to lack of collective action among farmers to take advantages of specialisation and economies of scale (in markets and input access). Functional produce markets will lead to a functional and vibrant seed sector.
4. Climate change continues to affect vegetable farmers. Irrigation in all its forms and scales will be critical in helping farmers to tap into the dry season market segment as well as overcome the effects of climate change.
5. Promotion activities should focus on fewer key regional vegetable crops for increased adoption.
6. Compared to males, fewer women farmers benefited from training sites yet many benefited from demonstration sites. It is highly recommended that design of interventions should consider the gender dynamics surrounding women participation in activities such as trainings that encroach on their workloads as home caretakers, food producers, and income earners and bread winners in female headed households. Flexible schedules and training curricula need to be designed to accommodate women in order to increase adoption impacts of technologies.

5.3 Lessons learned

From the results, field observation and stakeholder interactions, a lot came out that provides valuable lessons to learn from the ISSD Plus project's vegetable component and its interventions. Among the key lessons documented are;

i) Development projects and organisations such as ISSD can successfully partner with the private sector to deliver services that have huge impacts on the communities. The ISSD Plus project partnership with seed companies rolled out improved vegetable varieties and advanced

agronomic practices that have been adopted and have changed the livelihoods of many farmers in terms of increased incomes and food security.

ii) The extension system of a developing country such as Uganda can enormously benefit from the private sector-led and innovative extension approaches such as the sector professional training programme rolled out by ISSD Plus and her partners, demonstration sites, training sites and training events. Under such approaches, thousands of vegetable farmers were able to access extension services and gain lifetime skills that will impact on the vegetable sub sector in Uganda for years.

iii) Adoption focused projects need time to create impact on societies. However, the ISSD Plus partnership with seed companies was only 18 months, which was such a short time. Given the adoption levels registered in a short time, more would have been achieved if it was given more time and resources. Many farmers had just enrolled into the project when the time expired and were calling for continuation of the project. Hence, time was short to promote technologies and practices over a wide geographical area.

iv) Rolling out a number of interventions at the same time over a wide geographical area (countrywide) can overstretch projects since resources are scattered over many demands. The ISSD Plus vegetable component implemented a number of interventions such as training events, training sites, sector professional program, radio and use of demonstrations at the same time. We believe that a phased implementation would have delivered more impacts that what is reported now.

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ANNEXES

ANNEX 1: FARMER'S MOST IMPORTANT VEGETABLES

	Percentage of farmers				
Vegetable	**Central**	**Northern**	**Eastern**	**Western**	**Overall**
Tomato	45.18	69.28	29.34	14.01	35.78
cabbages	28.92	17.65	17.77	15.96	20.79
Pakchoy	0.6	3.92	0.83	0	0.97
Okra	0	2.61	2.48	0	0.97
pepper	4.52	2.61	1.24	0.33	2.22
onion	3.01	1.96	40.91	56.68	27.66
Others (Brocolli, beetroot,sukuma, water melon)	0.9	1.31	6.2	4.56	3.29
Nakati	6.33	0.65	0	0	2.13
carrots	0.9	0	0	7.17	2.42
Cucumber	1.51	0	0	0	0.48
Pumpkin	0.3	0	0	0	0.1
Spinach	0	0	0	0.33	0.1
Bbugga (Red amaranthus)	1.2	0	0	0	0.39
Doodo (green amaranthus)	0	0	0	0.33	0.1
Bitter tomatoes	4.22	0	0.41	0.33	1.55
Egg plant	2.41	0	0.83	0.33	1.06

