International Journal of Agriculture, Environment and Bioresearch

Vol. 07, No. 06; 2022

ISSN: 2456-8643

DIAGNOSTIC OF THE CURRENT LIVELIHOOD EVOLUTION, FARMING PRACTICES, PRODUCTION CONSTRAINTS, POST-HARVEST PROCESSING, TRADING AND VALUE-CHAIN SYSTEMS OF SWEETPOTATO IN NORTH-KIVU PROVINCE, EASTERN OF DRCONGO

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https://doi.org/10.35410/IJAEB.2022.5778

ABSTRACT

Although in many countries of Sub-Sahara Africa, sweet potato has been found to be very important for food security for farmers who depended on it for their livelihood, little documentation on the production constraints, preferences for sweetpotato genotypes by farmers, pre- and post-harvest handling and value chain issues were available for North-Kivu province. Hence, a survey assessment was conducted (March-December 2021) in major sweetpotato growing territories in North-Kivu province. Data was collected through field visits, semi-structured interviews, focus group discussions and field observations after structured questionnaire have been administered to farmers. Descriptive statistics were applied to analyze the data. The results indicated that sweetpotato is grown by rural households for food and cash, and women play a major role in cultivating the crop. The crop was cultivated on small plots, mainly in upland areas, during the rainy season and sometimes in valley bottoms during dry season. Most farmers provide their own planting materials or obtained vines free from neighbours. Vines were usually planted on mounds. Ridges were used in highland areas in lieu of mounds as a way to control soil erosion/land slide impacts. Sweetpotato is commonly sole-cropped, although it is occasionally intercropped with beans, maize, banana, and other crops. Key attributes for maintenance of varieties were access to healthy planting material availability and distribution, tolerance abiotic stresses, resistance to biotic stresses, good taste and high root yield , early maturity, cookability, low perishability during storage. Piecemeal harvesting was common except when larger quantities are harvested for sale. During the harvest period, people consume sweetpotatoes every day and sometimes for every meal. Peeling & boiling or steaming is the most common method of preparation. Pests and diseases were reported to be associated with severe and high yield loss although incidence of pests and diseases were of high seasonal variations. The overall identified factors constraining productivity included shortage of land and planting materials, landrace low yield, some variety high sensitivity to weeds, diseases and insect pests aggressions, inaccessibility to financial credits. Post-harvest and value chain constraints included: high labour and transport costs, poor access to markets & low market prices, inaccessibility to improved varieties, a lack of knowledge on processing and equipment, packaging, marketing and transportation problems, inadequate extension services and postharvest losses. Farmers indicated that flood and landslide/soil erosion were serious

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abiotic stresses. The result showed that age, education level of household head, land and household sizes, input costs, livestock ownership, access to market information and to financial credit or extension services, output and sales revenue may have a significant impact on outcome and affect household gross margin. Thus, enhancing farmers' access to market information, boosting the production and productivity of the crop through better extension services and infrastructures, awareness creation on gender balanced market engagement and improvement in transportation facilities are the critical points that should get policy attentions in the study area. Results of this study can serve as a baseline reference for strategic breeding and other interventions to develop sweetpotato varieties according to the needs of the farmers.

Keywords: Current, rural appraisal, Sweetpotato farming, Variety attributes, Production constraints, Post-harvest issues, Marketing, value chain , New breeding strategies, Kivu, DRCongo.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* Lam.) is a dicotyledonous tuberous plant of convolvulaceae family. , it thrives in the tropical, subtropical and in some temperate regions of the developing world (Oloniyo et al.2021) where it is an important staple crop. It has a short growing cycle of four to five months into maturity. Sweet potato allows multiple harvests and thus, ensures poverty alleviation, food security and income to rural households in lean seasons. It plays a major role in human diet, animal feed, and industrial raw materials (Neela and Fanta 2019, Abong et al.2020).

Sweet potato is an herbaceous perennial vine. The crop is a sweet tasting tuberous root vegetable (Adejuwon et al.2019). Sweet potato leaves are the traditional indigenous vegetables and most economically efficient source of micronutrients in terms of both land required and production costs per unit (Kuddus et al. 2020,Mark and Korpu 2020) .

Sweetpotato has many positive attribute such as production of more carbohydrate per unit area per unit time than other root crops, has short production cycle, grows well in many agro-ecologies, requires low inputs and is fairly tolerant to production stresses such as high temperature, water deficits, insects, diseases and low soil fertility. The crop has a good adaptive ability due to the short growth cycle and ability to survive in diverse agro-ecologies, marginal lands and water stress soils . Sweet potato grows well under harsh conditions and highly resistant to droughts , soil erosion and can survive where other crops cannot and has a short growing season.

The crop is also primarily grown for home consumption, thus in some areas, it is produced for the markets in both rural and urban areas and serves as source of various foods for human and livestock. In addition, sweet potato is easy to prepare and does not require much effort.

Sweet potato is rich in many vitamins, minerals, and beneficial fibers (Lubowa et al.2014, Mbithe et al.2016) The unpretentious sweet potato's antioxidant, vitamin, and mineral values make it a "superfood". Calorie-wise, sweet potato is an ideal food (Mahmud et al.2021). Both its roots and leaves are consumed as source of energy, essential minerals and vitamin A. Naturally sweet, one medium potato has only 105 calories with four grams of fiber and, unless it is served

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with butter, zero fat (Mahmud et al.2021). It also supplies 43.8% of the daily value of vitamin A and 37% of the daily value of vitamin C, as well as being a good source of important B vitamins, manganese, copper, and iron.

There is also good evidence from medical studies that antioxidants in sweet potatoes may be beneficial in preventing several chronic and deadly diseases, including diabetes and cancer (Mahmud et al.2021, Adejuwon et al.2019).

In sub-Saharan Africa, more than 40% of children under five years of age suffer from vitamin A deficiency (Low et al.2017). The crop is a source of vitamin A that serves in prevention of vitamin A deficiency related health problems. Among several interventions in place to address vitamin A deficiency is biofortification, breeding vitamin A into key staple crops. Staple crops biofortified with beta-carotene, the precursor to vitamin A, are orange in color(Low et al.2017) . Given the natural occurrence of high levels of beta-carotene in many sweet potato varieties, breeding progress for biofortified orange sweet potato has been much faster than for the other vitamin A enhanced staples (Low et al.2017, Laurie 2010) .

The varieties of sweet potato depends on either their skin, flesh colour and even both. Its colour ranges from orange, red, purple, yellow, brown, cream and white .Sweet potato with either orange colour on its skin or flesh is known as orange-fleshed sweet potato (OFSP) . OFSP is a bio-fortified variety of sweet potato with high beta (β)carotene which is a precursor of vitamin A, that is OFSP is a pro-vitamin A food crop (Oloniyo et al.2021).

Biofortified OFSP has been proven to be affordable, convenient, and sustainable food source of pro-vitamin A carotenoids for combating vitamin A deficiency in Africa (Abong et al.2020, Low & Thiele 2020). Apart from their high β-carotene content (Tumwegamire 2011,Ofori et al.2009) , OFSP varieties are known to have higher levels of other phytochemicals such as flavonoids, phenolics and anthocyanins that may influence the quality and stability of processed products (Abong et al.2020). These phytochemicals are known to enhance human health by acting antagonistically on incidences of cancers and chronic diseases, including cardiovascular disease, type II diabetes, and impaired cognitive function. Due to their preventive effects against chronic diseases, they are considered as indispensable components in a variety of nutraceutical, pharmaceutical, medicinal and cosmetic applications(Abong et al.2020)

Sweet potato is an important staple food in, which unfortunately remains neglected by research and underutilized (Sanoussi et al.2017). Besides, it is resilient to drought and less demanding in soil fertility. Its yields in African smallholder farmers' conditions are between 5 and 25 t/ ha and could reach 50-60 t/ ha at research stations (Sanoussi et al.2017) .

However, productivity of the crop is constrained by several biotic, abiotic and socio-economic factors. Among production constraints, sweet potato weevils, lack of planting materials, labour shortage, lack of farm implements, land scarcity, low soil fertility and vertebrate pests of moles, rats and pigs, lack of documented information on the common storage pests., all together may cause significant yield loss.. Amongst the biotic constraints, diseases (Sseruwu 2012) and insect pests such as the sweet potato weevil (Cylas spp.) causing significant yield losses (Ochieng 2018, Tortoe et al.2008). Yield losses caused by only virus diseases can reach up to 50-98% in lowlands.

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Sweet potato has become, after cassava, an important root and tuber crop in Democratic Republic of the Congo (DRC), where 411,257 tonnes were harvested from 82,108 ha in 2017 (FAO, 2019). Because sweetpotato is grown in virtually all areas of the country, it plays an important role in providing household food security. This crop plays a major role in food and income security in DRC where it is widely exploited on small plots by most smallholder farmers. The DRC is a major producer and consumer of sweet potato in Africa . Its 2018 overall production was 384,350 tons from 76,809 ha. At country level, sweet potato is the second most important root and tuber crop after cassava and used for human consumption, animal feed and processing. Eastern of DRCongo is the largest producer of sweetpotato in Africa. The sweetpotato production is concentrated mainly in three zones or territories : Masisi, Beni, Lubero, Rutshuru. Here, sweetpotato is an important crop that fits well in the country's farming and food systems. It stores well in the soil as a famine reserve crop, withstands extreme weather conditions, and performs well in marginal soils. In some households, sweetpotato generates cash income in addition to being a food source. Over 40% of the national sweet potato production originates from the North- and South-Kivu provinces. However, the full potential of this crop is yet to be exploited as the congolese yields are some time low (<5.5t/ha) compared to the African potential. Whereas production for the period 1970-1984 experienced a negative annual growth rate of 12% between 1985 and 1989 production increased annually at a rate of 7%. After 1989, production continued to expand.

Besides, there are downward production and cultivated area trends, 16.5 and 19.6%, respectively, from 2015 to 2019 . Tuberous roots and sweet potato leaves, called ‘‘Matembele’’ in the region, are highly valued by populations of the Kivu region. Its importance increased over the last two decades mainly due to the occurrence of cassava mosaic disease and Maize Lethal Necrosis Disease, which severely devastated these two staple crops (Shukuru et al.2019).

In some households, sweetpotato generates cash income in addition to being a food source. A typical household owns a sweetpotato plot of less than one hectare and cultivates more than 2 varieties, each identified by a name in the local language. Most varieties have different maturation periods, indicative of farmers' desires for a year-round supply of sweetpotato.

Despite the demonstrated importance of sweetpotato, its production still faces several biological, physical, and socioeconomic constraints such as the absence of high-yielding and disease-resistant planting materials, poor agronomic practices, lack of markets, unavailability of farm inputs, the high cost of existing inputs, poor storage facilities, limited use opportunities, and infestations of insect and vertebrate pests, abiotic factors such as low soil fertility, soil erosion and climatic factor variability.

In addition, during marketing, low price , lack of market, high labour costs and unavailability of transport, the high cost of existing inputs, poor storage facilities, weather fluctuations, scarcity of information on processing and storage, inadequate marketing system and labour shortage in processing as limitations in post harvest handling of processed sweet potato products, are among other common bottlenecks.,.

Although, it has been hypothesized that the low production and yields are linked to use of old landraces with low adaptation to climate change, emerging pests and diseases and not meeting

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expectations of an increasingly urbanized population of eastern DRCongo. This may be due to lack of improved plant materials with high yield potential and resistance to biotic and abiotic factors, poor cultural management, and non-consistent sweet potato breeding program in the region, low market value tubers harvested by farmers, lack of certified planting materials resistant to abiotic and biotic elements and modern storage facilities for long-term conservation.

There are losses of millions of dollars annually only due to infestation of sweet potato by weevils and these insect pests are more prevalent in the tropical regions. Based on this decline in sweet potato production and taking into account its high potentiality, it could be important to intensify research efforts to increase its production for the benefit of the producers and consumers and sort out the problem of food insecurity.

Also, there is increasing concern that agricultural intensification is causing loss of crop biodiversity due to displacement of traditional farmers' varieties by a small number of improved cultivars (Zawedde et al.2014). Thus, there is an urgent need to increase sweet potato yields and quality through the use of improved cultural practices and varieties. These issues should, therefore, be addressed to increase the fresh root yield in eastern DRCongo (Shukuru et al.2019).

Since its introduction, sweetpotato has received little policy and research attention in eastern DRCongo. This relative neglect is partly because of sweetpotato's status as a subsistence crop and because of historical research and policy bias toward cash crops.

Most common socio-economic factors influencing sweet potato varieties uptake among the African smallholder farmers include the education status, gender, off-farm incomes, access to credit and planting materials, farm size, farmer association membership, contact with extension agents, farming experience, field-to-market distance, market demand, cropping practices. However, there are huge disparities for leading factors among countries and among regions within a country. There is no report on the sweet potato farmers' attitudes toward introduced sweet potato varieties in South-Kivu

These constraining factors have a direct effect on storage root yield. Constraints related to socio-economic and quality attributes are the lack of improved varieties, lack of planting materials, low storage root yield, low β-carotene content in the white fleshed sweetpotato and low storage root dry matter content in the orange fleshed sweetpotato (OFSP) varieties currently available.

However, sweetpotato contributes greatly to the fresh market industry in which serves street food vendors and other formal and informal markets(Dery et al.2021).Sweetpotato production goes through processes from land preparation to harvesting and storage (production) as well as packaging, processing and marketing. Price fluctuations for cash crops also influence sweet potato production. The development and adoption of more productive crop varieties and the use of good agricultural practices are needed. Efforts are being made by local and international organizations to introduce high yielding sweet potato varieties with resistance to pests and diseases and high nutritional value (mainly high beta-carotene content) in eastern Africa, including eastern DRC. It has been showed that effective variety dissemination strategy requires

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a deep understanding of target farmers' socio-economic characteristics and crop varietal preferences.

Furthermore, the role of access to extension services in the adoption of agricultural innovations remains poorly documented in the target area. Yet, there is a link between farmers' perceptions and adoption of agricultural innovations. Knowledge of farmers' attitudes and associated socio-economic characteristics would be crucial for guiding efforts by sweet potato farmer support structures in the region.

Problem statement & justification of study

Sweet potato is grown throughout the province as a subsistence food crop. It's value is increasingly more pronounced as a major cash crop. Despite it's importance, there is little documentation on sweet potato constraints in the region. No recent data comprehensively report the sweet-potato production constraints in North-Kivu Province. This vital information which is lacking at the moment has created a vacuum which this research has the main objective of filling.

-In regions where sweetpotato is grown, it appears that some indigenous post-harvest methods are also practiced. These, however, have not been comprehensively documented. Literature on use of root and tubers like sweet potatoes value added a product is scanty. Value added products derived from sweet potato are not documented in eastern DRCongo..

Currently, it is not clear what are the key constraints faced by farmers to enable them producing more and more sweet potato as they already regard it is a food and livelihood security crop. In order to get a full insight of this problem, this research is designed and carried out to assess actors in sweet potato value chain. Thus, this study focus on sweet potato value chain analysis to clarify existing bottlenecks preventing farmers from venturing full swing into sweet potato farming and processing.

Value addition is necessary to enjoy higher benefits from the crop. Sweet potatoes are mainly boiled or roasted and very little attempt has been done to make flour or crips. However what is not well known is mapping of the subsector. Many actors in the value chain are not aware of the many value addition possibilities of sweet potatoes in the country. Before investing in value addition of sweet potatoes, it is important to investigate market potential for sweet potatoes value added products.

Generated information will enhance the sweet potato value chain through increased rate of innovation adoption. Apart from filling the existing research gap, the findings of this study may help the local value chain players and supporters to improve performance of sweet potato farmers in the study area, but will also lead partners and planners in development to better target investments in sweet potato sub-sector. Furthermore, it may contribute in getting information needed in development programs and in fixing strategies useful to improve the efficiency of sweet potato marketing system. The findings of this study may also be of benefit to sweet potato farmers, processors, governmental and NGOs that have a key role in sweet potato marketing systems. Researchers who are planning to undertake further study on sweet potato may equally benefit from the results.

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This study, therefore, attempts to fill this gap by providing supporting data to organizations involved in agricultural extension services. To this end, this survey was conducted in to analyze the techniques of production systems and marketing of the sweet potato by identifying the constraints that prevent the development of this sector. The information may help researchers to devise a better breeding strategy that considers farmers' preferences.

Significance of the Study

(i) The study is important because it acts as a mirror to North-Kivu province as a whole on looking on farming systems of sweetpotato and assessing market potential of value added products in boosting economy of the rural people.

(ii) This study may bring more influence to policy markers on how to review the existing policies for interest of all key actors in marketing of agricultural products

Research questions

(i) What are the sweet potato linkages/relationship that exists between actors, processes and activities in the value chain., and who are the stakeholders and what are their roles in sweet potato production and value chain ad addition systems to producers?

(ii) How is sweetpotato gross margin affected by factor of production, by institutional factors, by production cost, farming practices and good knowledge information on best farming, marketing practice?

General objectives

(i) To contribute on food security strengthen, income generation, and farming system stability through the generation of information likely to promote an help increase and sustain sweetpotato yield

(ii) To contribute on the improvement of the welfare of the rural poor by diversification and expansion of sweet potato value added products through the generation of information for better understanding the production/consumption, post-harvest system, trading, value chain and addition system constraints

(iii) To contribute on the documentation on livelihood evolution of communities and establish general ex ante information (baseline data) for future impact assessment.

Specific objectives

(i)To establish a baseline information about the farming systems, , identify need and opportunities and mechanisms for improvement of sweetpotato enterprises such as establishing future breeding priorities.

(ii)To assess and document the major practices and constraints affecting production, pre- and post-harvest handling, and variety preferences for by farmers

(iii) To characterize the current farming system, variety attributes preferences, and identify sweetpotato attributes that farmers consider as priorities for breeders to work on

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(iv)To determine factors affecting sweetpotato farmers' gross margin, profitability and identify current patterns of sweetpotato marketing, preservation, consumption, value chain and addition

(v)To recommend to policy makers on how to promote sweetpotato productivity in rural areas and increase agricultural value added products.

(vi)To collect baseline data and generate information to guide on-farm research for future impact assessment.

Hypotheses

The hypotheses tested as means of carrying out the specific objectives were:

(i) Current sweet potato production, consumption, post-harvest & commercialization systems may not be profitable to rural smallholders in eastern DRCongo

(ii) The current farming system, production constraints/practices, commercial and value chain channels in territories surveyed in rural areas of North-Kivu Province, may be similar to those found elsewhere in eastern and central Africa

2.MATERIAL and METHODS

2.1. Description of Study area and survey sites

This study survey was conducted from March to October 2021 in Beni Lubero-Butembo, Masisi, Rutsuru territories of North-Kivu Province, eastern DRCongo. The 5 surveyed territories contain about one-third of North-Kivu' population. The sites in the selected territories cut across the four principal agroecological zones of North-Kivu Province, eastern DRCongo (Figures 1 and 2).

Masisi to the East and Lubero to the southwest are in the high-altitude zone of North-Kivu. These areas have a near-temperate climate and can produce temperate crops. They are located in the southern and western tall-grassland zone, which supports both perennial and annual crops in mixed farming systems. The northern part of Beni-Butembo extends into the pastoral dry to semi-arid rangeland zone. The western part of Rutshuru is typical of the high-altitude zone that mainly represents.

Topographically, the study area is a mountainous zone. Altitudes range from 1400 -2800 m above sea level. The region is characterized by grassy savannah with a large number of streams and a mountainous tropical climate, moderate temperature. All territories receive bimodally distributed rainfall. Masisi is the wettest territory. In general, as one moves from the equator northward, the length of the dry season increases. The amount of rainfall ranges between 1300-2200mm, which is best suited for sweet potato growing. The area experiences a bimodal rainfall regime, four seasons divided into two rainy seasons and two dry seasons: a short rainy season covers from October to December; from January to February is the period of short dry season, a long rainy season start from end of February to beginning of June and a long dry season from June to the beginning of September.

. The annual temperatures range between 11.6 and 24.1 ° C.

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The landscape in is very hilly, interlaced with narrow and broad valleys. The area is characterized by a depleted and eroded clay soil., small, highly fragmented landholdings and declining soil fertility and a high rate of male migration in search of employment.

Populations depend mainly on agriculture, livestock farming and fishing for income. Agriculture is the major economic activity employing over 70-85% of the workforce. Major subsistence crops include cassava, maize, sweet potato, sorghum, banana, and beans while coffee, tea and sugar cane are the major cash crops. These regions are direct food suppliers to the Goma city which constitutes their primary market .

The four territories covered by this study are densely populated (>300 persons km2) and inhabited by more 1 million people each, from some main ethnic groups: Banande, Bahunde, Banyarwanda,…. For these people, sweet potato is not only a food and cash crop but also an integral part of social and cultural belief systems. For instance, sweet potato is part of all major festive ceremonies such as wedding in which it is consumed with fermented cow milk.

2.2. Survey strategy and Sampling procedures : population, sample size

The study aimed to cover North-Kivu agroecological zones. Altitude, weather patterns, soil type, and farming systems were collected based on importance of sweet potato as a staple crop . The territories sampled included Masisi, Rutshuru, Lubero-Butembo, Beni. The choice of these areas was dictated by the nutritional, economic and socio-cultural importance of sweet potato for these areas' populations. It is noteworthy that these areas possess agro-ecological characteristics conducive to sweet potato cultivation and host major local, agricultural research centers which promote improved crop varieties, including sweet potato. Also , these territories were selected because of their potential for sweetpotato production and chosen based on prior information on the importance of sweetpotato in these areas.

Thus, farmers of these regions are the major beneficiaries of these organizations' activities and support. Besides, their proximity to Goma City, the largest city in the South-Kivu Province, provides to them a unique market opportunity for their agricultural productions.

- As sampling strategy, 4 administrative territories were selected. In each territory, 5 villages were sampled among the villages highly engaged in sweetpotato cultivation. Random sampling techniques were employed in this study . In each territory, the 5 villages were randomly selected. In each village, 30 farmers were also randomly selected from the list of farmers engaged in sweetpotato cultivation, making a total sample size of 600 respondents for the entire study. In each visited village, 30 households engaged in sweetpotato cultivation were randomly selected along a transect cutting across the village. Eligible households were those hosting people who had been residing in the village for the past 12-24 months, with sweetpotato farming activities. Within each household, the head of the family or the spouse, or any other appropriate person involved in sweetpotato cultivation and/or transformation was interviewed. Household was taken as the sampling unit for the study. Farmers were randomly selected by village and hamlet leaders with the help of agricultural extension officers.

The list of villages involved in sweetpotato cultivation was given by the extension service agent attached in the villages. Villages selection was based on production data available at territory

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agricultural office. Villages and sub-villages were selected based on the knowledge of local leaders, chiefs, resistance councils), and local agricultural staff, and on accessibility.

To carry out interviews, the selected villages were visited: the first one, early in the morning before the farmers left for their fields, and the second one in the afternoon after they had returned from the field works.

In each village, farmers (household or individuals) were selected for household interviews and focus-group discussions,…. Each village agricultural extension officer assisted in selecting the villages and fields.

Information was obtained from the territory/village leaders and key informants using checklists complemented the questionnaires. Researchers participated as enumerators and, where necessary, interpreters assisted. The team composed of breeder researchers, graduate students, technicians, socio-economist, animal scientist, anthropologist, extension service agents and local key informants helped in data collection.

-Overall 150 individual farmers per territory responded to different questions in the questionnaire, in addition to information collected through focus group discussion and meeting with leaders and extension service agents met in the field.

Structured questionnaires had questions addressing different issues including on production and consumption, post-harvest, marketing and value addition practices and constraints

2.3. Data Collection during surveys

Both secondary and primary data were collected during the course of this study.

Complementary or documentary information review sources used obtained from secondary data that included: journal articles and text books, Internet research, extension agent reports and other written materials about sweet potato in eastern DRCongo that were relevant to the study. Also, relevant published and unpublished reports, scientific reports, maps and statistical abstracts, bulletins, and websites were also used to generate relevant information on the area were used as additional data. Such documents allowed the researcher to acquire relevant information to support the research findings. Additional secondary data sources were collected from village trade and market development office, extension offices of agriculture, custom agency, agricultural research center and their publications. Thus, demographic information, major crops grown and sweetpotato production trends over the last five-ten years were obtained from the extension service agents based in the territories. Secondary data provided a general overview about farmer's earnings by marketing sweetpotato.

-Main primary data were collected using semi-structured interviews , face to face individual interviews, focus group discussions, transect walk and field personal observation and visual visits (Mmasa & Msuya 2012) of sweetpotato gardens.

Additional secondary data were collected from previous reports where-ever they were available. For the formal surveys, the primary data for the were collect/gathered by distributing

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questionnaire to respondents (farmers). The informal surveys targeted key informants such as agricultural officers (extension agents), local leaders and to other development agents intervening in the study area.

The formal survey was undertaken through formal interviews with randomly selected farmers and traders using a pre-tested semi-structured questionnaire.

Face-to-face interviews were conducted in all villages and territories. The survey was done in collaboration with the local extension service agent. The villages were randomly selected from each territory.

A questionnaire was developed, pre-tested Kalehe territory with 150 respondents and corrections made before the study was carried out. Based on feedback from the pretest, the final questionnaire was prepared.

Semi structured interview was adopted and conducted as conversation between the researcher and an individual interviewed .The questionnaire was developed by open ended and close ended questions to get both quantitative and qualitative data. . All focus group discussion and individual interviews were recorded in local languages and later transcribed by a native speaker. The interviews were conducted in the main local languages (Kiswahili, Kinyarwanda, Kinande, Kihunde) spoken in the areas investigated, using interpreters where needed.

2.3.1. Individual interviews

Data collection was preceded by pre-surveys in each of the 4 territories to get information on the number of sweet potato farmers and an exhaustive list of farmers. With the help of key informants (resource persons such as leaders of farmers' associations, local authorities, extension agents, religious leaders and representatives of farmers' support structures), several farmers growing and marketing sweet potatoes in the study area were identified.

The individual interviews were conducted face to face with a questionnaire composed of several type of questions. In each village, interviews were performed at household levels and included households that were located at least five km from each other along the main road in village. Only households that were growing sweet potato at the time of the interview were selected. Farmers were queried systematically using key crop descriptors. These data were used to identify names that referred to local and improved varieties not grown at the time of the interview and to verify variety identity in the field. Researchers and extensionists worked together to ensure that farmers' descriptions were captured accurately and to act as interpreters when necessary.

The aim of the study was to capture men and women ' s perceptions , views, opinions, beliefs, and experiences of cultivation sweetpotato.

The questionnaire covered questions related to farmers' interest, consumer preferences and wishes. Data collection through individual interviews was carried out using semi-structured survey questionnaires(with open ended questions) about the following major aspects: (i)the socio-demographic characteristics of the farmers' household such as age of the household head, educational status of the household head, family size,… (ii) ownership of agricultural assets,

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(iii) location, land tenure, household ownership, farm size; cropping system, common crop management practices and challenges associated with crop management, mode of land acquisition, and types of labor, soil fertility management, development phase and yield of the sweet potato, production constraints, production and crop management, management and decision making, access to extension services, varietal susceptibility/sensitivity to pests and diseases, seasonal variation, yield loss attributable to pests and diseases (iv) access to markets, membership in farmers' organizations, input costs, access to market information, marketed prices, credit facility, access to microfinance credit (v) type of varieties cultivated, varieties dropped and reasons for dropping; criteria for adopting new varieties, criteria for maintaining old varieties, attributes of sweetpotato genotypes, seed supply system, sources of varieties challenges with adopting/maintaining varieties, farmers' variety exchange practices, genotype preferred attributes breeding priorities (vi) awareness and level of cultivation, source of information, willingness, and means of disseminating and maximum likelihood (rate) of adoption of improved genotypes, postharvest use post-harvest issues, marketing and value chain systems for the different genotypes,.

2.3.2. Focus group discussion strategy

The discussion was assisted by a facilitator who was proficient in both the local language and French. A checklist of discussion topics/questions was developed and used to guide the discussion. Open-ended questions were asked to generate discussion and the facilitator made sure every person present contributed towards the discussion topic.

Focus groups were held to gather information such as importance (Höllermann et al.2021) of the crop in food security and ranking of the currently grown sweetpotato varieties and their characteristics. Focus groups were used to collect basic and general information on sweetpotato cultivars and their characteristics, cropping systems, production calendar, production constraints, preferred traits and gender relations in the production system. Focus groups comprised sweetpotato farmers and other key informants with broad knowledge on diverse social issues in the village. Key informants comprised retired village leaders and other civil servants. The information looked for during these focus group discussions were similar to those addressed during individual interviews including : sweetpotato production constraints (biotic and abiotic and their causes), genotypes grown and preferred sweetpotato attributes, seasonal calendar,.. The sample size for focus group discussion was determined such as to selected a sample size small enough to enable an in-depth qualitative analysis of perception and opinions of farmers. Each focus group consisted of 15-20 people who included experienced sweetpotato farmers, opinion leaders/elders, local council or village leaders, a youth representative and a trader. The size was large enough to ensure that the data reached saturation point. Farmers were informed that participation was voluntary.

2.4.Data analysis

A formal semi-structured questionnaire with binary, closed, semi-closed, open ended questions were prepared to allow the informants to express their opinion in the way the researchers wanted it. Interviews were conducted and recorded, transcribed in local languages, and translated into French-English. Cross-cutting socio-economic characteristics that influence perceptions of respondents were analyzed. The information obtained at the village level was compiled at the territory level.

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Later, the answers were coded and grouped into similar categories. The collected data in survey sheets entered and codified. Codified data were processed using a spread sheet program (Microsoft Excel 2017).

Later codified and sorted out data in Excel file was entered and analyzed using MINITAB English version for Windows Version 20.0 (Minitab, 2017).