ANNEX 2: NUMBER OF FARMERS ADOPTING IMPROVED VARIETIES OF OTHER ISSD PROMOTED CROPS

Date	Activity	Location	Team	Number of field days	Remarks
Monday 7th – Wed 9th Sept 2020	Enumerator training & Tool Pretesting	**Kampala TIME 8AM- 5PM**	ALL Teams	3 days/	**Training Venue: GARDEN HOTEL, KAWEMPE MBOGO**
Thursday 10th Sept	Depart to field		ALL Teams		
Friday 11th Sept to 29th Sept	Field work	Kabale,Rukiga, Kisoro, Ntungamo & Kasese	Team D	20 days	• 20 days for Western Uganda (Total sample size=655 farmers/TOTs) • FGDs • KIIs & case studies
Friday 11th Sept to 22nd Sept	Field work	Wakiso, Mukono & Luwero	Team A	12 days	• 12 days for central Uganda (Total sample size =356 farmers/TOTs) • FGDs • KIIs & case studies
Friday 11th Sept to Wednesday 18th Sept	Field work	Gulu & Lira	Team C	8 days	• 8 field work days for Northern Uganda, 2 travel days, (Total sample size 162 farmers/TOTs) • FGDs • KIIs & case studies • Seed company
Friday 11th to Wednesday 25th Sept	Field work	Jinja, Tororo, Mbale, Namisindwa, Luuka & Kapchorwa	Team B	15 days	• 15 field days for Eastern Uganda (Total sample size=450 farmers/TOTs) • FGDs • KIIs & case studies
22nd Sept -2nd October	Field work	Kampala	Experts	11 days	• KIIs with ISSD, Seed companies • Case studies with seed companies

Number of farmers

Region	Spinach		Pakchoy		Pumpkin		Total
	2017	2020	2017	2020	2017	2020	
Central	0	0	1	3	0	1	5
Northern	0	0	0	3	0	0	3
Eastern	0	0	8	8	1	1	18
Western	2	3	0	0	0	0	5
							0
Overall	2	3	9	14	1	2	31

ANNEX 3: ADOPTION STUDY FIELD DATA COLLECTION ITINERARY

- ***NB: Team A=Central, Team B=Eastern, Team C= Northern, Team D= Western***
- ***Variation in field days per region is due to differences in ISSD interventions across regions***

Date	Activity	Location	Team	Number of field days	Remarks
Monday 7th –Wed 9th Sept 2020	Enumerator training & Tool Pretesting	**Kampala TIME 8AM-5PM**	ALL Teams	3 days/	**Training Venue: GARDEN HOTEL, KAWEMPE MBOGO**
Thursday 10th Sept	Depart to field		ALL Teams		
Friday 11th Sept to 29th Sept	Field work	Kabale,Rukiga, Kisoro & Kasese	Team D	19 days	• 19 days for Western Uganda (Total sample size=655 farmers/TOTs) • FGDs • KIIs & case studies
Friday 11th Sept to 20th Sept	Field work	Wakiso, Mukono & Luwero	Team A	10 days	• 10 days for central Uganda (Total sample size =356 farmers/TOTs) • FGDs • KIIs & case studies
Friday 11th Sept to Wednesday 16th Sept	Field work	Gulu & Lira	Team C	6 days	• 6 field work days for Northern Uganda, 2 travel days, (Total sample size 162 farmers/TOTs) • FGDs • KIIs & case studies • Seed company
Friday 11th to Wednesday 23rd Sept	Field work	Jinja, Tororo, Mbale & Kapchorwa	Team B	13 days	• 13 field days for Eastern Uganda (Total sample size=450 farmers/TOTs) • FGDs • KIIs & case studies
22nd Sept -2nd October	Field work	Kampala	Experts	11 days	• KIIs with ISSD, Seed companies • Case studies with seed companies

ANNEX 4: GROSS COSTS, REVENUES AND MARGINS BY ADOPTERS AND NON-ADOPTERS OF IMPROVED VEGETABLE VARIETIES

	Costs(UGX)		Revenues(UGX)		Gross margins(UGX)	
Region	**Non-Adopter**	**Adopter**	**Non-Adopter**	**Adopter**	**Non-Adopter**	**Adopter**
Northern	163,035.10**	195,371.40	7,200,719.00***	27,100,000.00	7,037,686.00***	26,900,000.00
Central	502,398.30	555,595.80	2,502,239.00	21,500,000.00	1,999,863.00*	21,000,000.00
Eastern	1,057,926.00	1,391,396.00	3,934,955.00 **	8,873,592.00	2,869,852.00 **	7,454,528.00
Western	2,570,735.00	2,599,983.00	3,403,308.00	8,703,341.00	897,100.00	6,556,577.00
Overall	875,138.60**	1,283,733.00	5,862,176.00 **	12,800,000.00	4,993,432.00	11,600,000.00

Significance:***1%,**5%

Annex 5: NUMBER OF FARMERS REACHED BY BRIGADIERS

Brigadier No.	Total (Male+Females)	Male farmers	Female farmers
1	60	0	60
2	2000	400	1600
3	570	430	140
4	1000	700	300
5	15	5	10
6	750	350	400
7	800	650	150
8	5000	1500	3500
9	250	100	150
10	2900	1500	1400
11	7	5	2
12	3	1	2
13	350	150	200
14	100	70	30
15	190	90	100
16	4250	1250	3000
17	205	85	120
18	650	300	350
19	8000	5200	2800
20	20000	13000	7000
21	500	300	200
22	5000	2750	2250
23	4000	2200	1800
24	230	80	150
25			
26	80	10	70

27			
28			
29	2880	864	2016
30	110	60	50
31	80	40	40
32	12000	8000	4000
33	22000	15000	7000
34	15000	10000	5000
35	1500	700	800
36	3000	1200	1800
37			
38	3600	1500	2100
39	240	100	140
40	10	5	5
41	145	67	78
42	3350	1340	2010
43	220	100	120
44	250	100	150
45	205	105	100
46	380	250	130
47	3000	1000	2000
48			
49	350	260	90
50	180	120	60
51	300	170	130
Total		**72107**	**53603**

ANNEX 6: MATRIX OF INDICATORS

Indicators	Result
Percentage of trainees who adopted the technologies enrolled by category (level and Intensity of adoption agronomic practices, Varieties, events, demos, sites) farmers	– 22.8% adopted agronomic practices & 33% adopted improved crop varieties from demonstrations – 62% adopted varieties & 23% adopted agronomic practices from training events
Percentage of adopters of promoted varieties	Tomato 25%; Cabbage 51%; Onion 24%
Level of adoption of advanced agronomic practices among vegetable growers	22.8%
Total area under adopted improved vegetable crop varieties by 2020	116,792acres (47,265 ha)
% of unintended beneficiaries (Spillovers) in the project areas who benefited by 2018,2019,2020	By 2020 30% spillover farmers growing tomatoes; 26% growing cabbage; 5% growing onion; 2 % growing carrot & cucumber; 4% growing sweet pepper, Bitter tomato & eggplant;
Number of promoted technologies from which unintended beneficiaries benefited in the project areas who by 2018,2019,2020	3 (Demos, Training sites, Training events)of
Percentage of the farmers that are aware of improved varieties, by providers and accessed information from demonstration sites;	– 39% aware about improved tomato varieties – 82% aware about improved cabbage varieties – 67% aware about improved sweet pepper varieties – 28% aware about improved onion varieties – 95% aware about onion varieties – 28% aware about improved carrot varieties
Percentage of farmers that are using the improved varieties	– Tomato 25%; Cabbage 51%; Onion 16%
Percentage of farmers that have purchased improved variety[35]	– Tomato 25%; Cabbage 51%; Onion 16%
Income levels of farmers adopting most advanced agronomic practices and use quality seed of improved varieties(% of low, medium & high income farmers)	– Income of adopters=UGX 6,013,809.70 – 69.24% low(<=UGX 5million),10.39% medium(5-20million,& 20.38% high(>20million) per cycle
Gender composition(by %women, %youth) adopting most advanced agronomic practices and use quality seed of improved varieties	– Variety adopters:Youth-35.35%, women 32.83% – Advanced practice adopters: Youth- 34.74%, women 32.26%
Costs incurred from using advanced technologies versus previously used technologies	Adopters spend UGX 215,037.50 /cycle higher than non-adopters
Income (net benefits) per HH per crop cycle: difference between cost of production and price (gender disaggregated)	Adopters get UGX -488,322.10 less benefits than non-adopters
Level of satisfaction with the ISSD Plus vegetable extension program	74% TOT were very satisfied with the extension program
Spread of trainees(Vegetable Brigadiers) who adopted the ISSD Plus vegetable extension program strategies	Central 23%, West 22.9, East 23.2 , North 30.7

[35] Percentage farmers currently using improved varieties=percentage purchasing improved varieties