Measures of central tendency such as frequency distributions, percentages were calculated and partly used to describe the socio- economic characteristics of sweet potato farmers in the study area. Data were analyzed and summarized using cross tabulations, means, frequencies, percentages, graphical representations and chi-square tests. Chi-squared tests were used for independence analysis of qualitative variables. . The chi-square test was performed to examine the association among the categorical variables such as the relationships between the different characteristics of participants with some variables included in the questionnaire. The chi-square teste was used to identify if the percentage responses of farmers were consistently different across territories. The results was considered statistically significant when $p < 0.05$. The results have been presented in tables and figures and interview have been described by using narration.

-The value chain analysis conducted involved the calculation of the gross margin to evaluate efficiency of an individual farmers so that comparison can be made between farmers from different territories. The gross margin analysis was used to evaluate the value chain and commercial channels , marketing and trading channels used by producers. The purpose of this analysis is to identify the cost, returns and profitability or loss per hectare. The gross margin by definition is the difference between the gross farm income (G F I) and the total variable cost (TVC) i.e G.M = GFI - TVC. The gross margin analysis was used to determine the profitability from sweet potato production in the study area.

3.RESULTS

3.1. Socio-economic characteristics and profile of respondents interviewed

The majority of respondents were married at Masisi (71.45%), Rutshuru (77.54%), Lubero (69.67%) and Beni (75.01%) territories. Most respondents depended on farming for their livelihoods. The farmers have been growing sweetpotato for a while. The producers of sweet potato investigated were all native. Across territories, the highest number of respondents of catholic religion were observed from Masisi (40.81%); and the lowest from Beni (24.78%) territory (Table-1).

Across the four study territories, there was no statistically difference ($P>0.05$) in marital status, age, sex, and number of children between respondents.

Across study territories, the average age of female respondents oscillated between 27.65 and 45.89 years whereas the age (in years) of male varied between 42.12 and 56.78.

The majority of respondents in the production survey were women. The high percentage of female respondents testifies to their important role in sweetpotato cultivation. Despite the high number of men, an increase in women in some tasks such as cutting of vines, planting and tuber gathering for storage were observed.

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The mean family size was 6.5 with more than half of interviewed households having a family size of 6–12 members. The average number of female children oscillated between 4.35 and 6.41; whereas that of male children oscillated between 4.32 and 6.72 per household.

Rutshuru had the highest number of interviewed households with family size >10 members. Household size has implications for family labour availability for production.

In villages surveyed, household composition was equally divided between members older and younger than 15. Assuming that members 15 years and above are actively involved in agriculture, then half of the household members were dependents. This has serious implications for the size of the available household labour force and underscores the importance of developing agricultural innovations that do not call for extra labour. Family labour availability can be a serious bottleneck. Hired labour is rarely used because of the lack of cash.

The majority of respondents were occupied by farming activities (crop/livestock/fishery/apiculture) at Masisi (65.78%), Rutshuru (78.9%), Lubero-Butembo (43.12%) and Beni (57.92%). Only a small proportion of farmers was employed elsewhere at Masisi (2.43%), Rutshuru (14.12%), Lubero-Butembo (34.32%) and Beni (5.19%), (Table-1).

Most male respondents had spent 6.34 to 9.43 years at school; whereas female respondent had spent about 5.56 to9.87 years at school. Across study territories, there were no differences ($P>0.05$) in the level of education of male and female respondents. Most of producers did not attend schools and were primary school dropouts

. The highest attained level of formal education was found Butembo-Lubero territory where more than half of the respondents had at least some secondary education. A few percent of the population possessed primary education, being able to read and write; those who attended post-secondary education were mainly primary school teachers and village leaders in Masisi territory

Overall, there significant differences ($P<0.05$) in the proportion of farmers having as main occupation the farming activity ($P=0.012$), employment elsewhere in other sector rather than agriculture ($P<0.0001$) or having off-farm employment such as teaching or working in a factory ($P<0.0001$) (Table-1).

With regards to major source of income (revenue/ capital), across study territories, there were no difference ($P>0.05$) in the proportion of respondents who declared having livestock (animal rearing), artisanal work or petty trade as main source of income.

Most respondents (66.43-88.21%) considered themselves as poor (<1$/day). There was a significant ($P=0.05$) difference among respondents who considered themselves as of medium poverty status (11.34 to27.12%). A small portion of respondents reported themselves to be rich at Masisi (6.12%), Ruthsuru (1.12%), Lubero (4.87%) and Beni (1.65%).

Most respondents (78.20-88.32%) were members of associations (NGOs, cooperatives, farmers groups). Most respondents (68.5-86.31%) were not previously trained on best agricultural practices and technologies (Table-1).

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However, there was a significant (P<0.05) difference between territories for the major source of income (revenue/ capital): farming as primary source of income was observed to be more significantly higher at Lubero (30.7% of respondents) as compared to other study territories. The significantly highest number of respondents earning more income from off-farm activities (informal employment) was observed at Beni (19.76%) and the lowest at Lubero (4.19%). A small portion of respondents declared obtaining additional revenue from personal saving in previous.

In addition, there were significant differences among farmers who were engaged in small business (P=0.001) or had savings in cooperative (microfinance) groups (P=0.005) or were engaged in informal activities (P=0.003), (Table-1).

Personal saving, although small, varied significantly (P=0.031) among study territories: Masisi (8.76%), Rutshuru (6.76%), Lubero (3.01%) and Beni (14.9%), (Table-1).

Sources of income varied significantly across territories. Most respondents owned farms , few of them rented farms. Land tenure varied significantly between the study territories. During focus discussion, it was indicated that other sources of income included off-farm employment and tuck-shops that have insignificant contributions. More respondents indicated livestock as a major source of income. Secondary-income sectors included mini-shops, gardening, labour hiring and the charcoal business. During offseason farmers grew vegetables and engaged in micro-trading such as making and selling local brews. The majority of households kept a limited number of animals, such as goats, sheep, pigs, guinea pigs and chickens.

3.2. Livelihood evolution & dynamics of households over the last 20 years in North-Kivu Province, eastern DRCongo

-Concerning the current status of arable cultivated land, respondents indicated no change (9.45-27.67%), whereas another group indicated the decrease in the current status of pasturelands at Masisi (67.95%), Rutshuru (43.54%), Lubero (54.76%) and Beni (21.87%). Responded mentioned an increase (58.65-76.12%) in the current household size as compared to previous situation (20 years ago). Respondents indicated that there has been no significant (P<0.0001) change in the current status of health services access (3.43-27.87%) as compared to the situation 20 years ago. Interestingly, respondents from Masisi (17.87%), Rushuru (11.76%0, Lubero (8.45%) and Beni (24.87%) indicated that currently non-farm activity opportunities have increased as compared to 20 years ago. Most respondents reported that the current status of peace and security (fair justice) had drastically decreased at Masisi (48.87%), Rutshuru (86.45%), Lubero (64.23%), and Beni (92.12%), (Table-2).

Similarly, the level of education and information access is judged to have significantly (P<0.0001) increased more at Rutshuru (67.43%) and Masisi (65.11%), than at Lubero (41.12%), and Beni (24.77%) territories. Respondents indicated a decrease in the public support services and local governance quality (44.88-83.12%). Other respondents mentioned no change in the status of availability of clean environment (water, toilets) and sanitation system (45.76-81.76%).

Respondents also indicated a decrease in delivery of qualitative/ quantitative ecosystem services from nearby landscapes (23.45-59.34%), (Table-2). Respondents indicated no change they

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perceived in the current status of access to clean energy, solar energy and electricity (21.54-76.45%) as compared to the situation 20 years ago. Similar no major changes were observed in the formal/informal financial (credit-saving) access (60.98-81.46%) as compared to the situation 20 years ago (Table-2). Interestingly, some farmers perceived significantly (P<.0001) and slight increase in the number of agro-dealer shop in their villages as compared to the situation 20 years ago.

The majority of respondents indicated a significant decrease in (i) the availability of public extension services (26.65-79.54%), (ii) transport facilities and road quality (67.98-89.55%). However, respondents indicated no change in the status of business opportunity (market and price of agriproduct increase) (63.54-88.12%), in the status of cooperative and farmers' group or initiatives (34.76-60.43%), and in the number of private sectors and NGOs operating in their villages (39.24-79.45%) as compared to the situation 20 years ago (Table-2).

3.3. Welfare shock, economic well-being trends, coping strategy adopted by farmers

- Across study territories, there were significant (P<0.05) differences among proportion of respondents who were declared themselves their status of being better off (P<0.0001), worse off (P<0.0001) or of same status (P=0.007) when asked if they perceived changes in their economic wellbeing from a year ago. Interestingly, across study territories, there were significant differences (P<0.05) among respondents who declared themselves of being better off (P=0.002) or being worse off (P=0.002), (Table-3).

Concerning the changes in economic well-being from a year ago, respondents from Masisi (40.02%), Rutshuru (27.21%), Lubero (15.43%) and Beni (12.86%) indicated differently (P<0.0001) that they were better off. The proportion of respondents who considered themselves that they were worse off varied among the four territories: Masisi (21.11%), Rutshuru (5.65%), Lubero (14.32%), Beni (39.76%). Overall, a significantly different (P=0.007) proportion of respondents (39.54-70.32%) indicated that, their economic well-being status was the same as it was a year ago. The expected change (P<0.05) in their economic well-being a year from now was estimated (projected) to be better off (13.64-40.67%) or worse off (18.76-49.98%), (Table-3).

Concerning the source of shock in the communities, a portion of respondents (24.76-39.23%) indicated the falling of the price of agricultural products (crops / livestocks) was the primary source of shock in the communities. Sickness/ death of household head(member) was cited as second key shock factor by respondents (9.54-16.77%) .

A small proportion of respondents that (i) poor harvest due to climate change/ natural disasters occurrence (6.76-23.44%), and rising insecurity (repetitive wars) and epidemy (Ebola, COVID-19) emergency (2.87-20.76%) were also significant (P<0.05) source of shocks in the communities (Table-3). Regarding the coping strategies that were mostly (frequently) adopted by farmers, respondents indicated differently (P<0.05) the following: engaging in small-scale entrepreneurships at Lubero (41.78%), borrowing food in kind or request for help from friends at Beni (7.98%), migrating to urban areas or to mining sites or join rebel groups at Masisi (28.98%) and migrating out of the country as refugee at Rutshuru (12.43%) territory (Table-3).

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Across study sites, there were no significant (P>0.05) differences in the proportion (%) of respondents who declared the reduction of quantity of meals (eat 3 meals out of 7/week) as coping strategy adopted against recurrent shocks.

Respondents who declared requesting assistance from humanitarian agencies as copying strategy did not differ (P>0.05) across the four study territories. Similarly, there were significant (P<0.05) difference in the proportion of respondents from the 4 territories with regards to the migration in other provinces/ territories/ villages (internal displacement) (Table-3).

3.4. Extension services, land allocated, agronomic and farming practices of sweet potato growers interviewed,

-Across study sites, most respondents (34.2-46.3%) had inherited the land they cultivate. The majority of respondents (53.78-71.20%) had two plots (0-11 to 1.5ha size).

Focus group discussion results revealed that the mode of access to land the most observed was the inheritance followed by purchase and renting. It should be noted that in some villages women were less involved in farm activities due to the fact that they are not entitled to land heritage, mainly because of their significant roles in the household affairs.

There was a significant (P=0.002) difference among study territories for the number of respondents who had declared having about 3 plots: Masisi (31.32%), Rutshuru (24.12%), Lubero-Butembo (14.12%) and Beni (9.67%).

Few respondents grew sweet potato on farm-land of 1 to 2 ha, some in lesser than 0-5-1.1 ha of land and very few of respondents in 3-6 ha of land. From the focus group survey, it was realized that the average size of farmland was 1.1 ha with farmers in Masisi owning an average of 1.2 ha while those in Lubero on average of 0.9 ha. In Rutshuru farmers had a larger area under sweetpotato production per season of 0.3 ha as compared to 0.2 ha Lubero.

The average size (0.11 to 1.49 ha) of land allocated to sweetpotato was small across study areas. Consequently, the average yield varied between 9.23 t/ha and 12.22 t/ha for male headed fields, between 17.11 t/ha and 23.18 t/ha for female headed fields, and between 6.43 to12.94 t/ha for youth headed fields (Table-4).

The majority (56.43-67.67%) of sweetpotato growers were female across study sites.

The major source of labor for sweetpotato cultivation was composed of family members (15.67-45.69%). Some farmers hired labour (1.56-40.56%) or used cooperative members collaboration (13.16-25.76%). An important group of farmers used more than one source of labor (26.64-68.98%).

Focus group discussion results indicated that the most farmer hired labor. Few of them used family workforce. Mutual aid was also observed in complement of family workforce. Family labor was only used during weekend and holidays. Male producers made use of the two types of labor whereas female producers often dependent on their husbands for help and occasionally used labor to supplement the family assistance. It was also mentioned that in addition to the high cost paid to manpower, producers also provided foods to the workers

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during the period they carried out the work in the field. Capital funds invested in the production of sweet potato by farmers included their own funds and loans. Their own funds were from other agricultural-related activities.

Most farmers (are used to establish sweetpotato plantations mostly in October-November (45.65-70.45%), frequently in February (24.65%-42.12%) and rarely in June in marshlands (3.19%-12.33%).

The majority (75.87-91.12%) of respondents mentioned not receiving at all extension services. A small portion of respondents declared receiving village extension officers posted by the government (0.54%-3.12%) (Table-4). There was a significant (P=0.011) differences among study sites with regards to the number of respondents who declared receiving extension services from private sector and non-governmental organizations: Masisi (22.34%), Rutshuru (22.12%), Lubero (12.33%) and Beni (6.56%),(Table-4)

3.5. Main crop types grown (sole or in intercropping) for food sovereignty of rural households

There was variability in top crops grown by farmers across study territories: for example, at Masisi territory, sweetpotato (16.41%) followed by cassava (14.88%), Irish potato (13.72%) and Bean (10.94% of respondents) were the top crop grown by respondents. At Rutshuru territory, Coffee (14.87%) followed by cassava (12.54%), and sweetpotato (11.77%) were the top crops grown by respondents. At Lubero-Butembo territory, cassava (16.56%) followed by sweetpotato (15.86%),Banana(12.27% and coffee (11.47%) were the top crops grown by respondents that were interviewed in this study. At Beni territory, Cassava (18.36%), sweetpotato (16.37%), banana (14.71%),Coffee (12.54%) were among the top crops grown by respondents (Table-5).

Overall, more than 13 different crops were found grown in the study sites. However, the dominant crops grown included maize, bean, sweetpotato, potato, cassava. These crops were mentioned by farmers at all places as an indispensable crop for their livelihood and as s valuable in their farming systems. These crops were primarily grown for household consumption and little for sale to earn cash for other family obligations, such as clothing and medical costs. Vegetables were the main cash crops in Rutshuru territory

Sweetpotato farming System

Most of the respondents were full-time farmers, few of them were engaged in off-farm activities. In general, women are more involved in sweetpotato cultivation, whereas more men engage in part-time farming. Relatively low levels of off-farm income were reported; these indicate the scarcity of off-farm employment opportunities in most parts of rural areas in the province. The majority of respondents owned and cultivated land allocated by a family leader. Land ownership is mainly under customary tenure. Renting land to cultivate sweetpotato was not common. Some respondents may have given false information because of a widespread suspicion that the government was planning to move them.

Farmers combine the different system components to achieve several objectives, such as food security (through own production or cash purchases), cash availability, risk minimization, and social prestige. Unfortunately, most system components compete for the farmers' scarce resources. Whereas no attempt was made to investigate non farm enterprises, with about 25-30%

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of respondents in most territories being part-time farmers and about 10% reporting off-farm income sources. Nonfarm enterprises are clearly important system components. Most households also own one or more kinds of livestock, mainly poultry, goats, sheep, pigs, and cattle. Livestock contribute to the system in terms of cash, protein (milk and meat), manure, and prestige.

Sweet potato cropping systems

From focus group discussion, it was realized the majority of the respondents, indicated that sweetpotato was among their priority crops . The remaining few respondents did not grow sweetpotato or grew it as a complementary crop in their backyards.

The majority of the farmers planted several sweetpotato genotypes in a single plot or garden. Land allocated for sweetpotato production varied among households with the majority allocating 0.35–6.5ha. However, productivity of sweetpotato under farmers' fields was very minimal. The timing of sweetpotato planting varied among territories. There were multiple planting seasons . Most farmers planted sweetpotato during September-October, January–March or June-July, plantings depended on the onset of long and short rains, respectively. Most farmers harvested sweetpotato from December to September.

Sweetpotato cropping systems varied greatly across territories. Sweetpotato was grown either as monoculture or intercropped. In all study sites, sweetpotato is typically grown as a field crop in rotation with other crops such as maize, groundnut, cassava, and vegetables. It was intercropped with either maize, peas , cassava or banana. Due to scarcity of land ,rotation with cereal crops was also practiced on a yearly basis.

Sweetpotato was favored because of its high productivity and low management and input requirements, which makes it an easy and potentially profitable enterprise. In some villages, sweetpotato is one of the few crops adapted to prevailing soil conditions. Moreover, fallowing was practiced for soil fertility restoration and disease and pest control. It was established that farmers did not use fertilisers in sweetpotato production. Farmers solely depended on natural soil fertility. A majority of farmers from Rutshuru perceive their soils as moderately to fairly fertile. Lack of awareness was the predominant reason.

-Women have a major role in sweetpotato cultivation. Sweetpotato played multiple roles for food and cash in all territories. The crop contributed significantly to generating household income. At harvest, farmers sold part of the produce to meet family and other community obligations; the remaining portion was for household consumption. Harvesting was done either in a staggered manner or at once. For household consumption, staggered harvesting was commonly practiced. It was revealed that men played a significant role in sweetpotato production contrary to the idea that sweetpotato was a women's crop. There was equal participation of men and women from land preparation to harvesting. However, men were decision-makers on selling and handling the money earned. Most of the resources were owned by men whereas most family care activities were women's roles

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3.6. Sources of vines (planting materials), farmers' reasons for or not cultivating sweet potato

-Concerning the sources of planting materials, respondents from Masisi (27.56%), Rutshuru (40.19%), Lubero (11.54%), and Beni (53.76%), differently (P<0.0001) indicated that they obtain their planting materials free from their neighbors (friends) or fellow farmers. Other farmers indicated they obtained their planting materials from their saved vines (plant nurseries, demonstration plots) (0.011-9.32%) or from the saved previous harvest (7.45-35.65%). A small portion of respondents acknowledged receiving their new planting material from Research centers (universities) with certified materials (2.19%-17.12%), (Table-11).

The major reasons that push a farmer to grow sweetpotato was that sweetpotato was very easy to cultivate (24.67-53.12%) across the 3 cropping seasons (season A: September-December, season B: February-May, season C (June-August) in marshlands). Few respondents indicated that they liked growing sweetpotato because the crop was considered as a resilient and hunger fighting crop (3.54-14.89%) or as pests-disease resistant crop (4.12-16.31%). Some respondents indicated that grew sweetpotato because its leaves and vines were medicines for infant and pregnant women (Table-11). The major reasons for not cultivating sweetpotato included the lack of knowledge about the crop (0.67-7.32%), the fact that the crop was not an economically profitable (26.12-71.32%)., and the fact in many villages, the crop was considered as crop for women-children and not for men (7.34-48.23%) (Table-11).

Advocating for the wide cultivation of sweetpotato in the village, respondents suggested various strategies including (i) linking (networking well) farmers to researchers/ universities and extension services (3.45-17.43%), disseminating climate-smart varieties (0.67-9.14%) and disseminating abiotic/biotic tolerant vines (2.11-25.92%), (Table-11).

From the discussion groups, it was realized that the principal source of sweetpotato planting materials (vines) was the farmers' own fields. Most farmers retained some vines from the previous season in the field as a source of planting material for the new season. Some farmers sourced their vines from other farmers. Both vines and storage roots were used. Vine production accounts for an average of more than the average of the total gross income from sweetpotato and is equally important for use on-farm as animal feed or for market. In Rutshuru, all vines were shared free of charge whereas in Masisi, the vines were occasionally sold. The other common sources of vines were research stations, development NGOs. The majority of farmers in both Beni and Lubero territories had problems with planting materials. The problems included lack of access to good (healthy) vines and scarcity thereof, especially after a long dry spell. Infestation by caterpillars of vines was a problem in Rutshuru .

-About the storage methods of vines, most farmers indicated during focus discussion that they obtain vines for planting from their own fields. Only during drought or other natural calamities do farmers resort to procuring planting material from outside their farms. Usually, such material is provided free of charge from neighbors. Under extreme weather conditions, vines are bought and sold. Few farmers said that they paid cash for vines. Farmers take the need for planting material very seriously and have developed a number of strategies to ensure that vines are available. Most farmers do not plant vines immediately after cutting, but let them wilt or pre-root in a cool place for several days. Most farmers store their vines in the field seedbed covered with

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trash, or under a tree for up to three days . In Ruthsuru, approximately one third of total gross income from sweetpotato comes from vines, with a focus on home consumption by farm animals. Storage roots find a variety of uses in Masisi whereas in Beni the bulk is sold to the fresh market . Other forms of vine storage are near the home, on verandahs, in a hole covered with soil, and sometimes inside the house. Explanations for not planting immediately after cutting include allowing vines time to sprout, lack of time or labour at the household level, drying to avoid breakage at planting, and removal of insect pests. Root formation (sprouting) also figured prominently as a reason for delayed planting. Few respondents indicated during discussion that they planted vines on the same day they were cut. Vines are planted by hand; hence, risk of breakage diminishes. Some times, farmers need to leave vines to wither for 3 to 7 days before planting to avoid damage during planting and to enable them to establish faster. Farmers select planting material based on variety and the condition of leaves. A high proportion of respondents reject planting diseased or wilted vines. Farmers recognize that vines will transmit diseases and that diseased vines do not yield well. Although the majority of farmers plant the apical portion of the vine, in some areas they plant the middle part. The selection of healthy vines, particularly the apical portion, can significantly reduce the spread of pests and diseases. Farmers also recognize that the apical portion (vigorous vine tip) establishes more rapidly. The mean length of a typical vine for planting ranges from 31 cm to 37 cm.

3.7. Cropping system, farming practices and seeds(vines) planting, crop rotation, soil/land management practice, crop calendars reported

-Concerning the conservation methods of sweetpotato genetic resources on-farm, there was a significant ($P<0.0001$) variability in the strategies. Farmers from Masisi (69.12%), Rutshuru (65.67%), Lubero (53.76%) and Beni (19.76%) territories adopted a strategy of leaving on-farm in small fields vines that will be used as new planting materials in the following cropping season. Planting in marshlands (bottoms of hills) (2.64-17.89%), planting sweetpotato vines in lands along waterbodies such as rivers (0.55-19.45%) or planting vines in field margins (6.12-24.76%) were strategies that were adopted by different ($P<0.05$) respondent groups from varied study territories (Table-12).

The top planting methods that were significantly ($P<0.05$) applied by respondents included flat ground at Rutshuru (34.65%), ridges at Lubero (81.43%) and stools or contours at Rutshuru (37.67%). Also, Intercrop (with annual/bi-annual crops) was more applied as cropping method at Lubero (47.32%) territory than at Masisi (25.87%), Rutshuru (14.95%) and Beni 33.12%).

A small group respondent indicated using the mixed cropping (with perennial crops) (5.89-31.89%) as best cropping method of sweetpotato. The majority of respondents used monocropping systems as common cropping method at Masisi (54.34%), Rutshuru (51.96%), Lubero (34.76%) and Beni (54.91%).

From focus group discussion, it was realized that sweetpotato was mainly cultivated as a sole crop, but intercropping was important in some villages. Associating sweetpotato with beans/cassava was the most popular intercropping system in Rutshuru. To a markedly lesser extent, beans, cassava, and maize were also planted in the same field with sweetpotato.

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In areas with high population densities (Lubero-Butembo, Rutshuru), sweetpotato intercrops appear to be more common. Intercropping was probably a response that attempts to maximize returns from land. In Beni almost all farmers sole-cropped sweetpotato, meaning that farmers planted sweetpotato in pure stands. In Lubero-Beni, some farmers intercropped sweetpotato with, dry bean, cassava or maize whereas in Masisi some farmers intercropped with mainly with dry bean or garden pea (*Pisum sativum* L.). In Rutshuru, farmers intercropped because of shortage of land whereas in Lubero intercropping was conducted for food security reasons.

The majority of the farmers planted several sweetpotato genotypes in a single plot or garden. In Rutshuru , all the farmers planted mixed genotypes, whereas in Lubero-Butembo few of them planted a single genotype per field and these were mainly for the production of vines and roots for the market.

All the farmers in Rutshuru planted sweetpotato on individual mounds whereas most of the farmers in Lubero-Butembo planted on long, narrow ridges across the hill slope. Few of the farmers from Rutshuru planted sweetpotato in the wetlands during the dry season to provide planting materials for planting on the hillsides in the forthcoming rainy season.

-The crop protection farming practice that was mostly adopted by respondents included, regular weeding (at least two times) (23.96- 78.56%),use of tolerant/resistant varieties (7.54-48.12%). A small group of respondents reported using no method to control pests-diseases (3.12-41.43%).

Most farmers did not fertilize their crop (37.23-89.56%), some farmers used organic fertilizers (7.87-62.89%) whereas mineral fertilizers were not commonly used by few respondents (0.065-7.62%), (Table-12). Among innovative farming practices applied, earthing-up (52.76-62.76% of respondents), harvesting in bits and de-topping to encourage more tuber production in subsequent days (13.23-39.32%), rolling/tying of vin at the base to increase tuber size (0.31-8.94%) were among the key farming practices and technologies (innovations) applied by farmers across s study sites (Table-12).

The farming systems also show diversity: for example in the high-altitude areas(Lubero-Butembo), sweetpotato was found to be a major root crop , whereas cassava predominates in Rutshuru. Maize, sorghum, Irish potato, and banana were other important crops. High-altitude fruits and vegetables were also found being grown.in Beni, sweetpotato also accounted for substantial land here because it was more important for home consumption. Sweetpotato and cassava were the major root crops. They were used for food and cash generation, and occasionally for brewing local beers. Sweetpotato was found to be, however, an important crop in this territory as a recovery crop following disaster events because it had a shorter maturity period than cassava. The major traditional cash crop was found to be coffee in Beni and Lubero-Butembo. In Rutshuru, allthough sweetpotato and cassava were also consumed, most production ends up in town markets, where both root crops are popular foods, especially for the urban poor.

Territory crop calendars showed planting and harvesting dates of major crops. The planting of most major crops was concentrated October-December at the beginning of the first rains in most areas . Harvesting of most annual crops took place from March to September in most territories. The dry season was found to be the most suitable time for harvesting and drying.

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Swamp cultivation, if practiced, occurred during the dry season. Whereas most farmers reported planting and harvesting sweetpotato throughout the year, planting was reported to be concentrated from October to June. Sweetpotato was found to compete with other crops during this planting period for labour. When labour becomes too limiting, sweetpotato planting is extended to July, when rains are tapering off. Farmers recognize that compared to other crops sweetpotato can establish itself at a lower soil moisture content. Sweetpotato can be harvested at any time of the year, and piecemeal harvesting can extend up to 12 months after maturity for some varieties. Several crops compete for farmers' labour during peak planting and harvesting periods.

-Multiple plantings of sweetpotato are common in Rutshuru. Respondents planted sweetpotato twice a year. In Lubero, three plantings was the modal number. Early planting for the first rainy season is in October-November , but it is still safe to plant till December. Planting in mid-July to August is the earliest possible time for the marshland cultivation. Some respondents perceived that ideal planting dates were variety-specific. Although sweetpotato is planted and harvested throughout the year, in most villages the first rains (main rains) start in September or in October, and this is the peak planting season. Peak harvesting occurs from July to September.

In the region, there exist different sweetpotato cropping systems in different areas. There are differences in seedbed type, rotation systems, intercrops, varieties grown, and type of land used for the cultivation of sweetpotato. Even where the same type of seedbed is used, seedbeds have differences in shapes and dimensions across farms, villages, and agro-ecological zones.

In the high-altitude zone, half of the respondents cultivate sweetpotato following a fallow period or sweetpotato comes next to last or last in the rotation system. In addition, respondents reported that sorghum/maize/beans/maize intercrops followed sweetpotato in the rotation. In Rutshuru, cassava was regarded as a resting crop. In other words, cassava was left in the ground for 2-3 years, and harvested piecemeal (bit by bit) as needed. Cassava varieties that did not easily rot were selected for this purpose.

The cropping systems described above were merely generalizable: rotations vared even by household. Each household formulated its own rotation system based on its resource endowments and priorities. Cropping systems analysis was further complicated because systems change according to climatic and economic factors as perceived by the household.

-From the focus group discussion, it was found that most farmers had a long experience cultivating sweetpotato. The average period of growing the crop ranged from 16-50 years. The majority of the respondents, therefore, have been growing sweetpotato for most of their lifetimes. Territories with high population pressure had experienced reductions in area devoted to sweetpotato over the past five years. However, with the continuing deterioration of soil fertility, expansion of banana weevil infestation, and high incidence of cassava mosaic disease in many villages, most farmers were likely to expand their sweetpotato acreage in the near future to ensure household food security. In Beni. more than half of the respondents have reduced the area devoted to sweetpotato since they started producing. Declining yield was reported as the main reason. Because of severe land pressure in Lubero, an increase in one crop was usually meant as a decrease in another one.