Indicators	Result
Level of adoption of most advanced agronomic practices and use quality seed of improved varieties by area of operation of Vegetable brigadiers	[36]39.5%
Number of extension methods adopted and used by vegetable brigadiers	12
% of farmers using improved technologies as adopted from vegetable brigadiers	39.5%
% of trained ISSD extension workers/brigadiers who adopted the ISSD PLUS extension methodology	74%
Percentage of the sampled project beneficiaries who accessed information of varieties from the Radio	48.92%
Percentage of sampled project beneficiaries who had access to information through radio and have adopted/used the knowledge	47.79%
Lessons learned/Success stories by farmers & by trained extension service providers.	– Time was short to promote technologies and practices – Over stretching in terms of number of interventions such as training events, training sites, radio and use of demonstrations – Over stretching in terms of geographical coverage in a very short period of time
Trends/Changes in business flow since start of the project	Revenue from improved variety seed sales(176%-2018, 11%-2019,-33%-2020[37]
Value of vegetable seeds traded	US$ 64million between 2017 and 2020,
Number of varieties introduced per crop from 2017 to date	– Tomatoes (10 varieties) – Cabbages (10 varieties) – Onion (8 varieties) – Sweet pepper (2 varieties)
Level of outreach by participating seed companies	10,000 farmers (estimates for 2 seed companies)
Number of agro dealers the seed companies are dealing with since 2017	1500 Agro dealers
Number of vegetable producers receiving training at the sites	- 97,862 farmers were getting training at training sites[38]

[36] Adoption level is averaged for (Proper nursery management, fertiliser application, soil and water conservation, pest and disease control and proper use of pesticides

[37] The negative growth in 2020 is mainly attributed to COVID-19 pandemic since many farmers failed to sell their vegetables to lucrative markets across the borders

[38] 25 percent of sampled farmers were getting trainings at training sites yet total farmer outreach was estimated at 392,704 farmers for 4 years.

ANNEX 7: DUTCH SEED COMPANY CONTRIBUTION TO UGANDA SEED TRADE

crops by DUTCH varieties	Mean annual seed cost per farmer (UGX)	%GROWERS	Number of farmers reached	Number of adopters				PERCENTAGE OF ADOPTERS				Total seed revenue by DUTCH companies(UGX)					Revenue seeds US$				Grand Total(US$)
				2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020	Grand Total(UGX)	2,017	2,018	2,019	2,020	
Tomato	275,949	49.43	194,113.59	25,545	52,352	42,142	30,651	13.16	26.97	21.71	15.79	7,049,224,496	14,446,624,974	11,629,077,797	8,457,998,085	41,582,925,352	1,922,341	3,879,330	3,165,098	2,263,312	11,230,082
Cabbage	346,909	50.46	198,158.44	20,331	60,973	71,139	28,792	10.26	30.77	35.9	14.53	7,053,025,416	21,152,201,955	24,678,714,663	9,988,348,860	62,872,290,894	1,923,378	5,679,968	6,716,832	2,672,825	16,993,004
Onion	967,750	34.19	134,265.50	11,748	30,210	41,958	31,888	8.75	22.5	31.25	23.75	11,369,350,589	29,235,472,943	40,604,823,532	30,859,665,884	112,069,312,948	3,100,451	7,850,557	11,051,458	8,257,872	30,260,337
Carrot	332,000	7.21	28,313.96	2,574	12,869	5,147	7,721	9.09	45.45	18.18	27.27	854,481,288	4,272,406,439	1,708,962,576	2,563,443,863	9,399,294,165	233,019	1,147,263	465,130	685,963	2,531,375
Sweet Pepper	85,909	6.39	25,093.79	2,281	6,843	9,124	6,843	9.09	27.27	36.36	27.27	195,960,794	587,882,382	783,843,175	587,882,382	2,155,568,732	53,439	157,863	213,339	157,314	581,956
Bitter Tomato	68,333	1	3,927.04	-	-	1,571	-	0	0	40	0	-	-	107,339,093	-	107,339,093	-	-	29,215	-	29,215
Eggplant	362,500	4.74	18,614.17	-	9,307	4,654	4,654	0	50	25	25	-	3,373,818,240	1,686,909,120	1,686,909,120	6,747,636,480	-	905,966	459,128	451,407	1,816,501
																234,934,367,665					63,442,469
			OUTREACH									Exchange rates									
		TOT/Brigadiers	392,704									**2017**	**2018**	**2019**	**2020**						
		TE	1,295									3,667	3,724	3,674	3,737						
		TS	23,265																		
		DEMO	17,218																		
		TE,TS,, DEMOS	41,778																		

ANNEX 8: FARMER CASE STUDIES

Farmer case study one

Name: **Adongo Suzan** Sex: **Female** Age: **23 years** District: **Tororo**

Adongo Suzan is a 23 year old female vegetable farmer. She is a resident of Kabosa village, Kwapa Sub county, Tororo district in Eastern Uganda. She grows green chili, Sukuma and cabbage as the main vegetables. Under ISSD Plus, she said she has worked with several seed companies including East West, Syngenta, House of Seeds and Home Harvest between 2016 and 2018.

Photo Credit: Sebatta Christopher & Kyomugisha Harriet

When asked about the vegetable varieties she grows and her farming journey under ISSD Plus, she said "I started growing collards because of my interaction with SimLaw Company, the distributor of Syngenta seeds in our area. They gave us trainings after which we bought our first vegetable seed packs. We were 30 farmers of whom only 4 bought a Sacket each at Shs. 12,000. When working with Home Harvest, I started growing hot pepper as well in 2019 starting with one tin of seeds".

Suzan said that before interaction with these vegetable seed companies in 2016, she used to grow pumpkin, cereals like maize and small portions of local vegetables like small Gobe from where she would get very little money. She was quoted saying: "The incomes generated were always very little compared to the cost of production". She attributes this to lack of knowledge and skills in vegetable growing coupled with difficulty in market access. The strategy of sensitization and trainings in vegetable growing has changed her life for the better because she can now easily acquire basic needs compared to before. She got skills in managing her vegetable garden. She says she can now more easily access quality vegetable seeds than before when she was not working with any seed company. Suzan further attributed her success in vegetable growing to the trainings and more so farmer exchange visits like the visit they had between Tororo and Hoima farmers in addition to the market linkages such as with the Kenyan market.

In spite of all this success, Suzan still faces some challenges as a youth vegetable farmer including: drought as she can't afford an irrigation system; and expensive agricultural inputs like fertilizers, and pesticides. It is on these grounds that she recommended subsidizing of the agricultural inputs to make them more affordable.

Farmer Case study Two

Name: Moses Kakonge Sex: **Male** Age: **68 years** District: **Mbale**

Moses Kakonge is a male vegetable farmer aged 68 and a retired driver. He is a resident of Kaloja village, Kabwangasi Sub-county, Mbale district, Eastern Uganda. Since 2014 to date, Moses has worked with different vegetable seed companies namely; House of seeds, Holland Green Tech and Home Harvest. He currently grows onions (terranova seeds), Okra (safari), tomato, cabbages, green pepper (California wonder) and eggplant. In his interview, Moses said that he used to grow cereals and grains like maize, rice, beans, and local vegetables like Doddo, Gobbe, Jobyo, local pepper and eggplants before collaboration with these seed companies.

Moses was a tour and travel driver when he met strangers from Dutch vegetable seed companies in 2014 who changed his thinking from growing cereals to horticultural crops. Based on the successive trainings he attended since 2017 such as the one held in Royal suites Bugolobi by House of seeds, Moses got exposed to superior vegetable varieties. From such interactions, he got a lot of skills and knowledge in vegetable growing which earned him some money and enabled him to expand his vegetable production.

Photo Credit: Dominic Chemutai

Moses was quoted saying: “Before the trainings, I used to grow inferior vegetable varieties and on a small scale. For instance, I used to grow green pepper on half an acre in 2016, but after that, I increased to two acres, and now in 2020 I have increased to four acres because I am now skilled, I can access the market and I use superior and higher yielding varieties. I grow vegetables intensively, in that I harvest more when I plant a small area. For example, when I plant one acre of onions, I usually harvest 100 bags, and with two acres, I got 60 million shillings in just one season”.

When asked about his experience in vegetable growing, Moses said that his life has been transformed through vegetable growing under the ISSD Plus project. He mentioned that his family is now food secure because he sells a bag of onions at 300,000 Uganda shillings and buys a lot of food, and his children now go to expensive schools. He added: “Surely Okra built my house”. Never the less, even with these recurrent episodes of success, Moses mentioned the challenge of expensive seed, the hot weather that sometimes hinders proper vegetable growth, and also failure of seed companies to follow up on farmers. He strongly recommended that seed companies should follow up on farmers they train at all stages and that the program should be farmer demand driven.

Farmer Case study Three

Name: Lubwama Lawrence Tebesigwa Sex: **Male** Age: **68 years** District: **Mukono**

Lubwama Lawrence is a male vegetable farmer aged 46 years and is a resident of Kaama village, Nagalama town council in Mukono district in Central Uganda. He has been engaged in vegetable farming for the past 15 years and has been engaged in cabbage growing. Before the ISSD project, the farmer used to grow three cabbage varieties namely Green boy, Gloria and Miira with limited success due to susceptibility of the above varieties to black rot which could cause 100% yield loss. The farmer took a one year break from producing vegetables. However, after engagement with ISSD PLUS project in 2019, the farmer started producing Tacoma cabbage variety.