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Uplands were commonly used for sweetpotato cultivation. But where population pressure (particularly in sloppy areas of Lubero-Butembo territory), has linked to drastic reduction in land availability, swamps were used, even during the rainy season. During the dry season, farmers usually cultivate swamps not only to obtain roots but also to "store" vines for the coming planting season. During the rainy season, most swamps are flooded and hence difficult to cultivate. Farmers cultivate uplands where soil moisture content is suitable. During the dry season, soil moisture declines in the uplands, while in swamps water recedes, making room for cultivation. Sweetpotato and vegetables are typically planted during the dry season in marshlands in Rutshuru and Lubero territories. Large trenches are dug to drain parts of the swamp for cultivation. Mounds or raised beds are used because they facilitate soil drainage. In Masisi, about an equal percentage of respondents grow sweetpotato on upland, swamp, and flat land. Because of population pressure in Lubero, most of the land, including hills and swamps, is used for agricultural production. In some areas, swamps exist but are not easy to use when there is no distinct dry season during which the land drains to some extent, making them easier to manage. Here, sweetpotato is a rustic crop, relatively tolerant of drought and infertile soils. In most cropping systems, the crop is either planted early to suppress stubborn weeds or late on land too poor for most other crops.

Most farmers also note that a finer seedbed is achieved after a sweetpotato crop. Even though most farmers use good land for sweetpotato, they are aware that the crop has too much vegetative growth and not enough storage-root development when grown on very good soils. This explains in part why some farmers use poor, over-used, or eroded land for sweetpotato production. It is difficult for most farmers to determine optimal fertility for sweetpotato cultivation. The general consensus is that soils of medium fertility are already good enough for sweetpotato cultivation.

-Most respondents did not apply manure on sweetpotato. The percentage of respondents using manure increased over time. Chemical fertilizers were applied in areas nearby cities and towns and where sweetpotato was grown as a commercial crop for the market. Farmers apply fertilizer or manure to the crop planted in the same field before the current sweetpotato crop. As a result, sweetpotato cultivation appeared to be starved for soil fertility resources. The use of commercial fertilizers may not be economical at current food crop prices. Moreover, commercial fertilizer is often unavailable.

Mounds were found to be the most common type of seedbed except in highland areas where both mounds and ridges were used . Mounds varied in diameter and height as did the number of vines planted per mound. Where soils were good (i.e., friable and light to medium), there was a tendency to have larger mounds than where soils were hard and difficult to work. A typical mound, however, did not usually exceed 1 m in diameter and height. Leaves and manure were sometimes gathered first, and later then soil was heaped on top to make a mound. Ridges were commonly used on hill slopes and in swamps, especially in highland areas. Ridges help control soil erosion on hillside slopes and were used to improve drainage in swampy areas. They were usually several meters long, about 1 m wide, and less than 1 m high. Ridges or raised beds predominatedin swampy areas or valleys in highlands of Masisi and Lubero-Butembo. The number of vines per mound was found to be a function of mound size. Mounds were found to be significantly larger in Lubero than those in other territories, often with a radius greater than

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30-cm. The diversity of mound size and number of vines per mound across farms and villages indicates the limited knowledge on optimal mound size and plant populations by agroecological zone and soil type.

When the ridges to be made for planting were not ready, the vines were kept in moist soils under the shades in order to maintain their viability. The majority of respondents conserved the planting materials in the fields for next planting. It should be noted that none of the producers interviewed used certified planting materials because breeders and seed agencies did not make this available to them

From the focus discussion dialogue, it was found that weeding was done by hand or by using a hand hoe. The rotation system, season, and weather conditions affected weeding frequency. Generally, the first rainy-season crop requires more weeding than the second rainy-season crop. For most varieties, the first weeding was carried out two months after planting. Most respondents believed that sweetpotato required a maximum of three weeding. On average, farmers weeded twice per cropping season. In wetter areas, some farmers needed to weed more than two times. Most farmers recognized the importance of hilling up around plants, especially when weeding. Reasons given for the practice of hilling up included root expansion, yield enhancement, and protection of roots from direct sunshine and weevil attack .

Farmers recognized that the practice of hilling up gave sweetpotato plant enough soil for expansion in addition to being a way to enhance nutrient supply. Yields tend to be higher with this practice.

Farmers also believed that exposed roots were susceptible to adverse weather conditions and pest infestations. Exposed roots tended to turn green, sprout, and become unpalatable. They were also easily attacked by enemies such as sweetpotato weevil and rats. Farmers were aware that hilling up during weeding could help to avoid these problems, although this did not appear to be the primary motivation for the practice. The practice of burying vine nodes varied among the different villages to obtain higher yields. Higher yields were achieved because buried vines tended to root at the nodes and produce more storage roots. Hence, farmers harvested more roots per plant than would be the case without this practice.

-Respondents reported no pesticide use even during high infestation of pests (sweetpotato weevils and caterpillars). In Rutshuru villages bordering Goma town, sweetpotatoes fetch a higher market price, making it more economical to use pesticides.

3.8. Physical characteristics of some sweet potato varieties found in the study area during interviews

-There was a variety of skin color of sweetpotato genotypes grown by farmers: The white cream (35.45-51.12%), Red and Dark red (11.21-25.54%), purple (5.15-12.12%) and Orange (5.13-12.12%) were the dominant skin color across study territories (Table-8). Similarly, white cream (50.31-57.12%), cream (21.43-33.67%) and orange (5.56-11.67%) were the dominant flesh colour cited by respondents across study suites (Table-8).

3.9. Current status of sweetpotato local varieties available in the villages

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Some farmers from Masisi (25.85%), Rutshuru (54.12%), Lubero (14.98%) and Beni (9.18%) perceived that the number of local varieties (landraces) in the village was increasing; whereas the majority of respondents from Masisi (63.51%), Rutshuru (42.76%), Lubero (41.88%) and Beni (73.65%) perceived that traditional varieties (landraces) were decreasing almost not available in the village (Table-9).

Similarly, total production in all villages (11.56-33.87%) was rated as increasing by some farmers; while the majority of respondents (43-67-78.73%) indicated that total production of sweetpotato was decreasing. However, respondents from Rutshuru (27.12%) indicated that there has been no change in the total production over years (Table-9).

From the focus discussion narration, it was realized that over time, farmers had selected a number of sweetpotato varieties that were identified by local names. This nomenclature was based on varietal characteristics such as yield, maturity period, root size and shape, leaf size and shape, and other factors such as place of origin and person who introduced the variety. They were identified by different names in different areas (villages). Some local varieties were fount cut across territories/villages. Currently, some farmers are dependent on local land races as no improved varieties have been released. Most of these had a good yields and good root qualities, and perform well in different types of soils. Even though varieties varied across farms and villages, several varieties were extensively grown in more than one village/ agroecology. Such varieties usually tolerated a range of climatic conditions, they had a high disease or pest resistance, and good yield. Most farmers grew more than one variety. Reasons given for this practice include varietal preference, lack of enough vines of anyone variety, food security, spreading of yield over time, and losses from storage and pests or diseases.

In Rutshuru most farmers grew only landraces while the rest grew both improved cultivars and landraces. Here, the most commonly grown genotypes were all landraces whereas in Masisi they were all improved cultivars. In Lubero-Butembo few farmers grew improved cultivars only and the majority grew both improved cultivars and landraces in Masisi territory. The farmers who planted only the improved cultivars were those involved in commercial vine production

Preferred sweetpotato varieties tended to be high yielding, resistant to common pests and diseases, of medium maturity with good in-ground storability characteristics, suitable for piecemeal harvest with no fibers, and of good marketability, medium sweetness, and powdery texture.

Some stable local varieties have been grown for 5-20 years without changing their culinary qualities of becoming extremely susceptible to diseases and pests. Varietal stability was attributed to pest/disease tolerance or resistance, maturity period, taste. yield, and in-ground storability. Fungal and viruses often caused varieties to degenerate over time. Moreover, if a variety was not adapted to poor soil conditions, then declining soil fertility could accelerate the varietal degeneration.

From the focus group discussion narration, it was realized that most popular varieties grown by farmers were chosen based on the following criterial: preferred by consumers, short cycle of 4 months, high yields and big tubers when compared to other varieties. The varieties grown

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means you can be in debt without worrying. According to the producers, varieties are grown by their high productivities to enable farmers to pay their debts.

Most respondent farmers expressed a desire for productive dual-purpose varieties in preference to specifically storage root or vine types. The farmers from Lubero listed several desired sweetpotato attributes.). The most highly ranked attributes by farmers were high yield, early maturity and sweetness of the roots .. The most important attributes ranked by the farmers was the high yield followed by early maturity(3-6months), sweetness/taste, the ability to yield well in all types of soils especially infertile soils, & lastly the drought tolerance. Most respondents from Rutshuru indicated that variety selection criteria were (in order of importance) resistance abiotic and biotic stresses, dryness of storage root after boiling, taste, storage root yield, earliness and cookability. In Masisi, one of the reasons that the farmers mentioned for not adopting recently introduced high yielding, disease resistant cultivars. Disease resistance was ranked as most desired attribute in Rutshuru whereas resistance to sweetpotato weevil was only importantantly cited in Lubero-Butembo. Good groundcover was reported as a desired attribute by some of the farmers from Masisi. The farmers Lubero wanted genotypes that covered the soil surface fast so that the speed of water runoff was reduced (because of the hilly nature of their terrain) and the requirement for weeding was less. According to the farmers such genotypes that cover the ground rapidly protect the roots from weevil damage and rotting during the dry season. This attribute goes hand in hand with good seed production in Lubero . There was no commercial vine production in Beni and the farmers preferred genotypes that produced enough vines and that were tolerant to dry conditions to provide planting materials at the beginning of the planting season.

3.10. Types of sweetpotato cultivated, and attributes of preferred varieties

Concerning the proportion of type of sweetpotato (WFSP, OFSP), there was a great variability ($P<0.0001$) in the types grown: Respondents from Masisi (59.22%0, Rutshuru (15.77%), Lubero (5.21%) and Beni (7.88%) indicated that they were forced to grow greater proportion of WFSP because OFSP were not tolerant to water stress (drought) on upland. Some respondents (0.11-27.12%) indicated that they had abundant WFSP varieties on their land because, planting materials of WFSP were more abundant in the villages than of OFSP. Those keeping animals (0.88-7.65%) indicated that WFSP were more palatable for livestock (Table-10). As compared to respondents from Masisi (0.99%), Rutshuru (5.12%), Lubero (5.87%), those from Beni (23.05%) indicated significantly ($P<0.0001$) to be not familiarized well with OFSP as medicinal crop. Un small group of farmers from Masisi (1.45%), Rutshuru (6.67%), Lubero (8.87%) and Beni (20.78%) indicated that OFSP genotypes were very popular because they were watery and too sweet. A small group of respondents from Lubero (5.32%) mentioned that WFSP were always more productive than OFSP, reason why they cultivated more WFSP (Table-10).

Some respondents (3.65-18.34%) indicated that they cultivated equal proportion of WFSP and OFSP on their land because they were convinced that some clones of OFSP were associated with high yielding than classically grown WFSP. A significant ($P<0.0001$) number of respondents (1.54-21.99%) were growing equal proportion of WFSP and OFSP because they believed that OFSP were high yielding and had better taste to fight kwashiorkor (anemia) or A-vitamin

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deficiency than WFSP. A small portion of respondents indicated that they still experimenting new OFSP varieties known to be more nutritional than WFSP (Table-10).

In terms of cultivar preferences, there was a significant (P=0.003) difference in proportion of respondents: farmers from Masisi (19.70%) preferred varieties that resistant (tolerant) pests and diseases more than farmers from Ruthsuru (7.87%), Lubero (6.85%) and Beni (4.83%). Few respondents from Masisi (1.23%), Rutshuru (15.76%), Lubero (0.85%) and Beni (1.13%) indicated they preferred locally adapted (landraces) cultivars than exotic (improved) ones for both OFSP and WFSP (Table-10). In terms of post-harvest and storage root preferences attributes, farmers were mostly interested in high dry matter content varieties (19.63-23.4%). Some other farmers (9.87-13.12%) in the taste (flavor, texture) of leaves/ fresh root. There was a significant (p=0.025) difference in the preference of varieties for their biomass at harvest (as animal feedings): Masisi (6.23%), Rutshuru (1.32%), Lubero (0.54%), Beni (1.12%), (Table-10).

From focus group discussion narration, it was realized that red was the dominant skin colour of the storage roots in surveyed territories. White-skinned roots were also common. The frequency of white-skinned varieties was substantially greater in Lubero than Beni. Reasons for preferring white-skinned varieties were not immediately clear. Some respondents stated that white-skinned roots are more susceptible to weevils than red or brown-skinned ones. White-fleshed roots were dominant in all surveyed territories . In Rutshuru and Masisi, most varieties had white-fleshed roots; whereas in Lubero, most varieties had white-fleshed roots. Cream-fleshed varieties were uncommon and were perceived to be more susceptible to weevil attack.

3.11. Preference of farmers to grow white and/or orange fleshed sweetpotato and willingness to adopt improved varieties,

-Concerning the preferences of farmers to grow white and or orange fleshed sweetpotato, some respondents preferred OFSP (14.23-17.54%), WFSP (21.78-41.44%), YFSP (2.13-6.67%)., and sometimes all three types (2.13-6.67%) (Table-18). Most respondents from Masisi (51.56%), Rutshuru (55.12%), Lubero (60.43%) and Beni (67.12%) were willing to adopt OFSP. Some other respondents were willing to adopt the three (OFSP, WFSP, YFSP) types of sweetpotato (16.12-31.89%), (Table-18).

Attributes of preferred varieties to grow/ retain/adopt

Farmers grew local cultivars bearing different names. The name of the cultivar was given either by place of origin or the person who pioneered it. There were significant ($P<0.05$) differences among the respondents with respect to their selection criteria for sweetpotato varieties in the four territories. Skin and flesh colour, and flavour were ranked relatively low and the selection criteria significantly differed across territories and villages. From the focus group discussion, it was realized that the majority of farmers interviewed would prefer OFSP than WFSP. The proportions of respondents on the level of sweetpotato preferences were not significantly ($P>0.05$) different across territories.

Orange flesh and red skin of the sweetpotato roots were lowly ranked in Masisi an Beni. The reason the farmers gave for the low ranking of the OFSP was the unpleasant flavour and low dry mass. Of the farmers interviewed, only those who produced for the market were concerned about the skin colour where red was preferred.

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Interestingly, OFSP were popularised by researchers through on-farm evaluation. Some of farmers were interested to grow OFSP cultivars. Despite lacking most of the preferred attributes, some cultivars were grown in pursuit of food security. Farmers received new sweetpotato cultivars from research institutes and development agencies. Cultivars received for the past 5- 20 years released although some of them are non-longer viable these days. Most the released cultivars are not yet registered by the Ministry of Agriculture.

The most preferred traits for cultivars included (in order of importance) high yield, resistance to diseases, high dry matter content , early maturity , drought tolerance , marketability , sweet taste and elliptic root shape for easy packaging for transportation. Farmers rejected some cultivars and yet opted to grow others. Low yield, susceptibility to diseases and pests, and poor marketability were the most important rejection criteria (for abandoning their cultivation). However, a cultivar abandoned in one area was found to be grown in other areas, suggesting varied preferences across territories.

3.12. Perception of the role of OFSP in combating malnutrition & Vitamin-A deficiency in children

-Richness in all vitamins (Vitamin-A & Proteins) (6.12-36.32%), health booter or keep healthy (28.54-49.11%), Orange or carrot colour look like (0.54-9.76%), attractiveness (sweet taste) (1.23-15.54%), preferred by children and pregnant women (10.11-23.34%), were the top attributes of OFSP clones that consumers were aware off during interviews (Table-13). When asked if sensitization of communities more about role of OFSP in combating malnutrition and vitamin-A d efficiency was important, there were a significant ($P<0.05$) difference in answers., respondents from Lubero (15.54%) mentioned that it was not import to sensitize communities. However, respondents from Rutshuru (32.45%) mentioned that it was important to carry out sensitization campaigns. Only respondents from Rutshuru (38.23%) indicated that it was very important to proceed to sensitization campaigns of communities. Most respondents from Beni (88.08%) indicated that they did not t known the relevance of campaigning for sensitization and wide mass communication about the importance of consuming OFSP (Table-13).

There was significant difference ($P<0.05$) in responses given by respondents from the 4 study territories concerning sources of information about attributes of OFSP and related improved sweetpotato varieties. Visiting markets at Rutshuru (22.08%), dialoging with traders (seed traders, agro-dealers) at Beni (16.43%), talking to friends (fellows consumers/ growers and family members) at Masisi (28.78%), visiting progressive farmer plots with improved varieties at Lubero (4.32%) and making a visit to public research centers demonstration plots available in the village at Rutshuru (6.43%), were the key strategies that were used by respondents to acquire the information about attributes of OFSP (Table-13). When asking some other respondents, the reason for not adopting the cultivation of OFSP, farmers from Rutshuru (34.94%) mentioned that they lacked the information on where to find vines of OFSP. At Masisi (24.77%), respondents indicated that local varieties still perform better, thus there was no need of cultivating new. Respondents from Lubero (25.45%) indicated that previously released varieties (landraces and improved varieties) were still performing well, thus there was no need of adoption new OFSP. Respondents from Beni (27.52%) reported that the absence of nursery/demonstration plots let by scientist in the village was the key reason for not adoption improved OFSP. Small group of farmers from Rutshuru (26.65) indicated they were willing to

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adopt OFSP, but the lack of money (cash) to buy vines of improved varieties was a major problem to them (Table-13).

3.13.Source of information on Vitamin A deficiency & associated OFSP health benefits

-Concerning the source of information on vitamin A deficiency and associated OFSP health benefit, there was a significant ($P<0.05$) difference in answers of respondents from the 4 study territories: Health workers were cited at Lubero (20.41%) as key source of information., whereas agricultural extensionists (from NGOS and private sector) were cited by to be key source of information by respondents from Beni (41.543%). Community members were major source of information at Rutshuru (37.76%). Respondents from Lubero (51.32%) indicated having no clear idea about the source of information on Vitamin -A deficiency and associated OFSP health benefit (Table-14).

Concerning the perceived benefits of eating OFSP, there was a variability ($P<0.05$) in answers of respondents across the 4 different study sites., some respondents from Masisi (65.66%) and Lubero (64.76%) perceived that the control of VAD (vitamin A deficiency) was the critical benefit of easting regularly OFSP. Respondents from Masisi (15.34%) were aware that OFSP were capable of making healthier the body of consumers. Some farmers from Rutshuru (49.65%) and Beni (33.12%) were convinced that OFSP provided energy to human body. More than half of respondents from Beni (50.55%) were not aware of any health benefit associated with the consumption of OFSP, (Table-14). Concerning suggested actions to control VAD, respondents suggested various strategies such as eating regularly vegetables (3.66-19.34%). Eating OFSP was judged as sufficient to control VAD (2.12-18.54%). Other respondents suggested that eating fruits (1.33-24.12%), eating vitamin A-rich foods (fortified maize, plantains, orange, rice) (9.12-41.87%) and eating regularly biofortified legume crops (0.54-7.87%) could help in eradicating VAD (Table-14).

Gender perception of economic benefits of some sweetpotato varieties such as OFSP

From the focus group discussion narration, it was realized that both men and women individual mentioned during interviees that increased incomes from vine production and marketing had helped them build or renovate houses that they were already staying in. However, benefits from sweet potato have to be understood from a systems perspective, where farmers used income from different agricultural sources to invest in developments around the home. For example, farmers mentioned combining money from potato and sweet potato, or sweet potato and maize or livestock sales to invest in housing improvement and other investments around the home. This complementarity amongst agricultural enterprises was seen not only to augment income and wellbeing in the household, but also to provide insurance against crop and market failure. Farmers regarded building a better house as a key benefit and priority investment from agricultural incomes. Extension workers also mentioned that both men and women farmers, who multiplied vines, used the money to build houses and in one case to install electricity in the house. The focus on housing construction may be related to the low housing standards which made it a priority investment for farmers.

More money and higher yields from a small piece of land was regarded as one of the benefits of OFSP. OSFP was regarded as having much higher yields as compared to other crops while linkage to markets made it financially more rewarding than other crops. Some farmers also

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mentioned that money from selling OFSP vines and roots could also be invested in the production of other crops. High demand for OFSP roots and vines was mentioned as a benefit since they sell fast (the aroma and smoothness of OFSP was preferred) and sometimes for a better price than their white fleshed counterparts. Farmers perceived that demand for OFSP was higher than for white fleshed sweet potato given the additional knowledge that people had about the health benefits of consuming OFSP.

Both men and women mentioned using money from the sale of sweet potato roots and vines to purchase livestock as a key economic benefit from cultivating OFSP roots and vines. Women however mentioned that animals like goats were really good to buy since, in addition to producing milk which could be sold or consumed by the household, they could sell goats to pay school fees or buy clothes for the children. Thus, livestock is key to both food nutrition and income security and also serve as an emergency fund and a way for both men and women farmers to save their money. Buying livestock often consistently ranked in the top three significant changes in men and women farmers ' lives. However it has to be noted that only male who multiplied vines and were linked to institutional markets were able to buy large livestock such as cows. Since the majority were men, none of the women mentioned buying cattle. This may in itself indicate that women are less integrated in vine markets than men are and are not able to benefit to the same level as men.

Farmers also mentioned being able to invest in land and other agricultural equipment from selling sweet potato vines. When men and women are able to access high agricultural incomes they diversify their investment portfolios. Farmers invested in small enterprises such as local restaurants and also livestock as mentioned earlier when their income increased. Farmers made major investments in housing, agriculture and other non-agriculture based enterprises.

-Many farmers depend on agricultural incomes for most household expenditure including purchasing clothing, household utensils as well as paying school fees for children. However, while men mostly mentioned buying clothes for themselves and their children, it was mentioned that women benefited more in terms of buying kitchen utensils. Men regarded women being able to buy kitchen and other household utensils as a benefit that the women enjoyed from increased incomes as a result of OFSP.

Some women mentioned that having money that they could control independently of their husbands was a huge benefit from cultivating OFSP roots and vines be-cause it gave them autonomy as well as the ability to purchase household needs without having to ask their husbands for support. For instance, while women did not have full control over money from the sale of vines, one female Vine Multiplier mentioned that she had become independent and self-reliant and that was a big benefit for her. She could use money from the selling of vines and roots to buy the things she wanted without consulting her husband: Thus even though women may not at the moment be able to invest in large items, their ability to make independent decision on small items within the household using some of their earnings from sweet potato was empowering for them.

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3.14. Knowledge, perception and awareness (%) of sweet potato biotic constraints (pests, diseases) of farmers interviewed

Across study sites, sweetpotato butterfly (*Acraea acerate*) (12.43-21.76%), Sweetpotato weevil(*Cylas* sp.) (21.87-45.54%), Red spider mite (*Tetranichus cinnabrinus*)(5.65-12.12%) and grasshoppers(6.67-18.21%) were mostly cited by farmers as top pests of sweet potato Sweetpotato viruses were cited by farmers as key disease constraint at Beni (23.92%), whereas at Alternaria blight was most cited as critical disease at Ruthuru (48.87%).Also, respondents from Masisi (57.43%) and Lubero (58.22%) indicated that fungal black rot were the top diseases of sweetpotato in their villages. Among other biotic constraints, newly emerging unknown diseases (30.67-45.12%) and newly emerging pests (37.12-46.73%) were cited. The emergence of new diseases was attributed to current climate variability and insecurity-instability (ongoing civil wars) (Table-7). -Farmers who grow OFSP as cash crops indicated that prevalence of pests-diseases and destructive weeds (34.65-79.65%) was a key challenge to the agri-business. There was a significant difference in perceptions of climate variability impact among study territories: Few respondents from Masisi (12.54%), Rutshuru (2.32%), Lubero (6.75%) and Beni (1.54%) reported climate change and rainfall variability as a challenge in OFSP production business. Because most farmers interviewed are locate d in mountain areas, Natural disasters (landslides, soil-water erosion) were ranked as key challenge in OFSP production business at Masisi (16.76%), Rutshuru (23.45%), Lubero (23.87%) and Beni (8.43%). At Masisi (18.54%), livestock keeping was a key challenge because sometimes animals enjoyed feeding on OFSP vines (leaves). Arable land scarcity (0.76%-10.54%) and market price fluctuations (1.54-16.76%) was a key challenge to production of OFSP (Table-7).

3.15. Production constraints cited/ranked by farmers

-Concerning land preparation constraints, most respondents (24.13-41.5%) indicated that shortage(scarcity) of arable lands was the major constraints. There was a significant($P=0.014$) difference among study sites concerning family labor (declining family/community aid) as a constraint: Massisi (1.21%), Rutshuru (5.54%), Lubero-Butembo (5.32%) and Beni (3.43%), (Table-6). There was a significant ($P<0.05$) variability in answers of respondents concerning planting material as constraints: Some respondents from Masisi (23.56%), Rutshuru (8.89%), Lubero-Butembo (15.45%) and Beni (27.23%) reported that shortage (lack) of lean planting material was a major constraint. The prevalence of degenerated varieties in the village was mentioned to be a significant ($P=0.002$) planting material constraint by respondents from Lubero (28.54%) as compared to respondents interviewed for the same question at Masisi (11.87%), Rutshuru (7.67%) and Beni (15.32%). Across study sites, there was a significant difference in proportion of respondents who indicated that prevalence of low yielding genotypes($P<0.001$) and variety genetic erosion($P=0.013$) were key planting material constraints in the village (Table-6). Climate change stress (heat, rain shortage, rainfall delay) was mentioned as a climate-environmental constraint to sweetpotato production: there was a significant difference in answers from the four different study territories: Masisi (4.12%), Rutshuru (8.81%), Lubero-Butembo (19.54%) and Beni (21.55%).Some respondents indicated that climate-related hazards and risks (floods, submergence, landslides) were key climate-environmental constraints at Masisi (37.32%), Rutshuru (32.43%), Lubro-Butembo (19.87%) and Beni (24.14%) .A good number of respondents (38.71-46.56%) indicated that soil-water-nutrient erosion on sloppy lands was a key constraints (Table-6).

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For harvesting and post-harvesting (storage, processing) constraints, there was multiple answers and a variety of answers given. Some respondents indicated key constraints for them such as (i) weevil pest infestation during storage (2.11-6.32%), rodents attacks during storage (1.98-3.12%), rotting of roots during storage (5.43-14.32%), lack of processing equipment& materials (0.64-15.43%). There was a significant ($P<0.05$) difference in proportion of respondents who mentioned other type of constraints for them such as poor (low) yields at harvest, birds-rats destroying roots in the field, vermin & wildlife (baboons, hippopotamus) harvesting roots (Table-6).

Concerning socio-economic factors (markets, trade, policy) constraints, some respondents (19.32-27.65%) indicated low & seasonal fluctuation price and low annual trend as key constraints. Another group of respondents (17.65-18.51%) indicated that the demand was not high at local market and this discouraged people to grow sweetpotato as cash crop. Other respondents (5.25-9.21%) indicated that lack of regular training updates on new sweetpotato technologies was a key constraint. The lack of government support (absence of public extension services) was mentioned by respondents (3.21-6.54%) as key sweetpotato constraint (Table-6).

-During production, several limitations were mentioned hindering increased and sustainable sweet potato production. From the focus group discussion narration, it was realized that production constraints were regarded as major limitations in sweet potato farming. Different sweetpotato production constraints were identified during the discussion. Constraints to sweetpotato cultivation vary across provinces and seasons. The major sweetpotato production constraints (impacting growth and yield) (serious impediments affecting sweetpotato production) described by respondent included (in order of importance): shortage of clean and improved planting materials, increasing incidence of diseases and insect-pests and weeds, shortage of money to cover input costs, a lack adequate methods for controlling pests, diseases, soil erosion and soil nutrient deficiencies, the lack of suitable varieties, limited access to credit, absence of modern equipment, scarcity and high cost of labor and absence of best methods for long-term storage, lack of postharvest processing modern equipment and related facilities , shortage of suitable land, rising shock of abiotic factors such as floods and landslides and high frequency of climatic variability events. Non significant differences were detected between territories and villages for the reported constraints. However, there were highly significant ($P<0.001$) differences among the respondents regarding the major constraints affecting sweetpotato production in the study areas .

Some farmers complained lack governmental follow up in sweet potatoes production. Insufficient skills of how properly to cultivate sweet potato and insufficient land were also rated by some farmers. Few farmers were frustrated by thinking about the non- durability sweet potato .Some other few farmers said that affordability of new varieties to replace traditional varieties was still problem.

During discussion, it was found that sweetpotato was traditionally processed into numerous products, including : flour, cookies, local beer and juice. However, the major post-harvest constraints identified by the farmers included : poor access to markets poor market prices, low yield , low dry matter content of storage roots of existing varieties , a lack of knowledge about sweetpotato processing and preservation, access to processing equipment and the logistics

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of transporting a heavy, bulky crop to market. Post-harvest problems affecting sweetpotato were mostly those related to its short shelf-life, which is affected by the quality of the storage roots. In Lubero, some farmers reported using solar energy to dry sweetpotato storage root slices after harvest. The majority of the respondents stored roots in-situ in the soil, harvesting them as and when they were needed for food consumption at home. In Beni, the major constraints that affect sweetpotato storage roots while leaving them in the soil were insect-pests , diseases and rodents and thieves . in Rutshru, respondent farmers believed that some rain was favourable for prolonging the lives of the storage roots in the soil, which was an unexpected observation.

In Masisi, the production, post-harvest, processing and marketing constraints mentioned during discussion included :limited access to credit, lack of storage facilities, lack of processing technologies, poor market channels, limited support from the government, high labour cost and high incidence of pests and diseases. In marketing, low price for the sweet potatoes was regarded as the major bottleneck and most farmers ranked it as either the first or second limiting factor in sweet potato marketing followed by lack of organized market which is controlled by middlemen. Taking on credit with subsequent delayed or no payment and lack of transport were other bottlenecks mentioned in marketing sweet potatoes during the Rutshuru focus discussion meeting. Several constraints were said to affect processing and storage of sweet potatoes., these included storage pests ,high costs of storage bags and lack of processing tools among others. Among these, storage pests were regarded as the major limitation. Storage pests were ranked as either the first or second major constraint in the post-harvest handling of sweet potato products by the farmers.