Photo Credit: Stella Namazzi

Mr. Lawrence's interaction with the ISSD Plus Project started when he was identified to manage a demonstration garden for his farmer group through the government extension worker and local council leader. However, due to varying interests among the 15 group members he was left to manage the garden up to the field day. As a reward he was given a coordination role to mobilize and encourage other farmers in his area to grow improved cabbage and tomato varieties that have been promoted by the ISSD PLUS Project through Holland Green tech Seed Company.

Mr. Lubwama attributes his success to the increased trainings on vegetable production and agronomy he has been able to acquire from agronomists from Holland Green Tech Seed Company. As a coordinator he has managed to sell 130 packets of Tacoma cabbage variety each containing 100 seeds and 30 packets of Garmah and Jarrah tomato varieties in a period of six months and he has been in a position to reach more farmers beyond his sub county and currently has farmers who buy seed from him as far as 30Km. Mr Lubwama attributes his success to being trust worthy and honest. For instance he narrates a situation were he has given 50 sackets of cabbage and 10 sackets of tomatoes without paying any advance to the seed company. Despite his success as a coordinator, he expressed that the adoption of improved tomato seeds is still limited by the high price of the seeds especially for UWEZO tomato variety were for instance a pack of 100 seeds costs 36000 Uganda shillings. He therefore advised seed companies to subsidise on the prices for preffered crop varieties. He concluded by recommending an improvement in the compactness of the Tacoma variety as a way of increasing on its marketability.

Farmer case study Four

Name: Jude Kalemba	Sex: **Male**	Age: **48 years**	District: **Wakiso**

Photo Credit: Stella Namazzi

Kalemba Jude is a male vegetable farmer aged 48 years and a resident of Luguzi village, Namayumba town council, Wakiso district. His interaction with the ISSD Plus project started in 2018 when he was approached by one of the agronomists for Holland Green tech to establish demonstration gardens around Namayumba town council. Before this interaction, Mr. Jude used to grow Gloria cabbage variety and Ancil tomato variety. However, after receiving a number of trainings from Holland green tech training site in Magere in Wakiso district, he changed to growing Garma tomato and Tacoma improved cabbage varieties, which he adopted up to today. According to him, the new improved tomato varieties that are being promoted by Holland Green Tech are high yielding. He noted that "Before Holland Green Tech I was harvesting between 20 tonnes and 26 tonnes of tomatoes per acre but currently I harvest up to 50 tonnes of tomatoes from Garma variety. He said that he used the first income to buy a piece of land and intends to start constructing a house in 2021. Garma 200boxes in an acre 10,000 heads

As a field coordinator he has continued promoting the production of improved vegetable varieties and has been able to reach out to 480 Village health teams in North Busilo County. He has also been engaging with other organizations engaged in coffee value chain such as NUCAFE and COMFARNAT who are interested in their farmers - diversifying incomes through vegetable farming before they start earning from coffee. In addition, he has been in position to train 760 home care facilitators under Red Cross in vegetable production and will be establishing vegetable demonstration gardens for Wakiso district and Buganda government in 2021.

Jude says his success is to a greater extent due to the quality and life changing trainings from Holland green tech Seed Company on vegetable production and agronomy he has been able to acquire from agronomists.

Farmer case study Five

Name: Solomon Luyimbazi Sex: **Male** Age: **40 years** District: **Kisoro, Mabanda**

Photo Credit: Aspa Mugabe

Solomon Luyimbazi is a proud male onion grower aged 40 years, and a citizen of Matugga village, Mabanda sub county, Kisoro district in Western Uganda. He currently grows red coach, red king and afri-seed onions. Before interaction with House of Seeds in 2017, Solomon used to grow open pollinated onion varieties (Kikutiya and Azela).