Villagers from Beni, indicated some other constraints including high temperatures, high moisture content of tubers, flooding of potato fields and late harvesting. Producers also listed weeds as serious constraints where the lands were rich in nutrients.

In Lubero-Butembo, declining soil fertility and disease were cited by discussant as the most serious problems affecting sweetpotato production. In some villages of Masisi, lack of reliable markets, low prices in inaccessible areas, and the absence of household storage methods were reported to be more important contributors to shrinking sweetpotato acreage than are viruses and pests. During field focus discussion meetings, the most important constraints identified by participant were pests and diseases, unreliable markets, land slides and low prices at local market. Other biggest bottleneck (constraints) cited included lack of transport, lack of credit facilities and extension services. The chiefs of some villages in Masisi and Rutshuru indicated that unreliable markets with low prices were regarded as major constraints of sweetpotato production limiting farmers to pull out of poverty. Extension service agents locally based in Masis and Ruthsuru indicated that farmers sold the produce in the fields, local markets and along public roads. The price for produce was very low and unprofitable to farmers. It was indicated that their sales did not fetch high market price. In Lubero, participants at the discussion meeting were discontented and ranked the sweetpotato price as low in their villages. The low prices were due to the fact that middlemen determined the price of the produce . they indicated that farmers were forced to sell at low prices due to the perishability of the crop. Early- and late-harvested sweetpotato fetched high prices as compared with produce sold during peak harvesting periods. Farmers from Rutshuru established informal micro-cooperatives to

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search for attractive prices. These farmers were previously trained on post-harvest processing technologies even if they were incapable of purchasing processing equipment due to lack of capital.

3.16. Consumption/peeling-processing sweetpotato

Seasonally, more sweetpotato is consumed from February to October, which coincides with the harvesting period, than at any other time of the year . During a period of abundance, sweetpotato is eaten daily; the frequency of consumption drops to about twice a week in the main scarcity period, from January through the planting season. Sweetpotatoes are eaten throughout the year. The major sources of sweetpotato were own production and the village market . Few respondents consumed sweetpotato obtained from their own fields or buying it on the local market. Peeling and then boiling or steaming sweetpotato is the dominant form of consumption. Some times sweetpotato is often boiled or steamed without peeling.

Respondents reported peeling and boiling fresh roots. Some times, they processed sweetpotato into dried chips to store for eventual home consumption. Sweetpotatoes is usually chipped and dried during some periods. The dried sweetpotato is then eaten seasonally. The high frequency of peeling and boiling or steaming as the prevailing form of consumption points to the limited use opportunities. Research into expanded use, including development of new, acceptable sweetpotato recipes, will be necessary to expand demand and stimulate increased production. Mashing with other foods such as beans and peas is acceptable in many areas, and research could take advantage of this to promote other combinations.

Cassava is widely viewed by respondents as a good sweetpotato substitute. In the market, cassava and sweetpotato are usually sold alongside each other, and their prices tend to reflect this substitution. An increased sweetpotato supply leads to a reduced sweetpotato price, which in turn shifts demand away from cassava, depressing cassava prices in the process. The reverse also seems true. Other alternatives to sweetpotato include Irish potato, posho (maize meal), and bananas/taro.

Although a higher proportion of respondents in all the districts reported that sweetpotatoes are never harmful, a sizable proportion mentioned some health problems associated with eating sweetpotato

Common complaints associated with eating sweetpotato included heartburn, upset stomach, flatulence, and diarrhoa. These problems allegedly occur if a lot of sweetpotatoes are eaten or if they are eaten every meal. Sweetpotatoes were also reported to cause bloat and death in livestock, such as goats and pigs.

3.17.Storage of harvested sweetpotato root

A reasonably large proportion of respondents said they store sweetpotato for a few days not more than a week. Sweetpotato was mainly stored inside the house, on the floor or in a basket; it was also stored in sacks outside the house. Respondents sliced and dried sweetpotato in Rutshuru. Although the slice-and-dry storage method preserves sweetpotato chips for a much longer time, holding fresh roots on the floor inside the house for about 4-7 days appears to be the most common practice. Slicing and drying occursed most frequently in areas where farmers are forced to harvest their fields to avoid substantial losses of roots due to sweetpotato weevils.

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Keeping recently harvested sweetpotatoes on the floor is not really a storage method, but a practice farmers have developed to reduce harvesting labour by gathering enough for several days. Therefore, on-farm post harvest storage was found to be still limited. Some farmers mainly use in-ground storage. Those who slice and dry can store sweetpotato from 5-6 months to one year if the chips were properly dried, well handled, and stored under good conditions.

Fresh sweetpotatoes have a rather short shelf life and are usually physically damaged during harvesting and transportation. They therefore tend to deteriorate rapidly under ordinary conditions. Weevils are the most common storage pest reported by those who slice and dry. For the other methods, rats were cited by respondents as main pest problem in storage. Farmers also recognized and reported rotting as a result of bacterial and fungal attacks in storages. Physical examination indicated the presence of different kinds of molds on stored sweetpotato. Rotting was found to be commonly caused by damage and bruises inflicted on roots during harvest and transportation.

In some villages of Beni, storage of sweetpotato was found to be commonly conducted in field pits .Farmers recognized that sweetpotato roots were perishable and should be properly stored after harvest. Different storage methods, such as household containers, leaves or grass, a pit covered with leaves or grass, and a pit covered with soil, were used. Some farmers lined the pit with grass before placing sweetpotatoes in the pit. Others just stack sweetpotatoes in a corner of the field and cover them with banana leaves, sweetpotato leaves, or grass. Shallow pits can be covered with soil once the sweetpotatoes have been selected and placed in the pit. Most farmers used the "pit covered with soil" method or the "pit covered with grass" method. Sprouting and rotting occurred with these methods,. May change in flavour and food value during storage.

3.18.Storage for marketing of sweet potato products

Most farmers preferred marketable storage roots. High dry matter content trait was preferred by most respondents across all sites(territories). Farmers wanted medium- sized roots . Non significant differences existed between territories in the choice of storage root size. Most farmers expressed their need for sweet-potato varieties with roots of red skin colour. White-fleshed storage roots were preferred by most respondents .Few farmers preferred yellow -fleshed types and there was similarity in preference across the territories. There was a significant($P<0.05$) difference in territories for flesh colour and skin colour preference.

The producers surveyed had several storage and marketing methods. They consisted in packaging the sweet potatoes in the bags and covering them with vegetable debris . None of the producers interviewed had sophisticated facilities for long period of storage.

Sweet potato was grown mainly for the fresh market although there were low market prices in some areas. In some villages of Beni, farmers face low productivity or low product quality. The fresh market sweet potato tubers are sold in the surrounding markets around the study areas, which need to be improved upon for high price and sub-sequent high income.

In Masisi , producers marketed their sweet potato produces in several local markets. But none of the producers did export their products to the subregion and international markets. The marketing options included direct sales to consumers and selling to wholesalers or retailers. During the periods where sweet potato tubers were much more available, the supply

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becomes greater than the demand. This caused the producers to sell their products at a low price. This was due to the lack of storage facilities and the financial needs of producers. The sweet potato tubers were sold either in a basin or packed in bags and transported by canoes to the markets. There was a rapid growth in demand for sweet potato in urban areas because it was fried every afternoon in every corner of the cities where sweetpotato was also boiled . This has created huge opportunities to sell and market sweet potato in urban and rural areas in Rutshuru territory.

3.19. Major buying and sale points for products, mode of transport used for marketing, trading systems, occupation (player/actor activity along the sweetpotato value chains

-Concerning the major buyers of sweetpotato in the village, there was no difference ($P>0.05$) among study territories in the proportion of rural assemblers (middlemen, traders) (19.85-46.76%). However, there were significant difference ($P<0.05$) among study sites in the number of consumers (33.87-56.12%), processors (cookers) (8.76-20.12%) and NGOs & schools/private sectors (1.23-10.54%) as key major buyers of sweetpotato in villages (Table-15).

- Across study sites, nearby local and street markets (34.12-59.12%), shop in the trading centers (4.54-14.12%), Nearby restaurants (0.87-7.18%) and boarding schools (prisons, hotels) (1.09-12.65%) were among the key most sale points for sweetpotato that were reported by differently ($P<0.05$) by respondents from the 4 study territories (Table-15).

Head load (back load) (22.54-49.54%), bicycle/motorcycle (116.65-33.43%) and public/private transport with a car (7.65-54.12%) were the key mode of transport that were used for marketing sweetpotato (Table-15).

The average distance to the nearest good market was of 25.88 km (Masisi), 11.43km (Rutshuru), 25.61 km (Lubero) and of 17.31 km (Beni), (Table-15). The major source of marketing information for traders included (i) direct visit to the market (4.12-27.55%), (ii) cross checking with a fellow (50.34-69.54%) and (iii) talking-hearing from friends (16.81-34.67%), (Table-15).

Farmers (producers/ consumers) (51.12-66.21%), consumers only (11.76-17.67%), processors only (1.76-9.65%), cooking vendors (0.97-2.14%), collectors-venders-processors (2.11-6.12%), village collectors (3.65-12.54%) and sale person (6.32-9.67%) were the key typology of actors and occupation of players/actors activities along the value chain of sweetpotato in the four study territories (Table-15).

Marketing and selling sweetpotato

Across territories, a substantially high proportion of respondents said they sell sweetpotato root/vines/leaves. Half sell and half do not in Rutshuru territory, whereas the majority of respondents do not sell in Lubero. Farmers reported selling one-quarter or less of their sweetpotato harvest in Beni during group discussions.

In Masisi, farmers buy and sell sweetpotato in rural markets. Frequency of marketing depends on closeness to urban centers and institutions, the household's food situation at the time, prevailing prices, and other factors, such as family cash needs and road conditions. In Beni most respondents reported using money gained from the sale of sweetpotato products to satisfy diverse

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household needs, such as salt, soap, sugar, clothes, paraffin, and food. Other uses include paying school fees, medical fees, and government tax, buying animals, hiring labour, buying new lands and animals.

In Ruthsuru sweetpotato was found to be grown primarily for home consumption. Nevertheless, selling was common and provided critical cash requirements for low-income households. In Masisi, sometimes, farmers sell sweetpotato mainly to traders who visit them .Where demand is high, traders will visit farms looking for sweetpotato. Where demand is low, farmers have to carry roots to the market. In areas nearby cities and towns respondents from Rutshuru sell the whole field as a commercial crop. These farmers depend on the local markets for selling sweetpotato. Farmers closers to towns, may not have to incur harvesting, packaging, and transportation costs as is the case with farmers in areas far away from towns. Some farmers from Ruthsuru reported having a market within 1-5 km. Head-loading was the most common method of transportation. Some times the nearest market was reported to be on average 15-50 km away, and transportation was mainly done by truck. Schools, hospitals, and other institutions constituted only a small proportion of buyers, probably because the quantities they require can only be organized by a few large farmers. Whereas farm-gate and market prices are low at harvest, prices may double later in the season. Prices are determined by market forces, and government intervention does not exist.

3.20. Problems (challenges) faced by farmers for marketing, transport, processing and trading sweetpotatoes

-The lack of access to credit (absence of rural banks) (9.12-42.12%), lack of availability of market information (4.65-17.92%) and low prices at markets were among the top marketing constraints cited by respondents from the four study territories (Table-16).

The absence of reliable transport means (33.45-58.09%), the high cost of transportation by vehicle (10.32-32.99%) and the scarcity of buyers in the village (7.43-23.12%) were among the top marketing challenges faced by respondents (Table-16).

The lack of processing facilities (27.54-50.65%), limited (low) market prices (7.56-12.43%), limited transportation (10-45-16.21%) and lack of knowledge on how to acquire good storage facilities (3.11-28.54%) and unfavorable taste (smell, shape, size) of roots (2.32-9.11%) were cited as the most important problems faced in marketing sweetpotato by farmers (Table-16).

Respondents from Masisi (45.65%) indicated that unreliable market (price fluctuation) was the key challenge that was faced by sweetpotato traders. Farmers from Beni (45.32%) indicated that poor storage facilities (lack of security) were the key challenge faced by sweetpotato traders. The seasonal availability of crop produce was cited as key challenge for traders by farmers from Lubero (23.53%) whereas at Rutshuru (14.32%), inadequate capital (lack of credit facilities) was cited as key challenge by sweet potato traders (Table-16).

Similarly, the top challenges faced by sweetpotato processors in buying was the seasonal price fluctuation (16.54-39.76%) followed by seasonal availability of the crop produce (2.87-13.43%), (Table-16).

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The top challenge faced by sweetpotato processors during storage was poor storage facility (lack of security) (12.65-36.65%) and the quality of the crop produce (floor, beverage) (4.32-12.39%). The top challenge faced by sweetpotato processors during marketing stage was the customers complaining (2.17-14.21%) and the dishonesty of some buyers (7.85-18.56%) (Table-16).

3.21. Sweetpotato harvesting, processing and marketing constraints

By far the most common mode of harvesting is piecemeal, reported consistently by more the majority of the survey respondents. Some farmers also harvest all at once or use both methods of harvesting. Harvesting all at once is usually done when sweetpotato is destined for the market. Piecemeal harvesting starts as early as 2 months after planting for some varieties. Women move around the field looking for cracks on mounds (indicative of a sizable root). One to two storage roots are carefully removed using a sharp metallic rod or stick, then the mound is properly covered with soil. Farmers usually harvest enough sweetpotato for one or more meals for 1 to 2 days. The duration of the piecemeal harvest varies by village, reported duration ranged from 3 months to 6 months.

Harvest duration seemed to be a function of variety, soil type, availability of other foods, household size, disease or pest infestation, and weather conditions. Harvesting too early resulted in reduced yields, whereas harvesting too late exposed roots to weevil attacks. Different varieties respond differently to piecemeal harvesting with some varieties producing larger roots and taking longer than others. Varieties with longer maturity periods were most suitable for piecemeal harvesting. Research is needed to understand clearly the reasons behind piecemeal harvesting.

In Lubero-Butembo, the main constraints in marketing sweet potato tubers was due to the infestation of some tubers by insect pests which lower its quality and nutritional value and therefore make the consumers not to be interested in it because oftentimes some farmers fail to remove the damaged tubers from the healthier ones. But most often it was sold at low price due to the low marketable root yields, which lead to low income.

3.22. Determining and setting selling price($/Kg) and use of money from vending by sweetpotato farmers

-Across study territories, there was a variability in price ($/Kg) of different types of sweetpotato. OFSP and YFSP had higher market prices at Rutshuru as compared to the other 3 territories. However, WFSP had almost equal prices across study territories (Table-19).

Concerning the perception of producers/buyers about the mode of determination of price of sweetpotato, the majority (67.89-81.45%) of respondents believed that prices were fixed by owners (sellers) of sweetpotato across study territories. In addition, respondents from Masisi (17.12%), Rutshuru (29.12%), Lubero (29.54%) and Beni (10.32%) indicated differently (P=0.006), that the price was formed by means of negotiation with a buyer (Table-19).

Concerning the factors considered by producers in setting selling prices, respondents (34.54-60.12%) indicated that the size and quality of roots was the key criteria (P=0.025). A small proportion of respondents (13.65-31.87%) believed that the quantity by set was the best criteria used by producers to fix prices (P=0.017), (Table-19).

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Concerning the use of money from vending sweetpotato roots, respondents from Masisi (18.43%), Rutshuru (7.65%), Lubero (6.12%) and Beni (7.12%) indicated differently (P=0.002) that they used the money to buy new animals (goats, pigs, cattle, chicken, guinea pigs).

Respondents from Rutshuru (16.65%) used more the money to buy household needs (clothes, radio, TV, chairs) than respondents from other territories (P=0.015). Some other respondents (9.12-14.12%) used the money to buy other types of food they were not growing on their own farms (Table-19).

3.23. Sweet potato marketing channels in North-Kivu,

-There are about four marketing channels in north-Kivu provinces. The dominant channels include the producers to consumers channel (43%) and the channel four (37%) of producers to consumers via retailers to local processors (Table-20).

The following market channels were identified during the study surveys;

1. Producers----------Consumers
2. Producers---------Retailers----------Consumers
3. Producers---------Retailers----------Local processors------Consumers
4. Producers --------Local processors------Consumers
5. Producers---------Collectors--------Wholesalers------Retailers------Consumers
6. Producers---------Wholesalers----------Retailers-------Consumers
7. Producers---------Wholesalers----------consumers
8. Producer---------Collector----------Wholesaler---consumer

From the discussion group narrations, it was realized that key players of sweet potato value chain comprised a number of participants (actors): producers/processors, small traders, rural hawkers , processors , retailers , end users , input suppliers , local seed stockiest.

The actors involved in the value chain were: producers, wholesalers, semi-wholesalers, retailers, transporters and consumers . Producers were the sweet potato farmers , who were involved in field production. After harvest, the sales were carried out in the fields by producers.

The wholesalers were big traders of the localities, they bought directly from the producers and the basket of sweet potato. The semi-wholesalers bought the wholesale from wholesalers; these were traders who bought in large quantities at a fair price per basket in rural areas . The retailers bought agricultural products at relatively high prices from semi-wholesalers compared to the purchase price practiced by semi-wholesalers from the wholesalers and the wholesalers from producers. They were market traders. The consumers bought from retailers for their own food needs. They bought at a relatively higher price. The semi-wholesalers sell tubers to the consumers at relatively higher prices as compared to producers (farm-gate). The producers preferred to sell their products to wholesalers instead of going to the market in order to

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avoid paying transport fees. The transporters were responsible for transporting products from the fields to the markets.

3.24. Value chain and addition across processing and trading to consumers the sweetpotato products

-Stored fresh in bags (39.31-47.89%), stored in the granary built in the corner of the homestead (4.12-17.43%), spreading on the floor (5.67-17.12%) and storage in the underground storage pit (0.84-1.45%), were the top practices of storage of root (including traditional sweetpotato products) that were implemented by farmers (Table-17). Transport and storage (27.33-58.34%) and transport (putting in clean sacks) (5.66-17.53%) were among the key sweetpotato value addition processes that were practiced by traders (Table-17).

Flour (breeds, cakes, porridges, buns, doughnuts, chapati) (11.76-35.32%), making beverage (food-beer porridges) (6.75-27.67%), making different types of alcohol (10.65-45.87%) and chips and snacks (fried chips) (3.67-29.12%) were the key technologies for consumers that were people engaged in processing sweeetpotato into these products. Boiled sweetpotat at Masisi (60.12%), roasted sweetpotato at Lubero (7.12%) and fried sweetpotato chips at Beni (8.32%) were the major consumption forms of sweetpotato at household levels that were reported by respondents across the four study territories (Table-17).

There were significant differences between respondents who declared consuming sweetpotato once week($P<0.0001$) and two times a week ($P<.0001$). However, there were no significant ($P<0.05$) differences among respondents who declared consuming sweetpotato three or four times a week (Table-17). There were significant ($P<0.05$) differences among study territories in the frequency of consumption of sweetpotato: most respondents had a high frequency of consumption of once a week (28.65-66.65%), two times a week (27.99-67.55%) and three times a week (3.12-10.12%), (Table-17).

3.25. Value chain of sweet potatoes

The concepts of value chain is regarded in terms of quality packaging assurance, respecting standard quality of consumable goods and physical appearance (hygiene, quantity and quality of delivered products)..

Some farmers were identified as the main actors in sweet potato value chain. Farmers were very attracted by the fact of being easiest crop to cultivate, or motivated by the fact of being considered as hunger fighting crops according to the traditional consideration. Few farmers accepted the resistance of sweet potato plantation against different crop diseases than other crops. They preferred to hire labour to support their capacity during the process of cultivating, some farmers preferred to be self employed by using their family members. The picture of getting labors in terms of hiring process put the farmers in the situation of getting the sweet potato harvest in expensive way. For this reason the farmers said that the majority of their neighbors chose to keep quiet in expending the area under cultivation. Other than labor force issues, farmers reported also on their frustration with respect to the problem of non-possession of the land .More than half of respondents used to rent for land whereas few use their own land.

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The issue of land is a challenge to farmers because the good land which was used for sweet potato are occupied an have taken by other crops considered as food security . Hence land and labor have an impact on sweet potato production because farmers do not engage to invest much inputs because the land might not belong to them. In terms of adding the value to the cultivated sweet potato, look for best varieties, respect the season of cultivation, to get best attractive harvests, respect customers' needs with respect to varieties produced. However, the level of application vary according to the understanding and ambition of each farmer.

There was different ways for increasing the value of sweet potato. Some farmers preferred to respect the customer needs varieties. It followed by the use of fertilizer and washing and sorting in order to get best attractive harvests at the market.

In Rutshuru, the study considered interaction in value chain between farmers and processors in terms of sweet potato price fixing process at the market. The evaluation of this variable also has an idea of focusing on power relations between processors and farmers. More than half of farmers agreed that buyers (processors) dominate sellers (farmers) in terms of fixing price of selling their products (harvested sweet potato) because of the lack of government regulation to fix sweet potato price. Some farmers think that sale is done through consensus and sellers have power in terms of selling sweet potato to the processors because they can sell to other buyers if the price offered by the processor is not favorable.

Regarding access to agricultural credit, the results reveal that the value chain experiences the lack of funding in most territories surveyed .The rate of access to credit was found to be too low to absent in several villages. Wage labour force was not widely available. There was a deficit in wage labor due to the rural exodus and the diversity of economic activities. However, there was some kind of mobility of labour within villages. The prevalence of very high costs of production in most village surveyed, hampered financial performance in terms of profit and added value to sweetpotato products. In Masisi territory, local administration policies were existing and they tended to fix sale prices while these policies do not facilitate access to inputs subsidies, agricultural financing . Farmers are not affected by the pricing policy (they are not price takers) and that is why the adhere rarely to cooperative organizations which impose them the sale price, mostly lower than the cost of production

3.26.Production cost, gross margins and profitability analysis of sweet potato products along the marketing and distribution chain at different nearby territory main trading centers

-There was a significant ($P<0.05$) variability in the sweet potato production cost (US $/ha) among the four territories with, for example, the gross income being higher at the main trading Center in Lubero territory. Across the four marketing channels, there was variability in cost and profitability of sweetpotato production in production center. Similarly, across the four marketing channels, there was a variability in the marketing costs and profits margins of sweetpotato as reporters by traders, (Table-21).

4.DISCUSSSION

This study investigated the varied role of sweetpotato as a food, fodder crop and as industry-commercial product. Although not all farmers were interviewed but the study captured some

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trends in sweetpotato production and marketing constraints. The study also outlined some guiding information to subsequent breeding of dual-purpose varieties.

4.1. Land tenure, gender, variety mixtures and intercropping system

Although access to land is a challenge in the region, the results from this study revealed that plot size, land tenure, land availability and accessibility were different issues which varied significantly ($P<0.05$) across the surveyed territories. Beyond that, prevailing wars, civil unrest made land a serious production constraint in this region. It was observed that land tenure insecurity and rebel movements disturbed sweetpotato production activities in this part of the country.

The results indicated that crop production was the main source of income although mixed crop-livestock system characterized the farming system in the surveyed territories. This gave an indication of the characteristics on the overall importance of crop production in the North-Kivu province farming systems. The mixed crop-livestock farming reflected the high level of livestock production in this part of the country. Similar results on the important role of crop production as main livelihood foundation was previously reported by earlier researchers (Munyuli et al.2017).

-The results from this study indicated that both men and women had farm responsibilities. Women were involved in the sweet potato farming more than women. This may be due to their awareness of the health benefits of orange-fleshed sweet potato for their children, which was found being promoted by some extension officers and NGOs to women in the study territories . Also, a study by Low et al. (2007) in Mozambique showed that orange-fleshed sweet potato had a high level of vitamin A content that could reduce malnutrition in children (Muthivhi 2019, Luthuli et al.2019).

In sub-Saharan Africa, women are the main sweet potato cultivators in small pieces of land, which gives them extra money to help their families. The women's role in sweet potato production is limited to harvesting only, while men traditionally take responsibility for cereal crops and cash crops such as maize and coffee. In Uganda, more female-headed households are found being engaged in sweetpotato cropping (Okonya & Kroschel 2014). On the contrast, In Ghana, the major activities (land preparation, planting, weed control, fertilizer application, harvesting/packaging and marketing) in sweetpotato production are not gender equally performed. Males dominated in land preparation and planting, whereas females dominated in weed control, fertilizer application, harvesting and marketing (Amengor et al.2016). Most male are aware of improved sweet potato varieties and do growing one or more of improved varieties.

The current study revealed that a large number of crops were grown alongside sweetpotato and in some cases as intercrops. Farmers intercrop cassava/ legumes with sweetpotato. This indicates a lack of good extension advice, since both cassava and sweetpotato are root crops and will compete for the same nutrients and root space, and therefore neither crop will yield to its full potential. Farmers who do not intercrop, plant several sweetpotato genotypes on the same piece of land either as mixed genotypes or each genotype planted separately in a small portion of the land. The major reason cited for this practice is a lack of enough

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planting materials for one genotype to cover the available land especially after the dry season.

In some cases the farmers plant several genotypes in mixture as a security measure in case one of the genotypes fails. Some farmers exploit the different maturation periods of the genotypes to meet their harvest requirements. Since some genotypes mature very early and others late, the farmers are able to sequentially harvest a crop over an extended period of time. This has been previously reported by other authors (Low et al.,2000, 2017). Access to disease free planting materials is also a problem in the area surveyed. There is no organised system of distribution of planting materials to the farmers. The major sources of planting materials are farmers replanting vines from their previous crop and others obtaining vines from neighbours and some time from NGOs and Universities/Research centers. Vines from the neighbours are normally provided free of charge thus there is no incentive for commercial seed production (Munyuli et al.2017). This informal distribution system lacks any proper seed quality control mechanisms and is a major avenue for the spread of pests and diseases since no thorough inspection is done. The informal farmer to farmer seed supply system may be advantageous in that farmers are able to select genotypes with the desired attributes for their particular locality.

4.2. Adoption (retention) of improved varieties

The results of the current study indicated that the majority of farmers had limited access to and awareness of improved varieties and largely depend on own varieties, which are mostly low yielding. Sweetpotato farmers grow a large number of landraces, many of them relatively low yielding, narrowly adapted and susceptible to diseases and pests (Niringiye et al.2014). The varieties are mostly white-and cream-fleshed, with negligible amounts of beta-carotene, the precursor of vitamin A contained in plants (Niringiye et al.2014). Low yielding potential of local varieties, susceptibility to pests and diseases is common in rural areas of East and central Africa (Niringiye et al.2014). Thus, the promotion of improved crop varieties may be an effective mean of increasing farm productivity and alleviating poverty in rural areas. A successful dissemination of such varieties requires a deep understanding of target farmers' attitudes, preferences and socio-economic status.

Obviously, farmers are the ultimate beneficiaries of newly developed cultivars and production technologies. Therefore, development of improved sweetpotato cultivars may contribute on alleviating socio-economic constraints therefore improving sweetpotato productivity. In-depth knowledge of farmers' preferences, production challenges and priorities in adoption of newly developed technologies is vital for eastern DRCongo.

Agricultural diversity can strengthen resilience of livelihood of farmers to climate change and market uncertainties while, potentially at the same time, offering better dietary and nutritional prospects for households (Fatch et al.2020).

The adoption decision of improved varieties by farmers may be influenced by socioeconomic (age, gender, education, farm size), ecological (agro ecological zones, temperature, rainfall, altitude, pH of soil/ water) and institutional factors (extension services from government and NGOs).

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The results of this study indicated that the primary criteria for adopting new cultivars by farmers were higher yield, taste, and duration to maturity. Yield stability, tolerance to native biotic and abiotic stresses, and good taste were important for maintenance of currently grown varieties (Zawedde et al.2014). Overall, criteria for variety selection varied with household characteristics including farmer age and gender, uses of the crop, micro-climatic conditions in the farmers' fields, and level of access to agricultural extension (Zawedde et al.2014). The observed heterogeneity in selection criteria, influence of social ties, and the role of environment in varietal maintenance have important implications for establishing breeding priorities and preservation of crop diversity (Zawedde et al.2014).

In Mozambique, diverse factors influenced the adoption and retention of improved varieties, including organoleptic qualities, taste preferences, access to planting material, agronomic traits, environ-mental conditions, lack of capital for inputs and labor, unstable markets, and limited sharing of information and planting material across farmer networks (Jenkins et al.2018). Current improved varieties were acceptable to Mozambican farmers and consumers, but there are several remaining challenges to reaching a critical mass such as lack of access to planting material, perceptions of superior drought tolerance of white-fleshed sweet potato (WFSP), and the belief that OFSP requires additional effort to cultivate (e.g. weed removal, measuring space between plants) (Jenkins et al.2018).

The road to adopt new varieties is varied in Africa. As the case of Uganda (Gibson 2013) sweet potato varieties are distributed in 3 systems: formal, project-based and informal. In a formal system, farmers acquire vines of varieties from breeders/ researchers. There are no national institutions that produce/provide vine stocks of varieties . Also. The seed system does (Andersen et al.2019) not involve any large private sector multipliers/cooperatives . Some farmers make business with vines of landraces. They are involved in vine multiplication that sell as small bundles of vines to many smallholders at the onset of the rains in vicinity of their sites of multiplication. The problem is that it is difficult to guarantee the distribution of healthy planting materials (Abidin et al.2017) since there is no reliable phytosanitary system during vine multiplication, particularly for OFSP varieties.