When asked about his experience with superior onion varieties, Solomon said that there is a big difference between the quantities of onion he used to harvest from the local varieties and now with the improved variety, Red coach. During his interview, Mr. Luyimbazi was quoted saying, "I used to harvest five bags from my garden of 'Kikutiya and Azela' varieties, but now I harvest between sixteen to eighteen bags of Red coach from the same garden". Worth noting is that Mr. Luyimbazi affirmed the wide coverage by small quantities of Red coach seed (high seedling rate) compared to the local onions at planting. He was cited saying: "One kilogram of 'Kikutiya and Azela' used to plant three gardens but with Red coach, one kilogram can plant nine and half gardens.

None the less, he said that marketing of superior Red coach is easy because of the high quality and long shelf-life of the produce. This has generated for him a steady and higher income than before which has enabled him to increase acreage under vegetable production hence increasing food and income security, and his family's standards of living. He said: "I have now built a permanent house, I have milk in plenty for both home consumption and for sale because I bought Friesian cows". In addition, Mr. Solomon was also quoted proudly saying; "I am far better off than many government workers in terms of financial stability all because of red coach". Mr. Luyimbazi attributes this series of successful events to the trainings through the demonstration sites set up by House of seeds company and the superior variety Red coach. However, even with such praises and credit go to House of seeds and Red coach, Solomon has had challenges including; late delivery of seeds, drought yet without irrigation equipment, and less time of interaction between trainers and farmers. For this very reason, Solomon recommended that there should be more trainings and monitoring of farmers to have a complete transition, and that these trainings should thoroughly exploit the farmer's demands.

ANNEX 9: SEED COMPANY CASE STUDIES

Sygenta seed company case study

Syngenta is a global seed company with 150 years of existence with its headquarters in the Netherlands. Currently, the company is promoting over 1000 varieties of improved seeds worldwide. The company has been in existence in Uganda for the past four years and runs two departments, one focused on promotion and distribution of vegetable seeds and the other focusing on chemical distribution.

The partnership between Syngenta Seed Company and the ISSD Plus project was initiated in February 2019. The purpose of the partnership was to promote vegetable production technologies including improved vegetable varieties. A number of approaches were used to promote the vegetable varieties including establishing demonstration gardens where a total of 50 demonstrations were established mainly in Central and Eastern Uganda. In addition, the company also used radio campaigns to promote its vegetable varieties and these were mainly aired on NBS FM in Jinja, Open Gate FM in Mbale and KRC FM in Fort portal. In addition team members from Syngenta also participated in the training of trainers program organized by ISSD.

During the 18-months partnership, a total of four cabbage varieties were promoted, namely; Escazu F1, Gloria F1, Tamisa and Riva (Red cabbage), the latter two being newly introduced during the partnership period. In addition, a total of two tomato varieties (Kilele and Rafano) and sweet pepper varieties (Crusader F1 and Indra F1) and one water melon variety (Fahari) were promoted.

One tomato variety (Rafano) was introduced on the Ugandan market in early 2020 while Fahari water melon was introduced in 2019. It is important to note that the partnership has led to an increase in the adoption of new varieties such as Kilele and Indra and increased awareness about improved vegetable varieties and hence increased adoption especially in Eastern Uganda in the districts of Soroti, Katakwi, Mbale, Tororo, Jinja and Namutumba. The company has reached about 5000 farmers (98 percent being males and 2 percent women while youth account for 12.5 percent). Syngenta has also established two new partnerships with Faith Agro inputs (to distribute Indra and Fahari F1) and Grow more seeds Limited to distribute (Tamisa and Rafano).

The company boasts of increased numbers of field days conducted from 2 to 12 every season. The partnership has also resulted into a 25 percent increase in the value of sales from US$1.2million to US$1.5 million. In terms of market share, Gloria FI accounts for 75%, Kilele 15%, Escazu 5%, Crusader 3% and Indra and Fahari 2% .The Company projects a 15% increment in their sales value in the next 3 years. The country manager is committed to continue lobbying for increased budget allocation towards establishing demonstration gardens from their headquarters in the Netherlands given these successes.

Home Harvest seed company case study

Home harvest Uganda is a distributor for a number of global companies. Its core business includes seeds, agrochemicals and fertilizers. The partnership between Home harvest and ISSD Plus project started in February 2019. Among the approaches used to promote improved vegetable varieties was establishment of demonstration gardens where a total of 40 demonstrations were established. According to the country manager, the partnership has resulted into the promotion of two tomato varieties (Volos F1 and Vilani F1), three cabbage varieties (Tanna F1, Karibo F1 and Red cabbage), two egg plant varieties (Ebony F1 and Karna F1) and Red King F1, an onion variety. In order to promote improved seeds in areas which were not readily accessible, the seed company initiated the agent model where farmers access seeds locally through agents in their communities.