In Kenya, factors influencing positively adoption of new sweetpotato varieties include output, land tenure, number of livestock, group membership, credit amount, training). In this country (Kenya) it was observed that the adoption of improved sweet potato varieties increased households' food security significantly, improvements in increased food diet diversity and household overall income (Wabwile 2016). Adoption of the improved varieties reduces liquidity constraints as they can be harvested at periods of food shortages and can contribute to mitigate seasonal gaps in food availability. The adoption of the variety (Okeke et al.2019) may contribute to improves access to other food groups and farm inputs for these households (Wabwile 2016). In fact in Zimbabwe, the incorporation of improved sweet potato into the smallholder farming system resulted in welfare gains for the households under the various scenarios considered (Mudombi 2007). The welfare gains resulted from sweet potato's contribution to food security and income. Relaxing the land, labour, transport-marketing and storage constraints increased household welfare (Mudombi 2007).In addition, in western Kenya, most farmers adopt improved varieties if they are high yielding, highly consumed, early maturing, resistant to pests and diseases and tolerant to environmental stresses (Nkirote

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2016). Similar observations reported were reported in Benin where within the existing diversity, consumer preference for varied significantly across agro-ecological zones (Sanoussi et al.2017).

In Nigeria, the adopters are generally motivated to adopt new and improved varieties mainly as a result of its pleasant taste, profit from the sale of its roots and vines and not necessarily because of its perceived health benefits of supplementing vitamin A (Chah et al.2020). In Sierra Leone, the adoption of improved varieties is influenced by farmer's category, production goals and environments model, availability/accessibility to genotypes and related improved varieties the goal of the farmer(cultivating for income), and have access to both upland and lowland ecologies suitable for sweetpotato production areas (Nabay et al.2020) . Therefore, it was concluded that these influencing factors should be considered in the future planning for improved variety dissemination interventions in the country (Nabay et al.2020).

Sweet potato technologies that increase productivity such as climate resilient sweet potato technologies or as resistant varieties and virus free planting material are being promoted in order to reduce the vulnerability of poor farm households to climate change (Ilukor et al.2014). The increasing adoption of sweet potato technologies may help to reduce vulnerability of poor farm households to climate change, enabling environments for farmers to market their produce so as to raise returns and reduce the opportunity costs of climate change adaptation strategies (Ilukor et al.2014).

4.3. Farmers' preferred variety traits (attributes) for consumption, storage and markets

It this study, it was observed that most respondents consumed sweetpotato at least twice a week. Most farmers preferred marketable root size of storage roots, respectively. This reflects the commercial value of the crop, which is steadily increasing across territories. Most farmers preferred red skin colour, few farmers preferred white skin colour. However, across the villages of Ruthsuru territory, white skin colour was consistently liked over time and years (Serungendo, personal communication).

High yield and taste (sweetness) were the most important attributes to farmers. Therefore, high yield may not always the most important determinant of the adoption of new cultivars. Some of the other quality attributes that farmers desire may be high dry mass, and certain flesh and skin colours. This was also previously reported by Low (2000).

Respondents across all study territories expressed a clear preference for sweetpotato varieties with high dry matter content. Thus, breeding of sweetpotato in the study areas should take into consideration these farmers' preferred traits. In Masisi territory white fleshed sweetpotato varieties were preferred over cream, yellow, and orange flesh colour . Orange flesh storage root colour is some time strongly correlated with low dry matter content in local varieties of sweetpotato., thus, OFSPs were less popular. Farmers who liked OFSPs are those who were informed of the value (high total carotenoids content, a precursor of vitamin A) of these varieties. In Ghana, there are always some contrasting consumer preferences (Atuna et al.2018) for fried sweetpotato sensory attributes in the community (Dery et al.2021). Such consumer segmentation can help emerging fried sweetpotato industries identify target markets and provides valuable information to breeders, growers and retailers to prioritise attributes in their breeding, growing or product sourcing decisions (Dery et al.2021). In RSA, more than young , adult

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consumers had a high level of acceptability (Laurie & Van Heerden 2012) of the colour and physical appearance and taste four products made from β-carotene-rich sweetpotato (chips, doughnuts, juice and sweet potato leaves cooked green vegetable dish).Adults were willing to buy and make these products at their homestead. Thus, it is recommended that these products are introduced to the formal as well as the informal sector in RSA (Laurie & Van Heerden 2012). In Zimbabwe, lack of suitable storage facilities among smallholder farmers continues to expose farmers to intermittent food shocks (Mutandwa & Gadzirayi 2007). Farmers are thus making use of locally available preservation methods, derived from indigenous knowledge systems , to improve storability of sweet potatoes (Mutandwa & Gadzirayi 2007).

Most farmers used sweetpotato vines for livestock feed, depending on their availability. Farmers needed to grow new sweetpotato varieties with improved root production combined with high aboveground biomass. Most respondents indicated that root-related traits of the crop such as high dry matter content, red skin colour, marketable root size, and yellow flesh colour were additional preferred traits, respectively.

Sweetpotato cultivars with diverse attributes were found to be grown in the four territories. This study revealed that farmers were knowledgeable about sweetpotato local cultivars and their attributes. Most of the cultivars were landraces with white or cream flesh. Similar to this study, Low et al. (2017) Indicated that different sweetpotato cultivars were grown by farmers in southern Africa.

In eastern Uganda, farmers mentioned several varietal attributes including attributes involved in storage roots (large yield, early yield, sweetness, mealiness, sequential yielding and ability to be left in the ground for a long time prior to harvesting), and weed-disease-pest resistance, maturity periods, root skin colour as important in marketing (Gibson et al.2008). In western Uganda, the main varietal attributes mentioned by farmers were sweet mealy roots, less susceptibility to weevils and diseases(such as Alternaria), high tolerance to drought and high ability to sustain continuous root yield (Gibson et al.2008)

Overall, farmers preferred cultivars with high yield and dry matter content, resistance to diseases and pests, early maturity, sweet taste, elliptic root shape and drought tolerance. Some farmers preferred sweetpotato cultivars with sweet taste, dry texture and good yield. High yield, taste and maturity period may be primary criteria for adoption of new cultivars. High yield, early maturity, sweetness and disease tolerance were the most important selection attributes of cultivated by farmers from Lubero territory. Also, low fibre, insect tolerance and high root firmness were considered important in Rutshuru territory. Similar findings were reported by Munyuli (2017) in South-Kivu province.

Therefore, farmers-preferred dual-purpose varieties with improved root and green fodder yields to enhance the sustainable production and adoption of sweetpotato in a mixed farming system. Similar variety preference observations were reported in Rwanda (Shumbusha et al.2020). The ability of sweetpotato to be used as food and forage was previously reported in neighboring countries such as Burundi and Rwanda (Shumbusha et al. 2020) .The use of vines as fodder for livestock production may cause rarity of vines in some areas during plantation seasons. There is a need for a variety that can produce vines for livestock as well as serving as source of plantation

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for next season. Thus, the need for sweetpotato varieties with strong dual-purpose attributes and for different vine cutting regimes and different uses.

Sweet potato farmers do not have many choices of sweet potato varieties. Farmers have abandoned several landraces for various reasons. There is a tendency of replacing local varieties with the high-yielding varieties. This might also be due to pest and disease infestations. Generally, farmers tend to discard their local varieties, for example, in favor of high-yielding ones, or plant large farming areas with one single variety once they are aware of the benefits.

In sub-Saharan Africa, sweet potato landraces are adapted to local climates with high pests and diseases resistance. Furthermore, the sweet potato farmers appear to have lost knowledge and practices that are related to these cultivars. This includes time for planting and harvesting, weeding, and post-harvest management. Nevertheless, farmers' knowledge is different than the knowledge farmers receive from extension services. The farmers' knowledge is based on years of experiences from local climatic and soil conditions. Sweet potato is usefulness for both food and feed (dual-purpose) make it attractive in areas where land availability is declining (Claessens et al.2009) like in Kenya. Farmers were also interested in breeding clones if they met the culinary tastes frequently required by local consumers as this was reported in Mozambique (Andrade et al.2017)

4.4. Sweetpotato production constraints

In this study , there was similarity in production constraints across territories. However, the perceived seriousness of the constraints differs considerably. Constraints considered to be very important in Masisis were not necessarily important in Beni. In Rutshuru. diseases and vermin were the most important constraints cited whereas in Lubero pests(caterpillars, weevils), soil erosion were cited as important by respondents during focus group. These differences in constraints may be influenced by the prevailing climatic/environment health in each territory. For example, moister conditions may not favour caterpillars but favour the development of fungal-bacterial diseases in highlands(Masisi). Consideration of the different constraints and attributes for the different territories calls for different breeding strategies. If this is not done, then breeding cultivars with multiple complementary traits that can be released in different locations. Farmers need genotypes in terms of resistance to diseases and pests and farmers should be involved in evaluation of advanced breeding materials. It is important to give resource poor farmers who use marginal lands, resistance materials. Thus, breeding efforts should be geared towards the development of new biotic stress resistant genotypes. The low yields may be attributed to highly degraded soils or due to overuse of the soil for crop production and subsequent loss of fertility, lack of manure to replenish nutrients, soil erosion especially on steep slopes in Masisi and use of landraces with lower yield potential.

For decades, planting material of low yielding landraces have been found being preserved in home gardens and valley bottoms . Similar practices have been recorded in South-Kivu Province (Munyuli et al.2017).

Despite the remarkable role of sweetpotato, its productivity is very low compared with the yield potential (above 15–50 t/ha) at research station. Low productivity arose from several

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biotic, abiotic and socio-economic constraints. Prevalence of virus disease, unavailability of healthy planting materials, drought, inadequate extension services, markets and low prices contributed to low crop productivity. Similar findings have been reported in other Sub-Sahara African regions.

Generally, diseases, pests and use of old vines constrained sweetpotato production in Beni toerritory. Farmers identified diseases and pests as the most important constraints in Lubero. Limited access to and unavailability of healthy planting materials contributed to persistence of diseases in Rutshuru. Hence, farmers needed production of healthy planting materials to control diseases and pests. This result concurs with findings by Munyuli et al (2017), who reported that unavailability of healthy planting materials and high-yielding cultivars was amongst the hindrances in improving sweetpotato production in South-Kivu province. Sweetpotato weevils and other insects, such as grasshoppers were found to severely damage sweetpotato storage roots and leaves in Rutshuru. Farmers controlled/reduced sweetpotato weevil damages by crop rotation and hilling up as it was previously reported for South-Kivu province (Munyuli et al.2017).

Combinations of social, ecological, and economic factors may be influencing the crop production in eastern DRCongo. In the region, factors such as pests and diseases, rain shortage, and lack of suitable cultivars for different climatic conditions affected the crop yield. Lack of the sweet potato planting materials and knowledge constrained famers in cultivating the crop.

If researchers and NGOs recognize the diversity of farmers' knowledge and sweet potato landraces, then the crop yield may increase through breeding programs at different locations. These breeding programs could include researchers working together with male and female farmers to breed varieties suitable for different conditions, with high nutritional value and yield, that are drought-tolerant, and that have high resistance to pests and diseases. This might also provide planting materials during the dry season, and sweet potato yield and knowledge could increase throughout the region, with farmers becoming an important part of this change.

Much as sweet potato is a crop known to grow in soils with marginal fertility and under fluctuating weather conditions , like any other crop, it suffers but mainly production constraints. Labour and planting vines shortage, pests, low soil fertility are the common problems in production.

Nevertheless, some of the constraints faced are being handled at farmers' level through use of cultural practices that provide favourable environment for plant growth. However, most of the current practices are concentrated on controlling pests (hilling-up, field sanitation, avoidance of adjacent planting and early harvesting), maintaining soil fertility (crop rotation and manure application) and; increasing yields (variety selection and planting season) and do not address the major constraints of labour and planting material shortages. As above mentioned. hilling-up is a direct weevil control method where soil cracks are filled and exposed storage roots covered with soil, thereby blocking the way for weevils to the storage roots. Some times neighbouring fields can be a very important weevil infestation source therefore, through avoidance of adjacent planting, farmers reduce on the suitable environment that is

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favourable for the survival of the sweet potato weevils. Contrastingly, some farmers said that having adjacent plots reduces on the labour needed to work in different fields. The farmers interviewed appreciated that they enjoy an early market and so harvest early thereby escaping high yield losses due to sweet potato weevils. It is known that late harvested potatoes suffer more weevil damage than those harvested as soon as they are mature (Munyuli et al. 2017). Despite this advantage, some farmers can not harvest early because they usually lack health planting materials that mature in a shorter time. There a need for effort to be aligned to enable farmers accessing to clean planting materials and strengthen breeding programmes to improve disease resistance (Echodu et al.2019).

As in other African countries such as Ghana, Tanzania, Nigeria (Sugri et al.2017, Mmasa et al. 2012, Sanusi et al.2016, Abdallah et al.2021), several production constraint have been cited by farmers including : pests, diseases, shortage of clean planting material, low prices paid to the producer, chronic shortage of seed of good quality, lack of capital, unpredicted weather and pests/insects, lack of tolerance to biotic and abiotic stresses, access to clean seeds/vines, short shelf-life, field pest and diseases, declining soil fertility. In coastal region of Kenya, there exist some time shortage of planting material during the rainy season. Therefore, different production techniques of sweet potato planting material using cuttings have been developed by native. These methods include planting in pits without lining, planting in pits with lining, planting on ground surface, planting in sacks without lining and planting in sacks with lining (Abdallah et al.2021).

In Benin, main constraints reducing sweet potato production include: lack of adequate methods for controlling pest and diseases, lack of financial resources due to no access to credit, absence of modern equipment, scarcity and high cost of labor and absence of best methods for long-term storage (Ezin et al.2018). The market value of sweet potato is still low at farmers' level when compared to that of other stakeholders along the value chain (Ezin et al.2018). In Tanzania, market studies indicated that price was a constraint since prices were observed to be low in the main season when the quality was good and higher in the low season when the quality was low (Kihinga 2007). In Tanzania, problems experienced by traders were lack of capital, poor marketing, short shelf life, transportation and price fluctuations due to seasons (Kihinga 2007).

Overall, low productivity characterize sweetpotato production this has been attributed to several factors. These include susceptibility to pests and diseases, use of marginal lands, low input use and use of low-yielding and narrowly adapted landraces .

Some of these constraints can be overcome by the release of improved cultivars specifically bred to overcome those constraints. Researchers released several cultivars in previous years(20 years ago) in eastern DRCongo. However, despite the abundance of new improved cultivars, the majority of the farmers still prefer their landraces which are lower yielding and more susceptible to diseases and pests. Lack of an organized seed distribution system is one of the factors for low adoption of the new cultivar. There still lack of farmer desired attributes from the researcher window. There is still lack of exposure to acceptable new cultivars that can replace the landraces in use. Farmers have good knowledge of the traits they would like to have included in a new cultivar. Therefore, a complementation between

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farmers' preferred traits and traits selected for by the breeder that the farmers may not understand due to the complexity, there is a need for the way forward. Farmer involvement has led to rapid selection and dissemination of new sweetpotato cultivars with desired traits in East Africa. In their selection criteria for sweetpotato, farmers take several factors into consideration which include the number and size of storage roots, the taste, skin and flesh colour, and culinary qualities. A farmer-oriented breeding process should start with a participatory rural appraisal in eastern DRCongo. It is important to involve farmers in evaluating advanced materials to be grown on their fields. With careful consideration of farmers' concerns and production conditions, genotypes selected using this procedure are likely to become widely adapted and more productive .

4.5. Economic and health benefits of OFSP

In this study, farmers perceived economic, health and social benefits of production, commercialization and consumption of orange fleshed sweet potato (OFSP). Men and women were receptive to health and nutrition based promotion messages. Health benefits included increased energy to work, for sex, improved health, general wellbeing and cognitive development for children (Hagenimana et al. 1999, Low et al. 2007). Economic benefits included ability to invest income from selling of OFSP roots and vines in housing, purchase of livestock, food, and land. Income from OFSP enabled farmers to diversify into other cash crops. Women also mentioned increasing self-esteem due to increased incomes since they no longer needed to ask for money from their husbands to buy household consumables. However, men and women did not have equal access to and control of economic benefits and therefore women could not invest in large assets like cattle, land and agriculture equipment which could contribute to food security and are important to moving out of poverty. The present study observed an increased participation of men in sweetpotato production, although, women were key actresses in sweetpotato production chain. Increased role of sweetpotato as a cash crop has attracted male involvement in sweetpotato production. Therefore, increased market demand for sweetpotato has greatly attracted male participation in sweetpotato production in some areas of eastern DRCongo. Thus, interventions to increase farmer incomes should be designed in ways that allow women to actively participate and benefit (Mudege et al.2017). Since livestock are a key investment option and also contribute to food security and diversification, options for making sweet potato based silage for animal feed would be an important intervention especially for vines that would other-wise go to waste due to lack of markets.

The link between agriculture, health, nutrition and income for rural households has long been established. It has, however, been suggested that gender is the ' key element ' in the linkage between nutrition and agriculture. If gender inequalities and differences between men and women are not considered in nutrition programming they may negatively impact outcomes. In Sub Saharan Africa women and children are the most affected by malnutrition compared to men and that the burden is greatest among poor rural communities. Another key link between agriculture and nutrition is income. Income from agricultural produce may increase rural farmers ' ability to pay for health care, purchase food and pay for children ' s education. Increasing women's control over assets (especially financial/physical) has been shown to positively impact food security, child nutrition, education and women's well-being in general. However, women do not always have the ability to access and control income and other benefits from agriculture at the same level as men. While strategies such as food fortification and

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micronutrient supplementation may be effective at addressing micronutrient deficiencies, emerging evidence shows that biofortified crops such as orange fleshed sweet potato (OFSP) may be an effective and sustainable way to address the burden of hidden hunger among vulnerable poor rural households. Agriculture coupled with nutrition education are beneficial as a potential pathway to nutritional benefits for food-based strategies to address micronutrient deficiency among children. Also, improved farmer access to markets can improve farm yields, incomes, specialization and consequently living standards. These outcomes, in turn, can contribute significantly to improvements in household food security, poverty reduction, agricultural development, and economy-wide growth and health in eastern DRCongo. Non-pecuniary benefits are as important to farmers as pecuniary benefits. It is therefore important to understand what makes farmers happy and interested in keeping use of a technology and how they perceive benefits from the different array of crops they grow, as these perceptions may also be key in determining whether they adopt biofortified crops or not.

4.6. Post-harvest processes and losses issues

The post-harvest value chains of sweetpotato was analysed in this study. Some of the important factors identified in the sweetpotato value chain were significant mechanical damages in the form of skinning injuries, breakages, cuts and poor retailing conditions resulting in loss of marketability, pest (sweetpotato weevil) infestation-induced by keeping the roots in the ground for extended periods (progressive harvesting) and lack of storage and curing facilities were adding to food losses. Weight loss and microbial rotting were identified among the two leading causes. Poor retailing conditions and mechanical damages during harvesting and handling can lead in a significant weight loss (>20 %) in 3 to 4 days, and this in turn, can eventually leads to a loss of marketability.

Post-harvest loss was a critical problem in all sweetpotato-growing areas. Given that the crop is perishable and there are no developed storage and processing facilities, harvest losses are to be expected. Hence, the need for improvement of post-harvest utilisation and marketing infrastructure. In an endeavour to improve sweetpotato production and productivity, improved extension services, supply of disease- and insect-resistant cultivars and well-coordinated markets are critical. Timely supply of healthy planting materials would improve productivity, income and nutritional status of farmers. Establishment of price-regulating boards and cooperatives were other wishes of farmers

-In this study, it was found that some portion of sweetpotato production was lost at farm level even if the majority reached the different market outlets. The factors affecting sweetpotato post-harvest losses were age of the farmer, farm size, land allocated for farming, access to extension services, trainings on post harvest processing operations, materials used in sweet potato harvesting and storage duration of the production. Storage was not for long because of household consumption/cooking.

A post-harvesting handling of sweetpotato is an important factor not only in preventing postharvest losses but also its safety and nutritional quality. Exposure of the sweetpotato to unfavorable conditions such as light, extreme temperatures and humidity can alter the quality (increase health risks to consumers) of the product during handling practices transportation, exposure to sunlight, bad storage practices) processes. It is important on how to improve the

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awareness information for farmers and traders about the post-handling practices in order to protect consumer and reduce economic losses. An increasing global population and the shrinking natural resources demand more efficient food value chains with minimum losses and higher returns. Reducing food losses is of utmost importance and can have a direct effect on income generation, food security and the environment in developing regions (Parmar 2018).

In Nigeria, it was found that household consumption had significant relationship with food security and with value addition practices (Omoare et al.2015). It was concluded that that sweet potato value adders were predominantly females, economically active and innovative, married, experienced and operated on a small scale but had low level of literacy. Sweet potato was processed in forms of boiled, roasted or fried. Many of the respondents preferred sweet potato to food fortified with vitamin because it was readily available, relatively cheap, and easy to cook, and have sweet taste, and the farmers were food secured through sweet potato (Omoare et al.2015)

In Africa (Ghana, Nigeria), prepared foods are increasing in popularity in alongside rapid urbanisation. Growing demand for fried products calls for targeted breeding efforts to meet consumer needs, but little is known regarding consumer preferences (Dery et al.2021). The knowledge of consumer preferences for fried sweetpotato sensory attributes (crispy, crunchy, mealy, sweet fried, flavour and dry texture, orange colour appearance, ripe plantain flavour, palm nutty flavour) can help emerging fried sweetpotato industries identify target markets and provides valuable information to breeders, growers and retailers to prioritise attributes in their breeding, growing or product sourcing decision making (Dery et al.2021)

In Nigeria, there are significant differences among genotypes for root colour and general acceptability for boiled roots, and root colour, mouth-feel, taste, aroma and general acceptability for fried roots(Afuape et al.2014). The fried sensory trait is often identified as fresh root colour, an easy-to-select trait to breed for consumer acceptability. Processing and acceptable traits should preferably heritable for the for boiled and fried food forms of sweetpotato cultivars (Afuape et al.2014). The identification of root flesh colour as an easy-to-measure trait that can influence consumer acceptability is an essential research task for breeders (Afuape et al.2014). .

Storage and processing were found to be influenced by price fluctuation at local market in eastern DRCongo. Also, low farmers' revenues hamper producer's ability to participate in retail markets outlets and afford dietary needs for their households' members. A need for improve of extensions services to encourage farmers to adopt different physical layout of stores is recommended so as to minimize loss and increase the nutritional status of sweetpotato.

-Sweet potato is an important root crop grown all over the world and consumed as a vegetable, boiled, baked or often fermented into food and beverages (Oke & Workneh 2013). It could be a very good vehicle for addressing some health related problems and also serve as food security. The research into sweet potato processing has established the fact that there is a lot more in sweet potatoes than its starch (Oke & Workneh 2013). The nutritional quality content in sweet potatoes can be enhanced by developing new varieties from available germplasm. Natural colourant and antioxidant present in purple- and red-

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flesh potatoes can be used for developing functional foods. Available evidence for Africa suggested that postharvest processing and subsequent storage of sweet potatoes need further research to explore the ways by which the new cultivars could be used for industrial and export purposes (Oke & Workneh 2013).

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The sweetpotato industry is largely a fresh produce market, targeting food vendors, processors, and direct selling to wholesalers, retailers and household consumers. The industry prosperity depends on favourable production ecologies, processing options, insatiable local and international market. The institutional actors need to network the primary actors to synergistically operate with a collective profit motive

4.7. Market channels

In this study, it was realized that there exist disorganised markets and marketing systems of sweetpotato in eastern DRCongo .The marketing systems were major factors in perpetuating poverty cycles and subsistence agriculture. These markets are characterised, among others, by too many players within a value chain, a lack of collective marketing and collective purchasing, poor transport infrastructure, a lack of value addition, poor market information, poor access to market information or a total lack of market information, and unfavourable trade policies and/or a lack of any. Although smallholder farmers are the highest investors in terms of land, tools, time, labour, inputs and transport along the value chains, they benefit least when it comes to earnings. Hence, it is not economical to produce surpluses in the absence of assured markets, good market policies and reliable marketing strategies. The gender is an important component in the value chains, depending on the historical realities in post-conflict zones of eastern DRCongo. Here, women have ventured into long- and short-distance trade of many crop products including sweetpotato. Here men and women do not necessarily share equally the trading space in their localities localities.

In this study, three main marketing channels were identified: producers selling directly to consumer; producers to retailers to consumer; and producers to hawkers/village vendors to consumer. Half of interviewed famers did set prices after hearing from their fellow farmers. Other farmers did sell their produce direct to the market. The sub sector in general faced a number of structural and technological problems that needed immediate attention to revamp agricultural sector development. In general sweet potatoes production is marked with low

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production and productivity in eastern DRCongo. Low productivity is a result of poor agronomic practices and low level of production technology application among others.

In RSA, there are solid evidences to substantiate that socio-economic factors influence the technical efficiency of marketing systems. Farmers only explored two marketing channels. The first channel was from the farmer straight to the consumer and the second channel from the farmer to the hawker and then to the consumer (Belete et al. 2016). It was then discovered that higher producer margins were attained from the latter channel. Main marketing challenges were found to be lack of transportation, lack of pricing decision and marketing skills. Thus, the need for significant amount of investment towards the promotion of improved varieties especially to consumers and retailers in order to increase awareness of the benefits attained from this variety (Belete et al. 2016)

Formal marketing channels are characterized by standardized branded products, use of efficient, integrated marketing, logistical, and financing processes. In addition, the terms of production, processing, procurement, payment and product type are set by buyers and not producers. This is due to the demand by urban consumers who require high quality products at consistent prices throughout the year. Supermarkets are becoming significant players in vertically integrated food marketing systems. Other market players include hotels and fast-food outlets. These trends confront smallholder farmers with market challenges and opportunities. As a result of such trends, the livelihoods of smallholder farmers are being influenced by the demands of urban consumers, market intermediaries, and agricultural (food) industries. Often smallholder farmers have limited access to marketing information, services, technology and capital. Production of sweetpotatoes is basically for subsistence use (mainly household consumption) with limited surplus for sale in order to earn income despite enormous opportunities for national, regional and global trade. There is limited cross-border trade , but this only occurs to meet the very short term potato supply shortages.

In this study, it was observed that sweetpotato was predominantly sold fresh after harvest. Poor, uncoordinated markets dominated by middlemen who set and control product prices diminish farmers' economic returns. Low (2000) reported un-organised markets with low prices being the major limiting factor in sweetpotato marketing.

Consumers need standardized products, yet these farmers have little knowledge of consumers demand and hence cannot produce what the market needs. Even if they produce what the market needs, they may have little information of reliable and profitable markets. In such circumstances, there is potential exploitation of farmers by the middlemen and wholesalers in the chain because the market value of the sweetpotatoes is subject to very limited negotiation, given that almost all farmers sell to middlemen at the farm gate. The exploitation is further exacerbated by absence of standardized packing and weighing scales .

The growing demand for sweetpotatoes in urban areas could therefore contribute positively to the development of the rural areas and the overall economy if there is 2 way efficient flow of market information. High marketing margins exist either because of monopolistic elements in the marketing chain or because the real costs of marketing are high. High marketing costs may be

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due to poor marketing services and infrastructure. Thus, improving the marketing services such as storage, transportation, and processing can lead to improvement of rural income by reducing marketing costs. Farmer collective action has also been proposed as a way of improving the welfare of smallholder farmers in the emerging high-value agricultural markets as it can improve the bargaining power.

It is common to see imperfect markets mainly depending on the primary agricultural commodities. The problem is severe for areas that obtain a big share of their gross domestic product, employment opportunity from a single industry. Diversifying the agricultural products and its market base towards non-traditional high-value horticultural crops could increase the earnings and reduce fluctuations. Despite this potential, the farmers‟ in the area rarely utilize the opportunity to improve their livelihoods.

It is well known that different household attributes put households under different production and marketing potentials. The market challenges of that the households face might influence the households/ farmers‟ participation decision and the extent of participation, the type of crops they would like to grow and the size of farmland they would like to allocate to a specific crop. This could be due to the fact that production and marketing decisions of households are two sides of a coin. The two decisions go hand in hand as farmers‟ produce what they could sell at an available market. Knowing the interaction patterns between the two decisions helps to understand what crop is sold at which market and whether the intention of selling at a particular outlet increases or decreases the size of farmland allocated to the specific crop .The supply from other parts of the country is seasonal; often needed to bridge the gap between demand and supply.

-Imperfections in markets and asymmetric market price information hinder the potential gain that could have been attained under the existence of markets with complete information. In this regard, marketing vegetable crops at farm-gate is an interesting process that has not been investigated much. Both buyers and sellers usually do not have equal market information on the crop prices at the central market. Under such circumstances, farm households selling crops at farm-gate deal with the trade-off between selling their crop harvests at higher possible prices and avoiding the risk of losing product quality if the transaction fails by holding on to higher prices. An interesting issue in this regard is what factors determine the farmers‟ to get gross margin in the crop market.

As efficient, integrated, and responsive market mechanism is of critical importance for optimal area of resources in agriculture and in stimulating farmers‟ to increase their output . A good marketing system is not limited to stimulation of consumption, but it also increases production by seeking additional output. However, there is a critical problem that stands in the course of formulating appropriate policies and procedures for the purpose of increasing marketing efficiency. This has to do with lack of pertinent marketing information and other marketing facilities, like storage and transportation. Thus, reducing the information gap on the subject by contributing to better understanding of improved strategies for reorienting marketing system for the benefit of small farmer development is found to be vital.

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-Enhancing sustainable sweet potato production system is government task. Product and market development of sweet potato is an appropriate way out to be tackled in attempt to help farmers from puzzle circle, and departure from poverty condition into better welfare (Widodo et al.2015). Product development is mainly processed sweet potato fresh into intermediate or final goods in the agro-industrial enterprises. Product development is expected to broaden the utilization of sweet potato than did the previously. Market development could be generated by linking the farmers and consumers, and facilitating the transportation, fund, and in line regulation, import of the other food crops. Maintaining traditional market and requesting supermarket to sell sweet potato fresh, intermediate and final products in rural, suburban and urban areas, supporting industrial enterprises with sweetpotato used as the raw material seem as the breakthrough to broaden the domestic market of sweet potato, aside to develop export for foreign earning (Widodo et al.2015).