In terms of success, the company has reached out to more agents with their seeds from 150 when the project started in 2019 to 1500 currently. Further still, the company has expanded into hard to reach territory in the districts of Mbale and Kabale reaching about 5000 farmers with improved vegetable seeds. The partnership has impacted on the business as evidenced by the fact that the company's sales revenue base has grown by US $20,000 from US$80,000 (75%) in only one year. Further still the company has been in a position to expand its team from 4 to 13 full time staff.

Some of the factors that have led to the success of the company include; putting in place a competitive pricing strategy, use of the agent model and use of demonstration gardens as an approach to disseminate knowledge about improved varieties and advanced agronomic practices to the farmers. In addition, the contribution of the radio towards creating awareness about improved varieties cannot be underestimated.

In order to sustain their new market the company intends to upscale some of the approaches that have proved to be successful such as agent model by recruiting more agents, intensifying the use of radio promotions, establishing more demonstrations for farmer learning and establish a multi-stakeholder platform to ease communication among key stakeholders the company is dealing with.

Holland Green tech is a Dutch horticultural input supplies company that aims at linking the whole value chain in vegetable production. Started operations in Uganda in 2016. The partnership between Holland Green Tech and ISSD Plus project started in 2017. In order to promote the improved vegetable varieties, the company carried out a number of activities that included identifying potential farmers to host the demonstrations, which were later trained in establishing demonstrations. The trained demonstration host farmers were provided with inputs and these later established demonstration gardens at different sites. These farmers were supported thought the whole production cycle and once the crops reached maturity farmer field days were organized to introduce the new varieties to the farmers. During the partnership the company promoted three tomato varieties (Gamhar RZ F1, Jarrah RZ F1 and UWEZO), two cabbage varieties (Tacoma RZ F1 and Toughma RZ F1), one cucumber variety (Mydas RZ F1), two eggplant varieties (Kazinga RZ F1 and KERIO RZ F1). It is important to note that all the promoted varieties were on the market even before the ISSD Plus project.

During the partnership, the company has registered an increase in sales volumes of the target crops' seeds. For instance up to 599 tons of tomatoes, 849 tonnes of cabbage, 10 tons of cucumber, 12 tons of eggplant and 77 tons of African eggplant have been sold as seed. Other indicators of success show that the company has reached 4000 farmers and has managed to create 15 business partnerships. Un like other seed companies which use dealer shops to market their vegetable seeds, Holland Green Tech promotion efforts have focused on the use of demonstrations as avenues for promoting improved vegetable varieties and these double as channels for seed sales. According to the country manager, the partnership has enabled the seed company to increase on the market share and to increase on the geographical coverage for instance currently, the company is engaged in the promotion of tomatoes in Kasese district in Western Uganda and has intensified efforts in promoting cabbages in Mukono district while in Wakiso it has focussed on promotion of both cabbages and tomatoes.

Going forward the company, hopes to increase its tomato seed sales to 800 tonnes in 2021 which will further increase to 1000 tonnes in 2022 and 1200 tonnes in 2023. Similary, the company projects to increase its cabbage sales volume to 1000 tonnes in 2021 which will then increase to 1300 tonnes and 1500 tonnes in 2022 and 2023.

Annex 10: Where varieties were promoted by region and crop

Tomato	**Where variety was promoted**			
Adopted tomato variety	**North**	**East**	**West**	**Central**
Gammar F1				Yes
Padma F1	Yes	Yes		
Uwezo F1		Yes		Yes
Jarrah F1				Yes
Anja F1			yes	Yes
Kuber F1		Yes		
Cabbage	North	East	West	Central

Adopted cabbage varieties				
Gloria F1	Yes	Yes	Yes	Yes
Tacoma F1				Yes
Escazu F1		Yes	Yes	Yes
BowieF1			Yes	
Bavero F1		Yes		
Indica F1	Yes	Yes		Yes
Karibo F1		Yes		
Nuzaka F1				
Fanaka F1			Yes	
Onion				
Onion varieties adopted	North	East	West	Central
Red coach		Yes	Yes	Yes
Red passion			Yes	
Super Yale	Yes	Yes		

ANNEX 11: TOOLS USED IN DATA COLLECTION AND PRESENTATIONS