Incentive or premium is required by farmers in order to sustain sweet potato production system in order to support continuously supply of the broaden demand for subsistence and commercialization. Despite farmers are never bothered with their own labour, but for fertilizer in a form of organic and/or inorganic need cash money. The use of external low input to sustain sweet potato production system is more recommended . It means that to generate and activate the internal or in situ sweet potato production system under sustainable circumstances is low cost.

On the other hand, the problem encountered with regard to biotic and a-biotic stresses are the challenge to sustain sweet potato at high productivity under stability (Widodo et al.2015). It can be understood, when the farm gate price of sweet potato is so low, many traders are not encouraged to buy, because traditional market is difficult. Under such situation, processor hunting a lot of benefit; due mainly to a huge margin between a lower price of raw material and a fix price for products. This fact is serious problem for the farmers, because they can not get cash income. Indeed government can help farmers by buying sweet potato fresh and distribute to the area which suffers from the hunger due to drought calamity. There is no strong of government to food diversification program (Widodo et al.2015).

Therefore, sweet potato that has flexibility to be harvested under various ages is recommendable for fulfilling and supporting food security . Based on the various experiences, in commercialization of sweet potato require the regulation to balance between supply and demand. Thus, there is no excessive supply due to many farmers grow sweet potato that consequence to farmers unbeneficial., or lack of supply that promotes to high price so processors difficult to enjoy a margin. It is suggested that government has to establish the board for maintaining price of agriculture produces, especially related to food security program. Regulation has to be undertaken between farmers, traders and processor, role of government as referee or to facilitate stakeholders to share risk and profit. By incorporating the ethical value with rationale and realistic in the regulation of sweet potato commercialization, risk is not loaded merely to farmers (Widodo et al.2015) but also profit for better income is also the right of farmers. Sacrificing farmers on the name of development must be terminated. Poor farmers who grow sweet potato are able to help poor community in rural, slum of urban and sub-urban areas. In future, commercialization in must be as a gate to share fairly the profit

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into equity as consequence to care farmers for sustaining high productivity under stability (Widodo et al.2015).

4.8. Trade and value chain systems

The value chain analysis was intended to provide a systematic knowledge of the flow of goods and services from their origin (producer) to their final destination (consumer).This knowledge was acquired by studying the participants/key actors in the value chain i.e. those who perform physical marketing functions in order to obtain economic benefit. There were successive functions which had to be performed by market agents/intermediaries through which they achieved both personal and social goals by earnings a personal financial award. In so doing they add value to products and satisfy the consumers needs. The channels, thus, vary in their efficiency e.g. in terms of profitability to actor, quantity moved or transformed.

As it has been observed elsewhere, the primary actors in a sweet potato value chain included seedling and other input suppliers, traders, brokers, processors, retailers, and consumers (Degu et al.2015).

In Tanzania, the chain for sweet potato is characterized by low value addition, informal marketing system and un-coordinated market channels and poor coordination (Mmasa 2014). Likewise, nutritional value and packaging are among factors that influence the decision of consumers towards purchasing the products. On the contrast, farm gate price, occupation of the household and education level influence the decision of producer to be engaged in a value chain system (Mmasa 2014). Hence, it is important to enforce of existing laws and regulations by creating enabling environment for the crop, to strengthen both vertical and horizontal coordination and build capacity to farmers in handling, preservation and processing (Mmasa 2014).

In Rwanda, besides farmers, processors also claim to have many problems encountered such as expensive equipment (long term assets and short term assets). Also lack of subsidies was cited as another challenge in the processing of sweet potato(Nyirahanganyamunsi 2016) . In Rwanda, there exist unbalanced power relations amongst sweet potato stakeholders engaged in the value chain and marketing channels. The unbalanced power exists also between farmers and a processor who dominate the market, in terms of fixing the price of products (harvested sweet potato). Yet, famers know their livelihood better than anyone else, and on that basis they formulated suggestions to address the challenges among the actors in sweet potato value chain. Also, processor in the chain is in a position of monopoly market and influence farmers quite seriously namely in fixing prices and enjoy profit without taking into consideration farmers' interest in the whole process. This is exacerbated by the lack of regulation of the sector by the Government of Rwanda (Nyirahanganyamunsi 2016). Hence, current policy to guaranty farmer's participation during the formulation of policy that may affect directly their livelihood is critical (Nyirahanganyamunsi 2016).

Knowledge on value addition and nutritional benefits, and availability of vines are the key factors for variety adoption. The participation in a value chain extension programme can enhance the probability of adoption of new varieties. Factors affecting intensity of adoption of varieties include site, value addition, vines availability, level of commercialization and having a

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child of up to five years (Kaguongo et al.2012). Participation in a value chain extension intervention programme increased farmers' likelihood of adopting improved varieties such as OFSP (Kaguongo et al.2012).

In the sweet potato value chain in Kenya, good agricultural practices was viable with an NPV (the net present value or the value of the discounted future net benefits) of US$ 28,044, an IRR(internal rate of return) of 328%, and a one-year payback period. This is in comparison to the improved sweetpotato seed varieties (US$ 8,738, 111%, and two years payback period) respectively (Akinyi et al.2022) .

Markets are important for economic growth and sustainable development of a given country, but, emphases in development policies in agrarian countries have usually been placed on increasing agricultural production to serve as a base for rural development. In the absence of well-functioning markets, agricultural production can experience several drawbacks . Market-oriented farmers play a significant role in the rural agricultural sector . However, these trader-farmers are often disadvantaged by limited access to information, services, appropriate technology and capital. These factors restrict their capacity to effectively participate in the marketing of their produce. In many instances farmers, including those in the sweetpotato innovation platforms are relegated to the lower end of value chains where they are price takers with little bargaining power. Therefore, they end up earning little margins while giant chain actors along the chain like middlemen have the power to determine prices paid by the final consumer and thus extract huge marketing margins.

-In North Kivu province, the sweetpotato value chain is not well organized or integrated because producers, transporters, marketers, wholesalers and retailers are fragmented. This lack of organization is one factor that isolates the sweetpotato sub-sector from regional and global markets. There are few initiatives for collective action in sweetpotato production and marketing and those existing are in their infancy and widely scattered leading to limited or no integration of stakeholders along the potato value chain. With increasing population and urbanization and thus growing demand coupled with the increase in fast food restaurants and supermarkets, the sweetpotato sub-sector is bound to expand. This is an opportunity for sweetpotato farmers to increase farmers gross margin and productivity of improved and suitable swwetpotato varieties, which will in turn increase their income and improve food security and livelihood. Given the challenges and opportunities that smallholder farmers face, it is important to identify factors affecting farmers gross margin in North-Kivu province. The smallholder producers are price takers since they have little participation in the value chain and imperfection of the marketing system. As a result, smallholder farmers‟ have repeatedly faced risk of unexpected fall in horticultural product prices .

Overall, lack of capital and credit facilities may cause farmers to remain underdeveloped for decades. Farmers need to be trained on post-harvest processing technologies and value addition. Moreover, lack of transport, transportation facilities and dilapidated roads are other bottlenecks in the sweetpotato value chain business. Unavailability and inadequate extension services may also contribute to low sweetpotato production and productivity. Furthermore, most private extension workers have limited knowledge of sweetpotato agronomy.

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Additionally, farmers don't benefit from their labor when considered the profit made by other actors along the value chain and this need to be tackled by policy makers so as lessen the suffering of the producers The policy makers must also invest in inputs which they could subsidy for the benefit of farmer, and also invest in modern tools for long-term storage and in research at national level for the researchers to develop certified and resistant sweet cultivars to pathogens and insect pests which could be available to farmers year round. This will definitely lead to sweet potato tubers free of diseases and pest infestation (high marketable sweet potato) which will also result in improving the high market value of sweet potato along the value chain(Okwadi 2015)..

5.CONCLUSION

The following findings were obtained from the current study :

Sweetpotato is cultivated mainly by small-scale farmers, mostly women, who plant on average less than one hectare per holding. As well as this useful property it can withstand adverse abiotic and biotic stresses and does not require intensive care (Mukhopadhyay et al.2011). They range in maturity period from 3 to 6 months. Many landraces are cultivated. Some varieties are very popular and versatile; they are cultivated throughout the study area. These varieties are sometimes called different names in different villages. Most of these varieties have been selected by farmers on the basis of factors such as yield, maturity period, palatability; root color, size and shape, root quality, sweetness, pest and disease resistance, storability and marketability. Therefore, farmers-preferred dual-purpose sweetpotato varieties with improved root & green fodder yields should be developed to enhance sustainable production and the adoption of sweetpotato in the mixed farming systems in North-Kivu Province.

Sweetpotato is cultivated in the uplands, on flat land, and in valley bottoms and swamps. Manure is seldom applied, and inorganic fertilizer applications are even rarer. Pesticides rarely used even in serious cases such as seasonal infestation of sweetpotato butterfly caterpillars and sweetpotato weevils.

Mounds are commonly used, but, in highland areas, land is prepared in ridges to control soil erosion. Farmers rely heavily on traditional cultivation methods. Well-researched and recommended techniques for sweetpotato cultivation are still limited. The few techniques available have not been widely disseminated, and most farmers do not use them.

Farmers tend to plant sweetpotato any time of the year, sometimes obtaining low yield as a result. Most farmers plant sweetpotato as a sole crop, probably because they lack knowledge on the advantages of intercropping, lack knowledge on proper intercrops, or plant sweetpotato when the season is inappropriate for other crops.

Piecemeal harvesting is prevalent and usually starts at about 2 months after planting. Peeling and boiling or steaming is still the major method of preparation for consumption. Sweetpotato is perishable and has very short shelf life; postharvest storage is virtually nonexistent. Only a few farmers slice, dry, and store their sweetpotatoes. Sliced and dried sweetpotatoes can be stored reasonably well, but they are attacked by storage weevils and palatability is affected. Industrial use of sweetpotato does not exist in eastern part of DRCongo. Hence, there are limited use opportunities both on and off the farm

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Like many other food crops, sweetpotato is cultivated primarily for home consumption. Nonetheless, significant quantities are sold in both rural and urban markets for cash. Usually, less than one-third of the product is sold and the proceeds are used to purchase household necessities. Commercial sweetpotato growers are currently limited to the vicinity of towns and institutions where good roads exist. Most rural roads are poor, and vehicles or bicycles are not available, so the main means of transporting sweetpotatoes to the market is by head-load. In accessible areas, motorized transport and bicycles are used to ferry sweetpotatoes to urban consumption areas. On-farm prices are still too low to encourage commercial production.

Several socioeconomic issues were reported as serious constraints to increased production and use. Notable among them were high transport and labour costs. There is a need for research on labour-saving technologies such as draft power at the household level and techniques to widen sweetpotato use so as to broaden the market. Many socioeconomic constraints have serious policy implications. Although farmers report a shortage of farm implements, the truth seems to be that implements are available but at prohibitive prices. A stronger policy emphasis on sweetpotato coupled with improvements in infrastructure could solve the current problem of low farm prices.

Sweetpotato has great possibilities for enhancing food and nutrition security in areas (Williams et al.2013, Epeju & Rukundo, 2018) where most of the farmers ' holdings belong to the small and marginal categories. Although the crop is assuming greater significance owing to the ever increasing population its importance is still underestimated and, unlike most staples, fails to attract sufficient attention of agricultural researchers throughout the tropics and subtropics(Mukhopadhyay et al.2011, (van Vugt & Franke 2018).

Farmers reported several biological, physical, and socio-economic constraints to increased production and use. Farmers believed that vertebrate pests and insect pests, especially sweetpotato weevils and sweetpotato butterfly caterpillars, were the most important biological constraints they faced. Farmers' present methods of pest management are far from effective. Therefore, appropriate measures need to be taken for their proper control in order to increase the return of farmers. This is followed by poor tubers due diseases and insects, low market price, scarcity and high cost of labor, and the lack of better conservation methods for a long time, low yield.

The study identified what the farmers considered to be their major production constraints, as well as the farmers' preferred sweetpotato attributes and their perceptions on pests and diseases constraints. Sweetpotato farmers in the different areas of eastern DRCongo face the same production constraints and have the same preferred attributes but the degree of importance of the constraints and ranking of the preferred attributes differ. Presence of resistant genotypes is an indication that sources of resistance to the disease are available within the germplasm and therefore it is possible to breed for resistance to the disease.

These findings will be important in designing future breeding programs as some farmers' production constraints and preferred attributes have been identified. However, careful parental and progeny genotype selection and involvement of farmers at

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an appropriate stage of selection is essential to ensure that the traits identified as important by the farmers will be incorporated into the new genotypes. In turn, this will lead to an increase in the adoption rate of the new genotypes since they will meet the requirements of the farmers.

-The policy implications of this study are therefore clear. Agricultural extension services in the province should focus on training farmers through capacity building programs on new sweet potato agronomic practices, not just for increased productivity but also high adoption rates. This would also require recurrent contacts with producers in major sweet potato growing areas. The implementation of land tenure policies in favor of women would also constitute one of the means of removing constraints to sweet potato production. As a food security crop, sweet potato is perceived as a women's crop, who, in turn, are also considered as prime responsible for households' food security. The results of the study also showed a relationship between participation in off-farm activities, access to credit and adoption of improved sweet potato varieties. These results suggest that reinvesting income from non-farm activities in agricultural innovations would reduce the risks associated with agricultural innovations as well as the amount of labor for agriculture. Thus, various actors involved in agricultural development programs are expected to promote off-farm activities in addition to purely agricultural technologies.

As for microfinance institutions, the establishment of small agricultural loans' system would guarantee access to credit for smallholder farmers and would provide them enough funds to venture into off-farm activities, and increase their production. Also, results showed that for the Kivu provinces, the access to planting materials was limiting extensive adoption of improved varieties among sweet potato farmers who were found only producing on small plots. A seed delivery system is, therefore, necessary to ensure that farmers can access at any time, desired amount of quality seeds in their vicinity.

-This study highlights the need to strengthen and empower organizations involved in agricultural extension. It is one of the few studies that address the role played by farmers' attitudes and perceptions in the adoption of agricultural innovations in eastern DRCongo. This aspect has long been neglected by agricultural economic studies in the region, even though it may be one of the main reasons for the rejection of agricultural innovations.

The results suggested that as the country's agriculture develops to meet the challenges of a growing population and changing environment, there will be need for a national policy to ensure effective conservation of varieties that possess unique desirable traits. Conservation policies must consider strategies that will facilitate preservation in the face of environmental and agronomic constraints such as limited land, losses to diseases, unreliable weather, and prolonged drought events, as well as financial constraints such as market access and price fluctuation.

It has been shown that sweet potatoes play an important role in maintaining food security and reducing poverty in rural Africa. There is, therefore, a need to increase yields and quality of sweet potato through the use of improved cultural practices and varieties. Indeed, the adoption of highly productive varieties and better agricultural practices will improve the sweet potato value chain and thus contribute to improved livelihoods and food security.

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A better understanding of farmers' attitudes and perceptions as well as the socio- economic factors determining the adoption of improved varieties, therefore, considered a prerequisite for an effective dissemination strategy in North-Kivu. Varieties adoption has been found to be associated with household, socio-economic and institutional factors. A positive relationship between income, off-farm activity, access to credit, education, cooperative membership, contacts with extension agents and improved varieties adoption in rural Kivu was observed. In contrast, age, farm size and field to house distance discourage adoption.

-Overall the sweetpotato survey has acted as an eye-opener on the extent of sweetpotato cultivation, production methods, use, marketing, and constraints. Containing as it does production, post-production, and socioeconomic elements, it provides a fairly complete picture of the constraints and opportunities of sweetpotato enterprises in various villages of the provinces. It gave an opportunity to discuss with farmers about their problems and priorities and to identify knowledge gaps future areas for research. The survey unveiled issues that had previously not been known with certainty.

The study may serve as a foundation for further production and use technology and research-extension development, and resulted in an operational workplan for the sweetpotato research group focusing on value chain and value addition. Needs and opportunities identified were directed more toward farmer learning than research, and more to crop cultivation. Consequently, the follow-up workplan concentrated on the development of an adapted-flexible protocol to suit the various production-postharvest use systems across the areas is needed to be developed by reading the output on this research

6.RECOMMENDATIONS/SUGGESTIONS

- In this study, it was observed that local cultivars tended to be low yielding and prone to pests and diseases. Therefore, research into breeding, evaluation, and selection of better varieties need to be advanced and strengthened in the eastern DRCongo.

- Research into storage and expanded use of sweetpotatoes both on- and off-farm is a priority. Currently, in-ground storage is the practice, and research is evaluating different varieties for the traditional piecemeal harvesting. However, in-ground stored sweetpotatoes are prone to pests, diseases, thieves, and extreme weather conditions. Unfortunately, varieties with a short maturity period do not store for long underground. Research into postharvest storage methods may supply longer term solutions. There is a need for research into the government credit structure with the aim of advising policy-makers on farm credit.

-The study identified the actual production constraints, desired genotype attributes and the extent to which the farmers regard pest and diseases as a serious production constraints. All these aspects are important in designing future suitable sweetpotato breeding programs.

Research is also needed to determine optimal planting and harvesting dates for different agroecological zones. Farmers clearly need high-yielding, disease-and pest-resistant varieties (Mukhopadhyay et al.2011). There is a need to educate farmers on diseases and to clean, multiply, and distribute disease-free planting materials. Controlling disease and pest practices should be promoted to increase production and productivity. Other constraints such as shortage

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of land, shortage of labour/manpower and shortage of money may need further interventions such as access to credit and entrepreneurship.

The most important climatic constraints reported included soil erosion/landslide and flood/soil infertility. Research into disaster-tolerant varieties and optimal planting dates would go a long way in addressing this problem. As already noted, farmers have devised several ways to preserve. Weather forecasting and early warning systems can provide farmers with useful advance information.

-Farmers expressed their persuasive needs towards improved extension service delivery, disease-tolerant cultivars, and reliable and coordinated markets.-This study recommends the need to strengthen extension services and seed delivery systems and amending the credit systems for increased impact on improved varieties adoption among Kivu province sweet potato farmers.

-Farmers gross margin was found to significantly and positively affected by extension service. Therefore, strengthening efficient and area specific extension systems by giving continuous capacity building trainings and separating extension work may increases farmers gross margin and benefits while reducing price between different sweetpotato markets.

These results call for policies aimed at encouraging new entrants to cultivate sweet potato and the experienced ones to remain in farming. Credit and subsidy from governmental and non-governmental agencies should be made available to rural farmers, for this will go a long way in addressing their inefficiency problems

-The findings of the present research ultimately stimulate calls for attention for more investment in sweet potato research in order to help farmers increase their productivity and revenues

-Strong policy frames targeted on best extension systems, access to market information, gender balances and farmers' income diversification mechanisms should be formulated to boost intensive commercialization of smallholder farmers in eastern DRCongo.

Awareness creation on sources of market information, how to select appropriate market channels and how to get fair price should be given by development agents and market experts in the study area.

Acknowledgements

Farmers who participle in the interviews and provided needful information and the extension staff, key informants, village chiefs who helped with the survey are duly acknowledged.

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Figure 1a: Map showing the 26 provinces found in in DRCongo including the North-Kivu Province

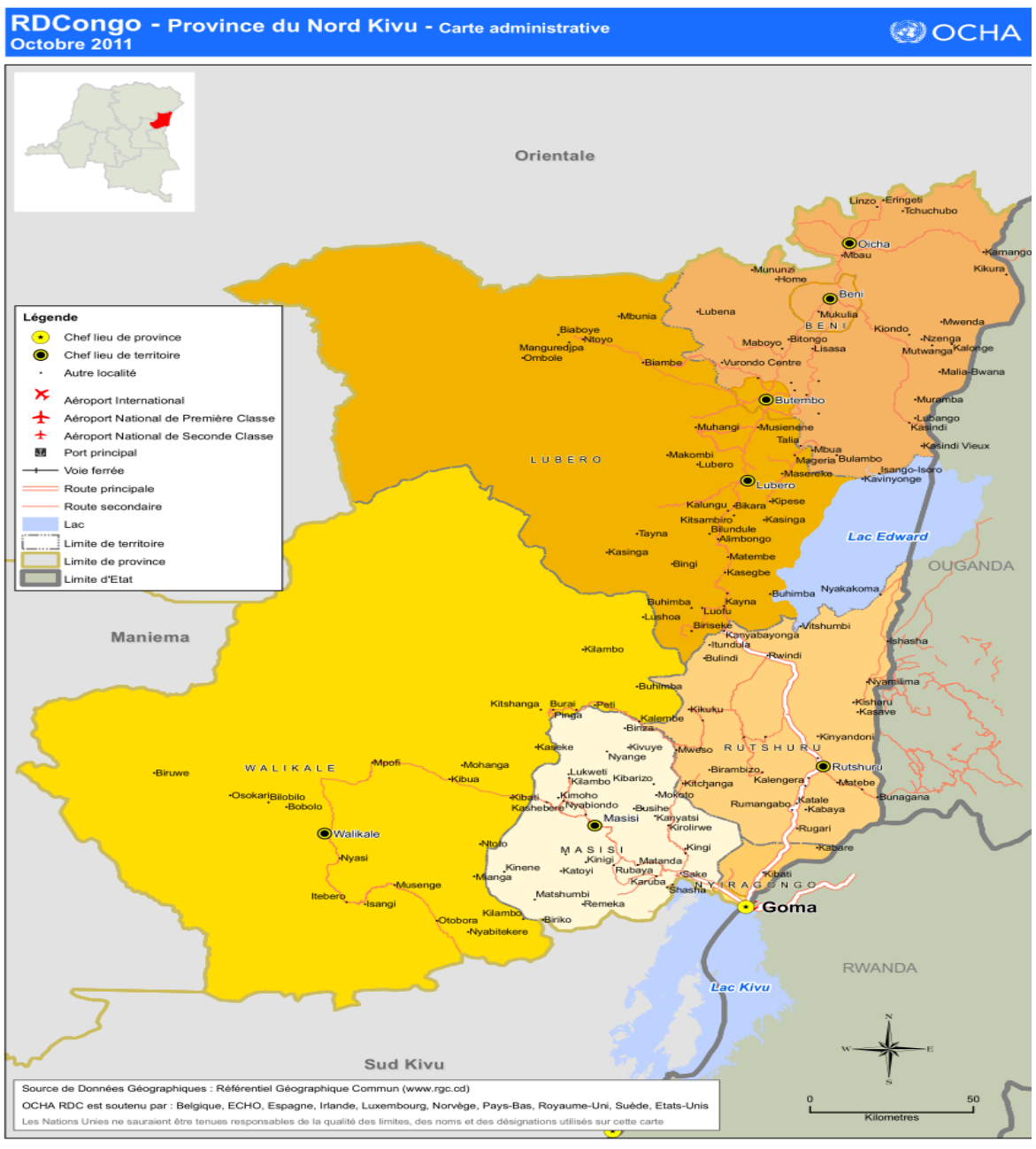

Figure-1b: Map showing the North-Kivu province with the four territories surveyed: Masisi, Rutshuru, Lubero and Beni territories

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Table-1: Socio-economic characteristics of respondents from Masisi, Rutshuru, Lubero-Butembo and Beni territories during interviews conducted in North-Kivu province, eastern of DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Leve of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Marital status	Married	71.45	77.54	69.67	75.01	0.51004	0.917
	Single	8.65	3.76	12.78	4.65	6.87729	0.076
	Widower	16.75	11.67	5.56	7.91	6.83123	0.077
	Divorced	3.45	7.43	12.65	13.11	6.91917	0.075
Religion	Catholic	40.81	41.12	46.45	24.78	6.88078	0.076
	Protestants	30.65	24.87	25.76	33.65	1.79634	0.616
	Adventist	18.78	27.76	18.6	18.12	3.100082	0.376
	Muslim	8.11	3.23	3.56	9.21	4.70837	0.194
	None (others)	1.98	3.54	6.12	14.5	14.2818	**0.003**
Age (years)	Female	33.67	45.89	27.65	30.65	5.57554	0.134
	Male	56.78	43.21	45.67	42.12	2.88834	0.409
Sex	Female	63.67	59.54	76.21	65.12	2.29993	0.513
	Male	36.54	40.7	23.7	35.67	4.6886	0.196
Number of children	Male	4.87	4.32	6.72	6.41	0.731219	0.866
	Female	6.41	5.76	4.32	4.65	0.534664	0.911
Number of years schooling (education level)	Male	7.54	6.34	7.68	9.43	0.627231	0.891
	Female	5.54	7.65	7.12	9.87	1.27466	0.735
Main occupation	Farming (crop/livestock/ fishery/apiculture)	65.78	78.9	43.12	57.92	10.9344	**0.012**
	Farm employment (elsewhere)	2.43	14.12	34.32	5.19	44.552	**<0.0001**
	Non-farm employment	32.76	7.76	22.78	37.24	20.3743	**<.0.0001**
Major sources of income (revenue/capital)	Farming as primary (crop cultivation)	10.78	13.6	30.7	25.45	13.4157	**0.004**
	Livestock (animal rearing)	32.26	24.51	18.54	15.76	7.03286	0.071
	Off-farm activities (informal employment))	8.34	7.12	4.19	19.76	14.2072	**0.003**
	Unskilled wage labor (e.g., daily laborer)	5.21	3.71	2.12	5.23	1.61703	0.656
	Skilled wage labor (e.g., carpentry)	1.22	1.13	1.67	1.12	0.158521	0.984
	Petty trade (e.g., retail shop, vending for someone)	0.13	0.05	0.01	1.43	3.47728	0.324
	artisanal work/handcrafts	1.91	0.04	0.65	1.33	2.01514	0.569
	Small business (owning mini-shops)	27.4	36.78	23.67	9.76	15.4544	**0.001**
	Donation by Friends/ family relatives/ diaspora, humanitarian aid	1.49	3.12	1.98	2.12	0.644443	0.886
	cooperatives, microfinances, micro credits	3.23	4.12	13.87	3.45	12.8957	**0.005**
	Personal saving (from previous years)	8.76	6.76	3.01	14.9	8.86797	**0.031**
Poverty and food security status of respondents (self-report)	Poor (<1$/day) & critically food insecure (eat 1-2 types/day)	66.43	88.21	71.65	71.56	0.305	0.305
	Medium (> 1-2$) moderately food insecure (eat 1-3 types of food per day)	27.78	11.34	23.76	27.12	7.7947	**0.05**
	Rich (>2-5$/day), food secure (eat 1-4 types of food/day)	6.12	1.12	4.87	1.65	5.17843	0.159
Membership to association (NGO, cooperatives, farmers groups)	Yes	78.2	78.43	88.32	78.92	0.893562	0.827
	No	27.78	22.54	11.76	21.95	6.40818	0.093
Previously trained on best agricultural practices and technologies	Yes	22.87	24.12	13.76	31.54	6.91557	0.074
	No	77.92	76.43	86.31	68.5	2.06703	0.559

Table-2: Livelihood evolution & dynamics of households over the last 20 years (2010-2020) in the Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern DRCongo.

		Territories (% of Respondents)				Statistics	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Current status of cultivated land	Increased	15.54	11.34	5.34	5.12	8.168	**0.043**
	Decreased	57.65	66.23	86.12	71.34	6.08426	0.108
	No change	27.67	23.12	9.45	23.87	9.06526	**0.028**
Current status of Pasturelands	Increased	12.65	19.54	34.65	6.65	23.7575	**<0.0001**
	Decreased	67.95	43.54	54.76	21.87	24.2952	**<0.0001**
	No change	21.34	37.65	11.56	71.54	58.4737	**<0.0001**
Current status of Household size	Increased	67.45	58.65	76.12	71.34	2.40103	0.493
	Decreased	21.87	12.54	17.54	23.54	3.84934	0.278
	No change	10.76	19.65	6.76	13.54	6.94563	0.074
Current status of Health services access	Increased	18.32	11.65	17.56	7.98	5.26311	0.154
	Decreased	54	79.54	79.98	74.23	6.24833	0.101
	No change	27.87	9.76	3.43	18.65	22.7942	**<0.0001**
Current status of Non-farm activities opportunities	Increased	17.45	11.76	8.45	24.87	9.92927	**0.019**
	Decreased	52.65	42.76	54.98	36.54	4.76555	0.1901
	No change	29.99	45.76	36.65	38.66	3.34741	0.341
Current status of Peace & security, fair justice	Increased	8.65	3.65	1.65	1.87	8.03952	**0.045**
	Decreased	48.87	86.45	64.23	92.12	16.534	**0.001**

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	No change	43.23	10.54	34.87	6.23	41.5126	**<0.0001**
Current status of education, information access	Increased	65.11	67.43	41.12	24.77	25.1355	**<0.0001**
	Decreased	11.87	23.76	39.76	42.12	20.7042	**<0.0001**
	No change	23.44	8.98	19.54	33.54	14.4681	**0.002**
Current status of Public support services & local good governance	Increased	10.65	3.65	4.12	1.43	9.52316	**0.023**
	Decreased	44.88	69.12	78.21	83.12	12.5795	0.061
	No change	45.08	27.89	17.76	16.23	19.7748	**<0.0001**
Current status of Borehole, well water, clean environments, clean toilets (WASH: Water, sanitation & hygiene)	Increased	8.97	6.45	18.54	7.87	8.63444	**0.035**
	Decreased	24.03	12.33	36.65	12.76	18.486	**<0.0001**
	No change	67.44	81.76	45.76	79.43	11.8588	**0.008**
Current status of qualitative/quantitative ecosystem services delivery from nearby landscapes	Increased	15.98	5.87	9.45	3.54	10.1257	**0.018**
	Decreased	59.34	23.45	29.54	51.43	21.6038	**<0.0001**
	No change	25.24	71.54	61.98	45.32	24.2707	**<0.0001**
Current status of access to clean energy, solar energy, electricity	Increased	13.54	4.43	8.126	4.21	7.53634	0.057
	Decreased	15.09	52.32	71.32	19.65	54.7215	**<0.0001**
	No change	71.77	44.12	21.54	76.45	36.8416	**<0.0001**
Current status of Formal/informal financial (credit-savings, microfinances) access	Increased	19.87	22.54	34.52	10.56	13.3678	**0.004**
	Decreased	7.03	16.54	4.65	8.78	8.58956	**0.035**
	No change	73.41	60.98	61.76	81.46	4.18991	0.242
Current status of Number of agro-dealers shops in the villages (Seeds, agri-inputs, planting material market)	Increased	11.11	10.32	43.54	7.98	47.0964	**<0.0001**
	Decreased	8.89	2.76	11.67	5.67	6.19282	0.103
	No change	80.02	87.45	45.43	87.12	16.0187	**0.001**
Current status of Extension services access	Increased	4.87	2.99	13.12	5.32	9.15153	**0.027**
	Decreased	73.67	26.65	43.12	79.54	33.9657	**<0.0001**
	No change	21.89	71.23	44.43	15.65	49.7199	**<0.0001**
Current status of Pavated roads, transport facilities	Increased	2.87	1.12	4.12	6.43	4.11491	0.249
	Decreased	67.98	89.54	89.55	85.12	3.80216	0.284
	No change	29.85	9.54	6.56	8.54	26.1119	**<0.0001**
Current status of Business opportunity, Market & Price of agriproducts increases	Increased	12.76	3.12	5.76	7.98	6.76217	0.0811
	Decreased	11.53	19.43	30.88	4.12	23.8529	**<0.0001**
	No change	76.26	77.55	63.54	88.12	3.98174	0.263
Current status of Cooperatives, farmers groups/initiatives	Increased	34.55	45.65	59.34	21.54	19.2734	**<0.0001**
	Decreased	25.2	7.12	6.12	18.43	17.8867	**<0.0001**
	No change	41.01	47.43	34.76	60.43	7.87395	**0.049**
Current status of Private sectors, NGOS interventions	Increased	47.44	15.32	23.55	18.67	24.1275	**<0.0001**
	Decreased	13.89	5.34	1.23	7.34	12.0325	**0.007**
	No change	39.24	79.45	75.87	74.43	15.7516	**0.001**

Table-3: Sources of household welfare shock and economic well-being trends (%)., expected economic well-being a year from now, source of shock in the communities, coping strategy most frequently adopted, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern DRCongo

		Territories (% of Respondents)				Statistics	
		Masisi (N=102)	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Changes in economic well-being from a year ago	Better off	40.02	27.21	15.43	12.86	19.4486	**<0.0001**
	Worse off	21.11	5.65	14.32	39.76	31.1578	**<0.0001**
	Same	39.54	67.65	70.32	47.43	12.18	**0.007**
Expected economic well-being a year from now	Better off	38.21	33.67	40.67	13.64	14.3527	**0.002**
	Worse off	49.98	45.65	37.01	18.76	15.1416	**0.002**
	Same	11.93	21.43	23.07	67.65	60.005	**<0.0001**
.							
Source of shock in the communities	Falling of crop/animal prices	24.98	32.76	24.76	39.23	4.75545	0.191
	Poor harvest due to pests and diseases (animal diseases)	24.45	24.76	13.47	14.98	5.61074	0.132
	Sickness/death of household head/member	16.77	9.54	28.65	9.76	14.9045	**0.002**
	Poor harvest due to climatic variability/natural disasters	14.66	23.44	21.09	6.76	10.1583	**0.017**
	Fluctuation/ Rising of food prices	11.34	7.45	2.43	9.24	5.70292	0.127
	Rising insecurity (wars), epidemy (Ebola) emergency	8.56	2.87	9.87	20.76	15.9433	**0.001**
Coping strategy most frequently adopted	Reducing quantity of meals (eat 3 days out of 7/week)	12.12	7.54	3.65	8.56	4.5708	0.206
	Eating foods other than staples (feeding on wild foods)	32.66	42.32	30.54	29.43	3.07073	0.381
	Engaging in small-scale businesses(entrepreneurships)	15.12	23.65	41.78	24.21	14.3553	**0.002**
	Borrowing food in kind (request for help from friends)	6.88	1.43	1.43	7.98	8.26298	**0.041**
	Requesting assistance from humanitarian agencies	1.67	1.76	0.09	4.87	5.72752	0.126
	Migration to urban areas (mining sites /rebels' groups)	28.98	18.98	9.67	12.65	12.4526	**0.006**
	Migrating out of the country (Refugee)	2.43	4.54	12.43	9.56	8.66638	**0.034**
	Migrating in other provinces/ villages within the country	0.32	0.56	0.66	3.45	5.23373	0.155

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Table-4: Extension services, land allocated, agronomic and farming practices of sweet potato growers interviewed, the Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Sources of land cultivated	Family land	12.87	14.67	21.12	9.87	4.63877	0.201
	Inherited	44.65	46.3	34.2	40.81	2.09034	0.5554
	Hired (renting)	5.78	7 .65	6.98	6.54	0.274178	0.965
	Purchased	36.98	31.76	38.32	43.31	1.79856	0.615
Number of plots (0.11-1.5ha) dedicated for sweetpotato growing	1	10.67	11.21	21.26	18.67	549752	0.139
	2	53.78	60.89	62.23	71.2	2.47466	0.481
	3	31.32	24.12	14.12	9.67	14.4517	**0.002**
	4	5.11	4.34	2.43	1.23	2.867227	0.413
Average Farm size (ha) allocated to sweetpotato	Farm size (ha)	1.49	0.46	0.11	0.39	1.5722	0.6666
Sweetpotato yield (t/ha, X±SD) of households interviewed.	Male headed fields	10.23 ±7.58	9.23 ±7.58	12.22 ± 8.38	11.23 ±8.58		
	Female headed fields	20.87 ±6.21	17.11 ± 5.24	27.13 ± 11.27	23.18 ± 8.54		
	Youth headed fields	6.43 ± 5.65	8.93 ± 7.68	12.94 ± 6.54	8.33 ± 4.89		
Gendered farmers engaged in sweetpotato production	Female	67.67	56.43	60.23	59.32	1.12881	0.771
	Male	33.12	44.31	40.56	41.34	1.70483	0.636
Source of labor for sweet potato cultivation	Family members	20.54	45.69	37.2	15.67	19.9044	**<0.0001**
	Hiring	40.56	1.56	5.76	2.65	83.0736	**<0.0001**
	Cooperative members collaboration	13.16	25.76	15.76	13.44	620615	0.102
	More than one source of labor	26.64	27.65	41.77	68.98	28.2994	**<0.0001**
Planting months of the year in the village	October-November (Mostly)	70.45	57.12	45.65	57.12	5.3553	0.148
	February (frequently)	24.65	36.12	42.12	40.12	5.1191	0.163
	June (sometimes, in marshlands)	5.12	7.12	12.33	3.19	6.69444	0.082
Extension services received for sweetpotato	Village extension officer (posted by Government)	2.12	0.54	0.12	3.12	3.9541	0.266
	*NGOs (local, regional, international)	22.34	22.12	12.33	6.56	11.3734	**0.011**
	Do not access any extension service	75.87	77.34	88.12	91.12	2.10523	0.551
	*= (CRC = Caritas international, WR= World Relief Services, STC = Save the Children, WV = World Vision, FAO)						

Table-5: Main crop types grown (sole or in intercropping) for food sovereignty of rural households in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Crop types grown	Cassava (0.22-1.25ha)	14.88	12.54	16.56	18.36	1.18192	0.757
	Sweetpotato (0.21-1.49 ha)	16.41	11.77	15.86	16.37	0.992913	0.803
	Banana (0.35-9.89 ha)	10.73	9.21	12.27	14.71	1.40856	0.704
	Coffee (0.21-2.54 ha)	6.76	14.87	11.47	12.54	3.05649	0.383
	Irish potato (0.35- 2.45 ha)	13.72	8.85	3.37	9.51	6.11366	0.106
	Beans (0-25-0.45ha)	10.94	9.33	8.98	3.61	3.70786	0.295
	Maize (0.22-0.45 ha)	7.67	3.86	3.38	3.45	2.78497	0.426
	Groundnut (0.11-0.66h)	3.52	2.56	7.39	3.12	3.4921	0.322
	Soybean (0.13-0.41 ha)	3.65	3.75	0.65	3.67	2.36751	0.501
	Sorghum (0.15-0.41ha)	0.41	6.51	0.34	2.74	10.0686	**0.018**
	Rice (0.16-0.39 ha)	0.21	3.36	6.86	2.54	7.02843	0.071
	Dry peas (0.23-0.33 ha)	7.33	1.84	2.53	2.11	5.87646	0.118
	Taro (0.15-022 ha)	0.43	2.54	2.32	2.42	1.56382	0.668
	Yam (0.12-0.28 ha)	0.67	1.54	2.11	1.19	0.797586	0.851
	Sunflower (0.09-0.22ha)	1.66	0.88	5.43	1.61	5.28722	0.152
	Fruits (avocado, mango, citrus,…) (0.11-0.35 ha)	0.75	1.73	0.54	0.63	1000085	0.801
	Vegetables (tomato, egg plants, amaranths, onions, pepper,…) (0.18-0.89 ha)	0.21	3.76	0.12	0.86	7.11925	0.068
	Medicinal plants (0.09-0.24 ha)	0.32	1.12	0.43	0.85	0.609706	0.894

Table-6: Farmers citing (identifying/ranking) the relative importance of constraints types of sweetpotato production, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variable	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Land preparation constraints	Shortage/ scarcity of fertilizers(manure)	6.65	7.23	12.12	13.65	3.70055	0.296
	Shortage/scarcity of arable lands	38.12	41.5	27.82	24.13	6.19982	0.102
	No enough land to grow sweetpotato	12.65	14.54	17.86	14.65	0.938941	0.816
	Lack of access to arable land	11.12	5.65	3.56	9.11	4.69622	0.195
	Declining soil fertility (soil infertility)	20.43	8.23	11.84	15.87	5.87306	0.102

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	Land degradation in mountain zones	2.98	2.34	12.54	7.12	4.69622	0.195
	Paid labour (unavailable, hired, scarcity, shortage, expensive, high cost)	5.65	11.11	5.12	6.76	5.87306	0.118
	Family labour (declining family/community aid)	1.21	5.54	5.32	3.43	10.6168	**0.014**
	Lack of ploughing materials-tools-equipment's	0.54	2.67	2.12	3.65	3.10115	0.376
	No problem at all	1.32	1.98	1.87	2.23	3.13819	0.371
Planting material constraints	Shortage/lack of clean planting materials	23.56	8.98	15.45	27.23	10.7087	**0.013**
	Shortage/rarity of improved varieties	24.45	19.81	11.11	16.43	5.28165	0.152
	Genetic diversity erosion (new varieties coming to replace landraces)	3.65	11.34	16.65	18.65	10.7132	**0.013**
	High cost to acquire improves vines (vine scarcity)	8.13	14.76	11.12	6.56	3.86111	0.277
	Prevalence of low yielding genotypes in villages	12.35	28.21	1.92	2.34	40.6319	**<0.001**
	High prevalence of degenerated varieties	11.87	7.67	28.54	15.32	15.3987	**0.002**
	High Prevalence of Delayed (late) maturity varieties	6.28	5.29	7.23	4.67	0.646625	0.886
	No newly released varieties	9.32	1.32	5.32	7.85	6.18239	0.108
	No problem at all	0.76	3.49	2.71	1.12	2.49238	0.477
Climate-environmental constraints (stresses)	Weather stress (Drought, heat)	1.21	3.54	5.12	8.54	6.17266	0.104
	Climate change stress (heat, rain shortage, rainfall delay)	4.12	8.81	19.54	21.55	15.6434	**0.001**
	Climate variability stress (early onset of heavy rain)	9.51	12.12	9.11	3.79	4.24101	0.237
	others climate related hazards (floods, submergence, landslides)	37.32	32.43	19.87	24.14	6.56503	0.087
	Soil-water-nutrient erosion on sloppy lands	46.56	40.16	45.7	38.71	1.08091	0.782
	No problem at all	1.34	3.42	0.67	3.56	2.85182	0.415
Harvesting, post-harvesting (storage, processing) constraints	underground roots damaged found by moles	6.34	4.12	12.12	9.13	4.54623	0.208
	Pests (weevil) infestation during storage	3.12	4.54	2.11	6.32	2.49061	0.477
	Other pest (insects, rodents) attacks during storage	1.98	2.32	2.12	3.12	0.326499	0.955
	Rotting of roots during storage/at harvest	5.433	8.12	12.76	14.32	4.97839	0.173
	Other disease attacks of roots during storage	2.34	1.14	0.54	2.12	1.39173	0.707
	Labour shortage for harvest	7.87	6.43	3.12	5.55	2.07461	0.557
	Lack of funds to hire harvesting labour (expensive labour)	3.12	2.44	1.67	2.54	0.436141	0.933
	Poor quality roots at harvest	3.43	2.86	5.43	2.54	1.41489	0.702
	Fibrous roots at harvest	2.65	1.67	0.43	0.23	3.09165	0.378
	Poor /low yields at harvest	12.45	5.65	21.65	13.11	9.75972	**0.021**
	Low dry matter content	2.12	0.65	0.11	0.21	3.34767	0.341
	Get poor yields after investing a lot	12.65	11.54	11.75	8.43	0.914787	0.822
	Lack of knowledge on processing techniques/practices	8.67	4.12	6.32	7.34	1.67269	0.643
	Lack of processing equipment& materials	11.67	13.23	0.64	15.43	12.7001	**0.005**
	birds & rats destroying roots in the field	6.67	11.23	12.43	2.87	6.96188	**0.0073**
	Vermin & wildlife (baboons, hippopotamus)	1.56	12.12	1.42	2.12	18.9795	**<0.001**
	Human being (thieves)	2.45	5.3	2.34	1.12	3.35646	0.343
	Lack of knowledge on best storage methods for a long time	3.66	2.34	1.43	0.81	2.23194	0.526
	lack of storage facilities	2.11	0.43	0.23	1.11	2.22515	0.527
	Rain(moisture) during storage	0.451	0.043	1.12	1.65	1.86118	0.602
	Exposure to heat (Sun) after harvest	0.071	0.21	0.33	0.09	0.247023	0.971
Other socio-economic factors (market, trade, policy) constraints	Lack of capital to carry out necessary farm activities	4.5	3.12	5.12	6.17	1.03029	0.794
	Lack/Shortage of capital (money) to purchase inputs	5.67	1.21	0.43	0.87	8.71721	**0.033**
	High cost of inputs	1.12	2.13	4.12	2.12	2.000003	0.572
	Low price, seasonal price fluctuation (low annual trend)	26.56	19.32	22.65	27.65	1.81297	0.612
	Lack market demand (low market/sale) at regional level	13.34	14.54	23.12	13.54	4.08307	0.253
	The demand is not high at local market	17.65	19.12	18.51	18.51	0.0594159	0.996
	Exploitation of farmers by traders (village collectors)	4.13	1.23	1.76	1.67	2.33915	0.505
	Bad road for transportation to the best market sites	9.98	17.56	11.21	6.43	5.72421	0.126
	Transport on risky rivers water body	1.23	1.43	0.56	2.12	0.926517	0.819
	Lack of regular training updates on new swetpotato technologies	9.21	7.77	5.25	5.26	1.67364	0.643
	Lack of harmonized interventions by diverse agents coming in villages	1.43	4.34	3.12	7.54	4.86434	0.182
	recommended best bet practices (innovations, technologies) are complex to implement	0.43	3.91	1.21	2.11	3.5093	0.321
	No governance support (no public extension services working)	5.54	4.42	3.21	6.54	1.25473	0.741

Table-7: Knowledge, perception and awareness (%) of sweet potato biotic constraints (pests, diseases) of farmers interviewed in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Constraints: **Pests**	Sweetpotato butterfly (*Acrae acerata*)	12.43	17.65	21.76	14.32	3.94117	0.385
	Sweet potato weevil (*Cylas* spp.)	45.54	36.71	39.76	21.87	8.48781	**0.037**

	Red spider mite (*Tetranichus cinnabrinus*)	9.32	8.54	5.65	12.12	2.38413	0.497
	Pests (grasshoppers)	6.67	7.32	9.11	18.21	8.33101	**0.041**
	Pests (rodents, snail)	2.11	1.55	2.32	3.12	0.557758	0.906
	Moles	6.12	3.65	4.87	10.87	4.69787	0.195
	Leaf worms (*Spodoptera littorallis*)	1.65	3.65	3.71	7.14	3.85959	0.277
	Whitefly (*Bemisia tabaci)*	7.78	11.65	8.62	4.11	3.59216	0.309
	Aphids (*Aphis gossypii)*	2.12	5.12	2.54	5.12	2.11337	0.549
	Cutworms, millipedes	6.12	3.12	1.12	3.23	3.739242	0.291
	No pest attack problem	0.45	1.23	1.12	0.51	0.593202	0.898
Constraints: **Diseases**	*SVPD (SPFMV + SPMMV)	23.56	19.65	10.11	23.92	6.42518	0.093
	Alternaria blight (*Alternaria bataticola*)	9.87	48.87	24.65	45.22	31.1961	**<0.001**
	Fungal Black Rot (*Ceratocystis fimbriata*)	57.43	21.78	58.22	8.32	52.7094	**<0.0001**
	Unaware (Not sure, I do not know)	9.55	10.12	7.76	23.23	11.9904	**0.007**
*SPVD = Sweet potato virus disease, SPFMV= Sweet potato feathery mottle virus (transmitted by aphid potyvirus), SPMMV= Sweet potato mild mottle virus (SPMMV) transmitted by whitefly-transmitted potyvirus							
Other biotic constraints	Diseases (new emerging unknown diseases)	30.67	35.12	45.12	33.23	3.33081	0.343
	Pests (new emerging unknown pests)	46.73	44.12	37.12	44.44	1.20117	0.753
	Weeds	7.54	3.12	6.88	6.11	1.93182	0.587
	Livestock (vagrant animals in the villages)	4.12	4.32	4.67	7.12	1.15213	0.765
	Birds (wild birds)	7.12	6.23	1.12	7.54	4.81659	0.186
	Human being thieves	1.23	3.12	4.21	1.11	2.82369	0.421
	Vermin (wild animals)	3.12	4.23	1.14	0.97	3.16909	0.366
Challenges faced by OFSP sweet potato farmers	Prevalence of pests and diseases, destructive weeds	44.12	49.12	34.65	79.65	21.8923	**<0.0001**
	Unreliable rainfall (climate variability)	12.54	2.32	6.75	1.54	13.2333	**0.004**
	Natural disasters (landslides, soil-water erosion)	16.76	23.45	23.87	8.43	8.67284	**0.034**
	Livestock keepings	18.54	4.65	12.32	6.21	11.5591	**0.009**
	Thief	3.21	6.76	1.87	0.76	6.47181	0.091
	Poor farm inputs	2.65	1.51	0.56	0.21	2.90943	0.406
	Poor access to ownership of land	0.76	10.54	5.12	1.56	13.2363	**0.004**
	Market fluctuations	1.54	2.65	15.76	1.66	26.6135	**<0.0001**

Table-8: Physical characteristics of some sweet potato varieties (clones) found in the study area during interviews & field visits , in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				**Statistics**	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Skin color	White	4.23	7.12	16.12	5.91	10.1634	**0.017**
	White cream	35.45	39.12	37.12	51.12	3.72094	0.293
	Red, Dark red	25.54	20.12	11.21	18.76	5.53926	0.136
	Purple (violet, Pink)	10.67	5.15	12.12	8.12	3.11917	0.374
	Purple (light/cream)	3.56	1.23	5.12	1.23	3.90984	0.271
	Orange	8.87	12.12	5.42	5.13	4.13084	0.248
	Orange (Light, Brownish)	5.78	8.43	7.54	8.32	0.598081	0.897
	Yellow (purple/ white)	6.76	7.33	6.18	1.54	3.86455	0.276
Flesh color	White-Cream	42.54	57.12	50.31	50.12	2.12813	0.546
	Cream (Yellow/Purple)	33.65	21.43	33.67	25.12	4.02763	0.258
	Orange	6.12	11.67	5.56	6.12	3.37851	0.337
	Orange (Deep/Light)	7.12	4.12	5.33	1.54	3.63474	0.304
	Orange (light/Pale)	3.65	1.11	3.12	3.32	1.41121	0.703
	Yellow	4.55	3.12	1.13	9.12	7.72469	0.052
	Violet	1.87	1.12	1.43	4.87	3.84804	0.278
	Purple creamy	0.88	0.87	0.42	0.31	0.429355	0.934
Shape (%)	Oval	43.98	45.78	77.12	66.54	13.4331	**0.004**
	Round	56.09	55.12	23.56	34.12	18.2981	**<0.0001**

Table-9: Perception of farmers about the current status of sweetpotato production and local varieties available in the village, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				**Statistics**	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Number of local varieties (landraces) in the village	Increasing	25.85	54.12	14.98	9.18	45.9082	**<0.0001**
	Decreasing	63.51	42.76	41.88	73.65	13.3703	**0.004**
	No change	10.65	3.12	43.54	18.05	49.0928	**<0.0001**
Total production in all villages	Increasing	33.87	29.67	27.89	11.56	11.1559	**0.011**
	Decreasing	63.44	43.67	72.67	78.73	10.8961	**0.012**
	No change	3.121	27.12	0.321	10.34	42.4493	**<0.0001**

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Table-10: Proportion of types of sweetpotato (WFSP, OFSP) cultivated, cultivars & post-harvest (storage) root preferences by farmers: Different selection criteria (desirable attributes/most preferred traits) & characteristics looked for in sweetpotato varieties by farmers/ growers, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variations**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Planting greater proportion to WFSP	Limited quantity of OFSP vines	59.22	15.77	5.21	7.86	86.5766	**<0.0001**
	OFSP not tolerant to water stress (drought) on upland	7.92	42.43	44.34	0.12	66.7376	**<0.0001**
	Abundant planting materials of WFSP	1.96	0.31	0.11	27.12	70.7636	**<0.0001**
	Not familiarized well with OFSP as medicinal crop	0.99	5.12	5.87	23.05	32.6781	**<0.0001**
	WFSP are more appropriate for animal feeding	0.88	1.79	1.43	7.65	10.2231	**0.017**
	OFSP are watery and too sweet (not very popular)	1.45	6.67	8.87	20.78	21.2267	**<0.0001**
	WFSP are always more productive than OFSP	0.22	1.65	5.32	1.34	6.88332	0.076
Planting equal or greater proportion to OFSP	Some varieties are associated with High-yield (bigger root size than WFSP)	3.76	11.78	18.34	3.65	16.03161	**0.001**
	Experimentation of new varieties (that nutritionally better for young children)	1.68	3.35	0.65	7.45	8.18604	**0.042**
	High-yield and better taste to fight kwashiorkor & anemia	21.99	12.12	10.23	1.54	18.4163	**<0.0001**
Cultivar preferences	Total (high) yield	25.71	29.8	35.7	36.43	2.43455	0.487
	Earliness (early growth, early maturity)	17.27	16.75	17.52	21.44	0.76291	0.858
	Resistance (tolerance) to pests & diseases	19.71	7.87	6.85	4.83	13.7886	**0.003**
	Resistance(tolerance) to heat and drought	13.22	19.54	19.41	22.28	2.36539	0.5001
	Broad adaptation to local environments	3.81	1.86	4.55	3.89	1.14451	0.766
	Good appearance of storage root	3.11	3.21	1.83	2.53	0.453333	0.929
	Root numbers/plant	4.13	4.12	5.12	1.76	1.61641	0.656
	High vine yield	7.25	1.25	4.16	3.17	4.75863	0.1978
	Off-season propagation capacity	4.75	0.75	4.27	2.67	3.15061	0.369
	Locally adapted/ landraces, consistency (dry matter content)	1.23	15.76	0.85	1.13	34.1433	**<0.0001**
Post-harvest & storage root preferences	High dry matter content	24.4	22.9	23.4	19.63	0.566353	0.904
	Good shape of roots	6.68	5.11	2.12	7.26	3.00317	0.391
	Good root size	0.45	0.76	0.11	0.54	0.470753	0.925
	Crumbliness (breakability) of the root	0.98	0.11	0.16	0.97	1.27369	0.735
	Resistance to rotting during storage	9.91	11.21	3.17	11.77	5.25492	0.154
	Skin/flesh colour of the root (more orange than white)	17.4	18.7	22.7	14.3	1.98782	0.575
	Cookability (cooking time)	0.98	0.31	0.62	0.35	0.50708	0.917
	Shorter duration of the cooking time is better	2.31	5.14	2.12	6.12	3.10018	0.376
	Dryness of root after boiling (taste of boiled root)	1.81	1.83	1.81	2.87	0.400192	0.941
	Low fibre content after cooking	1.44	0.12	2.51	1.11	2.24873	0.522
	God culinary taste (Sweetness)	0.34	1.12	3.12	5.23	5.87086	0.118
	Taste (flavour, texture) of leaves/ fresh root	10.44	12.65	13.12	9.87	0.670642	0.881
	Smell & Odor (bad to good odor) of fresh/boiled root,	6.12	12.43	7.12	4.98	4.25429	0.235
	Level of water (too watery to less watery)	1.09	0.65	0.32	0.41	0.576316	0.902
	Said/expected nutritional value (Richness in Vitamin A)	2.12	2.12	6.43	5.12	3.60154	0.308
	Biomass at harvest (as animal feedings)	6.23	1.32	0.54	1.12	9.07504	**0.025**
	Good price at local market	8.11	4.13	11.4	8.86	3.3509	0.341

Table-11: Sources of planting materials, farmers' reasons for not cultivating sweet potato (those interviewed not growing the crop), reasons that pushes others farmers to cultivate sweet potatoes (incentives that motivate all farmers to cultivate sweetpotato), and suggestion on the ways(incentives) of increasing the value (intensive cultivation) and cultivation of sweet potato everywhere in the in the village, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variations**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Sources of planting materials	Free from Neighbour (friend), fellow farmers	27.56	40.19	11.54	53.76	29.2378	**<0.0001**
	Research Centers / Universities with certified materials	5.12	2.19	17.12	4.21	19.1015	**<0.0001**
	NGOs extension services	6.12	9.31	2.34	3.17	5.73717	0.125
	From own production plots (own cuttings)	23.21	23.32	37.12	8.11	18.3618	**<0.0001**
	Buy from fellow farmers	2.34	6.54	0.76	0.018	10.5636	**0.014**
	local agricultural extension officers	0.06	0.07	0.054	0.013	0.0382284	0.9998
	Local vine markets	0.65	0.09	0.043	0.079	1.17368	0.759
	Saved from previous harvest (previous crop)	35.65	7.45	18.03	23.21	19.5353	**<0.0001**
	Saved vines (plant nurseries, demonstration plots)	0.011	8.12	9.32	2.12	12.5768	**0.006**
	Buy from market/multiplier (specialized seed grower)	0.045	2.78	4.12	6.23	6.10932	0.106
Reasons that pushes farmers to cultivate Sweet potatoes	Very easy to cultivate across all 3 cropping seasons	46.78	58.18	24.67	53.12	14.3197	**0.003**
	Climate resilient crop, Hunger fighting crops	14.89	11.32	3.54	5.55	9.25395	**0.026**
	It does not require many things such as agricultural inputs	6.18	3.12	7.54	11.76	5.39664	0.145

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	Try to resist to different crop diseases than other crops	4.12	5.31	16.31	6.43	11.6636	**0.009**
	Crop easily grown by young entrepreneurs as cash crop	5.55	7.54	11.54	3.15	5.44508	0.142
	Some (OFSP) are good to fight malnutrition	7.68	6.67	7.54	3.54	1.75907	0.624
	Leaves are good for human beings to consume	2.138	7.12	9.34	14.87	9.99058	**0.019**
	Leaves and vines are medicines for infants, pregnant women	9.79	0.78	15.32	2.12	22.6657	**<0.0001**
	Sweetpotato grows covers need of cassava in dry seasons	3.04	0.65	4.43	0.067	6.1252	0.106
Farmers' reasons for not cultivating sweet potato	Lack of sweetpotato knowledge	2.43	2.12	7.32	0.67	8.01203	**0.046**
	lack of planting materials	3.12	6.76	8.23	2.89	4.05086	0.256
	Not economically profitable	65.12	55.12	71.32	26.12	22.0779	**<0.0001**
	Crop for women & children, not for men, orphan crops	21.43	22.54	7.34	48.23	34.971	**<0.0001**
	Crop for marginal lands, yet my land is fertile	8.48	13.54	2.43	22.89	18.9971	**<0.0001**
Ways (incentives) of increasing the value and cultivation of sweet potato	Adopt/ grow market demanded & adapted varieties	5.67	15.54	2.56	4.12	14.7301	**0.002**
	Observe and respect local growing seasonal calendar	2.12	1.23	7.66	3.12	6.93647	0.074
	Washing and sorting in order to get best attractive harvests	0.45	1.65	8.22	4.41	9.69403	**0.021**
	Comply with needs-wants of customs (consumers) for varieties	41.23	9.56	14.98	27.32	25.5947	**<0.0001**
	Linking well farmers-researchers-universities-extension services	3.45	6.54	4.89	17.43	15.0303	**0.002**
	Create village-based centers of excellence on local genetic resources	0.87	0.445	11.12	21.23	34.6935	**<0.0001**
	Disseminate well best production/processing techniques/marketing techniques/information	12.43	6.12	2.99	2.86	9.87525	**0.021**
	Improve transport (roads, rivers) & facilitate access to agricultural tools	5.34	7.12	3.98	11.87	5.02766	0.171
	Disseminate drought-pests-diseases tolerant vines	15.76	19.45	25.92	2.11	19.1748	**<0.0001**
	Disseminate climate-smart varieties	0.67	6.12	9.14	0.87	12.2952	**0.006**
	Linking farmers to best markets (in and out the village)	12.55	26.54	8.98	5.12	19.6605	**<0.0001**

Table-12: Methods of seed (vines) conservation, cultural practices (sources of planting materials, planting method used, cropping system, fertilizer use) and other farming practices (innovations-technologies) used by sweetpotato farmers, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				**Statistics**	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Conservation method	Left on-farm in small plots	69.12	65.67	53.76	19.76	29.2344	**<0.0001**
	Plant after harvest in the same field	6.34	0.76	4.23	0.66	7.727001	0.052
	Planting in marshlands (bottom of hills)	5.76	2.64	9.12	17.89	14.6746	**0.002**
	Plant in lands along water bodies (rivers)	4.87	0.55	6.12	19.45	25.7736	**<0.0001**
	Planting in in shading environments	3.54	9.76	7.78	2.12	6.59517	0.086
	Plant in field margins	6.12	19.12	11.42	24.76	13.2464	**0.004**
	Put all vines in a hole	1.43	0.99	0.56	4.12	4.34394	0.227
	Maintain/multiply nursery beds	0.21	0.65	4.87	4.37	7.04075	0.071
	Do not conserve at all (Do not care)	3.56	0.65	2.58	7.79	7.48765	0.058
Planting method used	Flat ground	20.76	34.65	11.43	19.43	12.9427	**0.005**
	Ridges	66.78	27.89	81.43	78.43	28.6512	**<0.0001**
	Stools (contours)	12.89	37.67	7.88	2.43	47.7668	**<0.0001**
Cropping method	Intercrop (with annual/bi-annual crops)	25.87	14.95	47.32	33.12	18.2378	**<0.0001**
	Mixed cropping (with perennial crops)	12.55	31.89	17.56	5.89	21.5205	**<0.0001**
	Relay cropping	7.65	1.29	0.67	6.54	9.46167	**0.024**
	Monocropping system	54.34	51.96	34.76	54.91	5.61275	0.132
Fertilization	Mineral fertilizers (NPK, DAP)	2.65	0.065	7.62	0.31	13.8501	**0.003**
	organic fertilizers	7.87	44.27	26.45	62.89	47.2824	**<0.0001**
	None (The crop is not fertilized)	89.56	56.21	66.76	37.23	22.8782	**<0.0001**
Crop protection	Regular Weeding (at least two times)	78.56	53.76	23.96	51.43	28.7916	**<0.0001**
	Natural control of pests-diseases (Resistant varieties, early harvesting, crop rotation, using clean seed, trapping pests, scaring away pests)	15.78	43.87	48.12	7.54	42.3856	**<0.0001**
	Chemical control of pests-diseases	3.39	0.556	0.098	0.064	7.39632	0.0601
	No method used to control pests-diseases	3.12	2.66	28.34	41.43	58.7404	**<0.0001**
Other farming practices & technologies/innovations	Earthing-up	62.76	33.98	56.34	52.76	8.91459	**0.031**
	Cutting of the vine from the base at maturity to prevent boring attack by weevils	9.12	10.54	1.54	19.92	16.608	**0.001**
	Rolling and tying of vines at the base to increase tuber size	4.12	8.94	8.12	0.31	8.83638	**0.032**
	Correct length of vine cuttings (2-5 nodes)	0.23	0.45	4.21	0.071	9.53974	**0.023**
	Storage in pits with ash and dried grass	0.45	3.12	1.54	0.082	4.29585	0.231
	Use of sprouts for planting	0.34	3.87	0.43	0.041	8.37525	**0.039**
	Use of seeds \ leaf buds for planting	0.32	0.043	0.41	1.76	2.78867	0.425
	Use of compatible intercrop	1.56	0.54	12.23	12.33	19.0005	**<0.0001**
	Harvesting in bits and de-topping to encourage more tuber production	21.34	39.32	16.12	13.23	18.2601	**<0.0001**

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Table-13: Attributes of OFSP that consumers are aware of., and need to sensitize communities more about role of OFSP in combating malnutrition & Vitamin-A deficiency, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variations**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Attributes of OFSP that consumers are aware of	Health booster, keep healthy	49.11	39.56	28.54	34.65	5.96799	0.113
	Richness in all vitamins (Vitamin-A & Proteins)	6.12	35.12	29.45	36.32	22.2233	**<0.0001**
	Orange or Carrots colour look like	9.76	2.43	1.23	0.54	15.5434	**0.001**
	Attractiveness & sweet taste	15.54	3.56	9.34	1.23	16.5601	**0.001**
	Big size of roots, root appearance	5.32	2.56	2.12	0.54	4.50441	0.212
	strange smell	4.67	0.56	0.98	4.12	5.18106	0.159
	Preferred by children& pregnant women	10.11	16.43	28.65	23.34	9.98318	**0.019**
Sensitize communities more about role of OFSP in combating malnutrition T Vitamin-A deficiency	No, it is not important	4.12	5.78	15.54	3.65	12.8759	**0.005**
	Yes, it is important	23.55	32.45	17.87	2.32	25.2577	**<0.0001**
	Yes, it is very important	27.67	38.23	33.41	5.97	9.945	**0.041**
	I do not know	44.66	23.54	33.18	88.08	13.567	**0.014**
Sources of information about attributes of sweetpotato (OFSP) & improved varieties	Personal (own) experience	9.54	7.54	24.56	8.12	15.9145	**0.001**
	Visiting Markets	6.12	22.08	4.54	5.23	22.3877	**<0.0001**
	Traders (seed traders, agro-dealers)	5.23	7.12	6.54	16.43	8.93411	**0.03**
	Mass media (Radios/TV, social media)	34.65	25.12	17.87	19.12	7.27258	0.064
	Friends & relatives, fellow consumers/ growers	28.78	6.54	5.43	23.54	26.2172	**<0.0001**
	Trade/agricultural fairs/shows	5.54	5.32	7.12	3.65	1.118201	0.773
	Posters (T-shirts, wall mural), brochures, newspapers	0.32	0.06	4.12	3.12	6.45601	0.091
	Extension services (extension agents) of NGOs	0.11	0.02	1.12	2.18	3.58959	0.309
	Farmers' groups(cooperatives), farmers' field schools	1.54	1.15	3.19	0.017	3.51151	0.319
	Churches, primary-secondary school gardens	0.43	0.01	0.05	0.02	0.963725	0.81
	Public Research Centers/stations (Universities)-demonstration plots found in our villages	0.31	6.43	2.21	0.87	9.358	**0.025**
	Village multiplication plots of improved varieties	0.26	1.65	7.12	4.32	8.26705	**0.041**
	Farmer to farmer exchanges & local leaders	3.41	12.54	7.87	3.18	8.69319	**0.034**
	Workshops, Group meetings, fields days	2.34	2.12	1.14	3.03	0.84895	0.838
	Visiting progressive farmers plots in the villages	0.045	0.98	4.32	6.66	9.31293	**0.025**
	During on-farm and off-farm trainings	1.43	2.11	2.97	0.88	1.32031	0.724
Reasons for non-adoption of improved varieties (including OFSP)	Lack of information on where to find seeds (vines)	34.98	29.43	7.56	26.32	17.2709	**0.001**
	Local varieties still perform better, no need of new	24.77	23.54	17.87	5.43	13.0992	**0.004**
	Previously released varieties (land races) are still doing well	11.34	9.87	25.45	22.54	10.6709	**0.014**
	Absence of breeding centers in the villages	5.97	3.34	0.78	1.32	5.81955	0.121
	Little to Absence of nursery/ demonstration plots	7.23	7.56	11.12	27.52	20.718	**<0.0001**
	Lack of money (cash) to buy vines	16.11	26.65	37.76	17.54	12.2082	**0.007**

Table-14: Source of information on Vitamin A deficiency & associated OFSP health benefits and knowledge on Vitamin A deficiency (VAD), suggested preventives actions, perceived health benefits of eating OFSP, suggested actions to control VAD by respondents, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variations**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Source of information on Vitamin A deficiency & associated OFSP health benefits	Health workers	14.67	6.54	20.41	0.41	22.1829	**<0.0001**
	Agricultural workers & extensionists	22.75	11.76	2.87	41.543	42.2036	**<0.0001**
	CGIARS projects staffs	2.76	0.54	6.54	41.87	87.8203	**<0.0001**
	Community members	23.34	37.76	19.65	3.33	28.5644	**<0.0001**
	Had no clear source of information	37.45	43.43	51.32	13.78	21.5032	**<0.0001**
Perceived benefits of eating OFSP	Control of VAD	65.66	22.56	64.76	11.42	58.093	**<0.0001**
	Makes the body healthy	15.34	1.45	5.43	0.67	23.8294	**<.0.0001**
	It gives energy	14.54	49.65	8.99	33.12	38.7344	**<0.0001**
	Provides the required nutrients for the body	0.87	23.12	4.44	5.12	35.7459	**<0.0001**
	Do not Know	3.65	3.31	16.54	50.55	80.0703	**<0.0001**
Respondents knowledge on VAD (Vitamin A deficiency), Suggested Preventives actions & Perceived Health Benefits of Eating OFSP	Respondents Knew something on VAD	22.56	22.12	33.12	64.98	34.2079	**<0.0001**
	Respondents thought something could be done to control VAD	78.12	78.32	67.12	35.76	18.64	**<0.0001**
Suggested actions to control VAD	Eating vegetables (tomato, cabbage, Amaranths, cassava leaves..)	17.56	3.66	19.87	19.34	11.7594	**0.008**
	Eating OFSP is very sufficient	18.54	7.89	9.98	2.12	14.4239	**0.002**
	Eating Vitamin, A-rich foods (orange maize, plantains, orange cassava,),	22.45	27.87	9.12	41.87	21.7582	**<0.0001**

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	Eating fruits (mango, passion, guava, avocado,)	11.45	7.87	1.33	24.12	24.6142	**<0.0001**
	Eating at each meal a variety of foods (mixture of food crops)	5.12	14.23	45.23	0.76	73.9338	**<0.0001**
	Vitamin A supplementation powders	2.43	0.07	0.99	2.12	2.50715	0.474
	Eating frequently orange maize	1.69	29.54	11.65	3.78	41.2507	**<0.0001**
	Eating regularly legume crops (Groundnut, beans, soybean)	2.85	7.87	2.12	0.54	8.99531	**0.029**
	Nothing to suggest	18.23	1.45	0.12	5.67	32.1034	**<0.0001**

Table-15: Major buyers of sweetpotato in the villages, most important sale points for sweetpotato products, mode of transport used for marketing sweetpotato., Source of marketing information for traders, occupation (player/actor activity along the value chains, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Leve of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Major buyers of sweetpotato in the villages	Rural assembler (middlemen, traders)	46.76	55.87	19.85	37.54	7.3146	0.063
	Consumers / other farmers	33.87	34.51	56.12	34.65	17.738	**<0.0001**
	Processors (cookers)	14.12	8.76	20.12	17.54	8.94787	**0.031**
	NGOs & Schools/Private sectors	5.81	1.23	4.54	10.54	8.07389	**0.045**
Most important sale points for sweetpotato products	Hawkers (sellers, vendors, traders)	5.76	25.32	9.54	2.12	29.3036	**<0.0001**
	Village/local processors	0.52	1.21	2.43	0.89	1.62842	0.653
	Boarding schools (prisons, hotels)	1.09	5.43	12.65	9.55	10.5416	**0.014**
	Fellow farmers (local consumers)	2.34	27.56	18.54	9.12	25.2708	**<0.0001**
	Shop in the trading center	14.12	4.54	2.76	1.89	16.3598	**0.001**
	Nearby local markets	56.16	34.12	47.21	59.21	7.72762	0.052
	Nutritional rehabilitation centers	7.13	0.67	2.12	6.11	7.20451	0.066
	Nearby restaurants	8.56	0.87	2.43	4.12	8.27777	**0.041**
	NGOs & travelers (visitors)	4.33	0.45	3.12	7.18	6.20334	0.102
Mode of transport used for marketing sweetpotato	None (because sell in the field at harvest)	13.43	18.78	7.54	16.23	4.99305	0.172
	Head load/(back load)	49.54	41.76	22.54	27.65	13.1692	**0.004**
	Bicycle/motorcycle	29.67	29.65	16.65	33.43	5.92793	0.115
	public/private transport with a car	7.65	10.65	54.12	23.65	56.3245	**<0.0001**
Distance (Km) to nearest good market		25.88	11.43	25.61	17.31	7.3146	0.061
Source of marketing information for traders	Direct visit to the market	8.66	13.56	27.55	4.12	22.9217	**<0.0001**
	Cross check with fellow	68.87	50.34	53.62	69.54	4.98914	0.173
	Hear from friends	16.81	34.67	12.56	25.12	12.8994	**0.005**
	From NGOs extension officers	5.76	2.13	6.54	1.89	4.2825	0.233
Occupation (player/actor activity along the value chains), typology of actors	Farmers (producers/consumers)	55.88	51.12	66.21	52.45	2.4813	0.475
	Consumers only	17.67	13.65	16.92	11.76	1.5423	0.673
	Vendors only (fresh roots)	2.52	2.76	2.31	2.12	0.0937	0.992
	Processors only (biscuits/flours)	3.56	6.32	1.76	9.65	6.6734	0.081
	Cooking vendors (Ndazi, chapati, bread….)	1.56	1.31	0.97	2.14	0.4673	0.923
	Collectors +vendors+ processors	2.12	4.54	2.11	6.12	3.11201	0.375
	Village collectors (Traders/Transporters)	7.71	12.54	3.65	8.76	4.9089	0.179
	Sale person (bulky whosalers/ retailers)	9.67	8.65	6.32	7.31	0.8149	0.846

Table-16: Mode of transport used for marketing sweetpotato, marketing challenges faced by sweet potato farmers in the study sites, most important problems faced in marketing, challenges faced by sweet potato processors and traders, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Major institutional, infrastructural, and market constraints	Unavailability of improved seeds on local market	40.78	26.12	47.82	53.12	9.79941	**0.004**
	High price of seeds	10.45	17.54	7.43	6.54	7.11823	0.068
	Lack of access to credit (absence of rural banks)	10.34	42.12	21.43	9.12	33.7677	**<0.0001**
	Lack of market information	17.92	5.12	4.65	7.23	13.3316	**0.004**
	Low output prices	10.22	2.12	3.33	4.23	7.82354	**0.05**
	Lack of physical access to markets	11.17	7.12	16.21	20.12	7.1189	0.068
Marketing challenges faced	No reliable transport	43.23	43.89	58.09	33.45	6.91071	0.075
	High cost of transportation	32.76	32.99	10.32	27.23	13.2356	**0.004**
	Market located too far	1.12	1.45	4.44	1.43	3.46303	0.326
	Open market price too low and regularly fluctuating	1.65	1.21	3.23	3.65	1.73515	0.629
	No enough buyers within the village	12.12	11.08	7.43	23.12	10.2054	**0.017**
	Absence of farmers association	6.21	0.89	8.17	6.67	5.1561	0.138
	Absence of producers cooperatives	1.65	0.94	4.71	2.76	3.22342	0.358
Nature of most important	Lack of processing facilities	35.86	45.12	27.54	50.65	7.83705	**0.05**

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problems faced in marketing							
	Limited market/Low market prices	10.32	12.43	23.54	7.56	10.9442	**0.012**
	Selling on credit	8.99	3.12	1.76	7.45	6.66398	0.083
	Unfavorable taste/ smell/shape/size of roots	7.33	2.32	5.34	9.11	4.21851	0.239
	Quick rotting after harvest	6.23	4.54	3.54	11.43	5.74423	0.125
	Limited transportation	16.21	14.76	10.45	11.43	1.67935	0.642
	Lack of knowledge on how to acquire good storage facilities	15.45	18.54	28.54	3.11	20.0783	**<0.0001**
Challenges faced by sweet potato traders	Unreliable market/price fluctuations	45.65	42.68	18.67	34.43	12.4129	**0.006**
	Poor storage facilities and lack of security	18.24	21.49	36.65	45.32	16.0697	**0.01**
	Seasonal availability of crop produce	18.97	14.31	23.53	7.54	8.69734	**0.03**
	Inadequate capital and lack of credit facilities	9.17	14.32	9.12	7.21	2.80278	0.423
	Customers complaint	8.48	7.55	12.04	5.76	2.4753	0.48
Challenges faced by sweet potato processors: **in buying**	Seasonal price fluctuation	39.76	16.54	34.54	35.76	10.0894	**0.018**
	seasonal availability of crop produce	13.43	12.45	5.24	2.87	9.67718	**0.022**
	Some of crop produce are not easy to cook	8.76	3.23	6.32	1.98	5.54209	0.136
Challenges faced by sweet potato processors**: in storage**	Poor storage facilities & lack of security	12.65	36.65	18.54	26.78	13.7776	**0.003**
	the quality of the crop produce (floor, beverage,…)	4.32	7.65	9.46	12.39	4.04973	0.256
Challenges faced by sweet potato processors: **In marketing**	Customers complaining	14.21	5.76	9.87	2.17	10.1303	**0.017**
	Dishonesty buyers	7.85	18.56	16.54	18.56	5.08999	0.165

Table-17: Storage of roots & traditional products, value addition processes done by traders, technologies for consumers, processing into, Major consumption forms at household levels frequency of consumption of sweetpotato in, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				**Statistics**	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(DF=3)}$	***P-Value***
Practices of storage of roots & traditional sweetpotato products	Piecemeal harvesting	19.54	20.12	25.99	12.98	4.31984	0.229
	Spread on the floor	17.12	5.67	12.43	5.87	8.96647	**0.031**
	Underground storage (Pit)	0.84	1.12	0.11	1.45	1.11023	0.775
	Dried and put in sacks	1.54	4.56	0.32	0.87	5.89217	0.117
	put under a shade	2.76	3.11	6.43	2.65	2.61712	0.454
	stored fresh in bags	39.31	42.65	45.12	47.89	0.91307	0.822
	stored anywhere in the house	4.12	1.54	3.65	7.12	3.86529	0.276
	covered with SP vines in the garden	3.11	4.65	1.65	3.12	1.43696	0.697
	stored in the granary built in the in the corner	8.32	15.78	4.12	17.43	10.3421	**0.016**
	damp wet store	3.56	1.43	0.45	1.12	3.30305	0.347
Sweet potato value addition processes done by traders	Transport (putting in clean sacks)	5.66	7.12	17.53	11.76	8.16328	**0.043**
	Storage in sacks for a short period	6.32	23.82	14.1	4.77	18.6413	**<0.0001**
	Transport and storage	56.41	39.65	58.34	27.33	14.2684	**0.003**
	Transport and processing	11.72	5.93	3.12	25.76	26.1831	**<0.0001**
	Transport, storage, processing	19.98	23.96	7.76	31.12	13.8694	**0.003**
Technologies for consumers, processing into	flour (breads, cakes, porridges, buns, doughnuts, chapati)	21.78	12.54	11.76	35.32	17.7361	**<0.0001**
	Chips & snacks (fried chips)	3.67	17.54	23.24	29.12	9.1227	**0.028**
	Alcohol	38.76	45.87	18.54	10.65	28.9861	**<0.0001**
	Beverage (Food-beer porridges, Syrup, culture media)	27.67	13.12	26.43	6.75	16.9788	**0.001**
	Obtaining animal feeds	7.32	2.12	13.12	5.43	9.1227	**0.023**
	Flour (Fortification of baby ‘s food)	1.45	8.87	7.17	13.12	9.15775	**0.027**
Major consumption forms of sweetpotato at household levels	Flour to be mixed with other flours	2.12	9.12	2.33	4.11	7.20457	0.066
	Boiled Sweetpotato	60.12	45.12	54.33	56.98	2.31305	0.51
	Raw Sweetpotato roots	13.11	6.12	11.65	10.19	2.64903	0.449
	Roasted Sweetpotato	5.73	6.12	7.12	5.12	0.35103	0.95
	Porridge	0.453	0.56	1.08	0.65	0.33306	0.954
	Fried Sweetpotato chips	1.44	5.12	7.12	8.32	4.94633	0.176
	Processed products (mandazi, juice)	1.12	5.12	2.12	3.99	3.15876	0.368
	Making local bear (alcohol)	16.66	23.17	14.48	11.44	4.51303	0.211
Frequency of consumption of sweetpotato in the study area.	Once a week	66.65	54.12	38.66	28.65	17.9305	**<0.0001**
	Two times a week	27.99	33.67	50.87	67.55	21.3387	**<0.0001**
	Three times a week	3.88	10.12	7.12	3.12	5.11604	0.163
	Four times a week	1.87	2.45	4.12	1.54	1.58128	0.664

Table-18: Preference of farmers to grow white and/or orange fleshed sweetpotato and willingness to adopt improved varieties, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	**Level of variation**	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Preference of farmers to grow white and/or orange fleshed sweetpotato	OFSP	15.78	14.23	15.76	17.54	0.34696	0.951
	WFSP	36.3	34.12	21.78	41.44	6.24245	0.101
	YFSP	6.67	6.45	2.13	6.11	2.60262	0.457
	All three types	41.5	45.34	61.21	35.11	8.09009	**0.044**
Willingness to adopt improved varieties	WTA (OFSP)	51.56	55.12	60.43	67.12	2.3499	0.503
	WTA (WFSP)	18.65	12.12	15.43	14.54	1.44067	0.696
	WTA (YSPF)	2.44	1.67	2.11	2.76	0.29047	0.962
	WTA (all types)	28.12	31.89	22.12	16.12	5.84589	0.119

Table-19: Price ($/Kg), factors considered by producers in setting selling price producers perception of mode of price determination, Role (use) of money from vending sweetpotato roots, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
Variables	Level of variation	**Masisi (N=102)**	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Price (US $ / Kg), (x±SD)	OFSP	(0.66±0.31)	(0.71±0.14)	(0.63±0.32)	(0.69±0.34)		
	YFSP	(0.40±0.16)	(0.44±0.15)	(0.42±0.17)	(0.41±0.11)		
	WFSP	(0.34±0.09)	(0.32±0.19)	(0.32±0.09)	(0.31±0.13)		
Mode of price determination: Producers perception	Price fixed by owners(sellers)	77.87	67.89	70.12	81.45	1.64697	0.649
	Price fixed by buyers	6.98	3.12	1.11	8.43	6.98969	0.072
	Negotiation with a buyer	17.12	29.12	29.54	10.32	12.3986	**0.006**
Buyers perception	Price fixed by owners (sellers)	85.99	80.12	87.45	74.21	1.3403	0.721
	Price fixed by buyers	2.87	4.12	4.78	0.43	3.6179	0.306
	Negotiation with a buyer	11.53	16.12	7.78	25.54	11.565	**0.009**
Factors considered by producers in setting selling price	Size and Quality of roots	40.12	60.12	34.54	55.43	9.34891	**0.025**
	Quantity by set	24.05	13.65	31.87	15.12	10.199	**0.017**
	Demand forces	15.65	20.12	11.65	6.76	7.16264	0.066
	Supply forces (monopoly)	6.66	1.87	6.45	10.21	5.6809	0.135
	Const incurred during production process	5.88	3.12	8.98	8.56	3.33533	0.343
	Nutritional values	3.87	0.87	3.21	3.43	1.90745	0.592
	Type of environments where the market is located	4.12	0.45	4.12	0.76	5.25006	0.154
Role/Use of money from vending sweetpotato roots	Increase overall income	14.65	16.45	6.12	7.12	7.3852	0.061
	Building new houses	2.23	3.12	1.32	2.13	0.73936	0.864
	Buying new animals (goats, pigs, cattle, chicken, guinea pigs)	18.43	7.65	3.12	6.43	14.8069	**0.002**
	Buying other types of food not grown	8.65	9.12	14.12	11.65	1.7603	0.624
	Buying household needs (clothes, radio, TV, chairs)	6.23	18.54	16.12	6.43	10.774	**0.015**
	Pay school fees	12.56	8.32	16.65	21.43	6.40251	0.094
	Pay health fees	7.21	11.56	15.31	12.12	2.88296	0.41
	Pay various taxes	3.67	2.34	2.12	4.12	0.94618	0.814
	Pay various membership contribution	0.43	0.67	0.98	0.12	0.72473	0.867
	Buy new lands	21.11	15.21	21.54	23.55	1.89919	0.594
	Buy farm tools & equipment's	4.87	7.12	3.12	5.32	1.58627	0.663

Table-20: Sweet potato marketing channels in North-Kivu province, eastern DRCongo

Sweet potato marketing channels	Channel - I (43%): Producers →consumers
	Channel - II (14%): Producers → retailers →consumers
	Channel - III (7%): Producers →local processors →consumers
	Channel - IV (37%): Producers → retailers →local processors →consumers

Table-21: Farmers' estimates (declared, reported) of sweet potatoes production cost (US$/ha), reported Cost and profitability analysis of sweet potato production (US $/0.25ha, and marketing costs at various levels of sweet potato distribution chain (US $) for 100Kg at different nearby territory main trading centers, in Masisi, Rutshuru, Lubero and Beni territories, North-Kivu Province, eastern of the DRCongo

		Territories (% of Respondents)				Statistics	
		Masisi (N=102)	**Rutshuru (N=214)**	**Lubero-Butembo (N=185)**	**Beni (N=88)**	$\chi^2_{(Df=3)}$	***P-Value***
Farmers' estimates (declared, reported) of sweetpotatoes production cost (US$/ha)							
	Harvest in (tons/ ha)	7.87	9.67	19.32	13.77	6.12063	0.106
	Quantity consumed (30% of the yield)	3.2	3.56	5.47	7.54	2.42243	0.489
	Gross income (ha, at 0.2$/Kg)	1574	1934	3864	2754	1224.13	**<0.0001**

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	Ploughing, clearing, Ridge preparation ($)	150.1	78.54	68.54	89.54	41.6383	**<0.0001**
	Seed costs, seed procurement (buying vines) (US$)	24.5	5.34	17.54	6.81	18.3543	**<0.0001**
	Cost of organic fertilizer (manure, cattle feces) (US$)	17.8	1.76	7.89	10.32	13.9845	**0.003**
	Cost of hiring labour (US$)	136.7	60.43	110.32	120.21	30.2703	**<0.001**
	Imputed cost of family labour (US$)	29.56	10.54	34.56	17.57	15.6734	**0.001**
	Cost of weeding (US $)	100.23	45.65	79.65	113.44	30.8885	**<0.0001**
	Cost of harvesting (US $)	57.4	37.87	41.76	26.87	11.6898	**0.009**
	Cost of transportation (field-home-market) (US $)	44.53	78.98	90.54	100.34	22.5974	**<0.0001**
	Total variable cost ($)	560.82	319.11	450.8	485.1	67.3703	**<0.0001**
	Gross margins (Gross Income-Total cost) (US $)	1014	1614.89	3413.2	2268.9	1523.65	**<0.0001**

Reported Cost and profitability analysis of sweet potato production (US $/0.25ha), (Kibumba production center, Nyiragongo Territory, nearby Goma town)

		Marketing channels					
Variables	**Level of variation**	I	II	III	IV		
Cost/profit item	Land rent (if any need of rent)	16.25	16.25	16.25	1.25		
	Land clearing and preparation	20.18	20.18	20.18	20.18		
	Planting materials/seed (vines)	36.47	36.47	36.47	36.47		
	Planting on ridges	18.47	18.47	18.47	18.47		
	Weeding (hand hoe manpower)	11.96	11.96	11.96	11.96		
	Total cost of production /0.25ha	103.33	103.33	103.33	88.33		
	Total production (kg of tubers/0.25ha)	1660	1160	1701	1205		
	Price/producers (price in $/kg)	0.31	0.33	0.41	0.29		
	Total value of sweetpotato produced for selling (/0.25ha)	517.92	382.80	697.41	349.45		
	Net benefit (Profit/0.25ha land)	414.59	279.47	594.08	261.12		

Marketing costs and profit margins of sweet potato traders per sac of 100 Kg (US $) (Munigi production center, Nyiragongo Territory, Goma town)

			Marketing channels				
		Cost/profit item	I	II	III	IV	
Group of market players	Retailer	Buying price		40.55		40.55	
		Transport		3.48		3.48	
		Sack		1.88		1.88	
		Levy		1.88		1.88	
		Loading		1.63		1.63	
		Unloading		1.25		1.25	
		Market fee		0.63		0.63	
		Profit margin		17.10		16.97	
		Selling price		68.38		68.25	
						68.25	
	Processor	Buying price			43.75	1.31	
		Transport			0.28		
		Sack			0.18		
		Levy			0.19		
		Loading			0.25		
		Unloading			0.13		
		Market fee			0.06	0.06	
		Processing			4.20	4.20	
		Profit margin			1.944	0.381	
	Consumer price		4.78	6.84	11.60	11.60	

Marketing costs at various levels of sweet potato distribution chain (US $) for 100Kg (Kibumba, Nyiragongo Territory, near Goma town)

		Marketing costs					
	Cost item	Retail level	Local processor level-1	Local processor level-2			
	Transport	3.48	2.81	1.31			
	Sack	1.88	1.75				
	Levy	1.88	1.88				
	Loading	1.63	2.50				
	Unloading	1.25	1.25				
	Market fee (tax)	0.63	0.63	0.63			
	Processing		42.00	42.00			
	Total marketing costs	10.73	52.81	43.94			
	Total marketing costs (as % of retailing price)	0.02	0.06	0.05			